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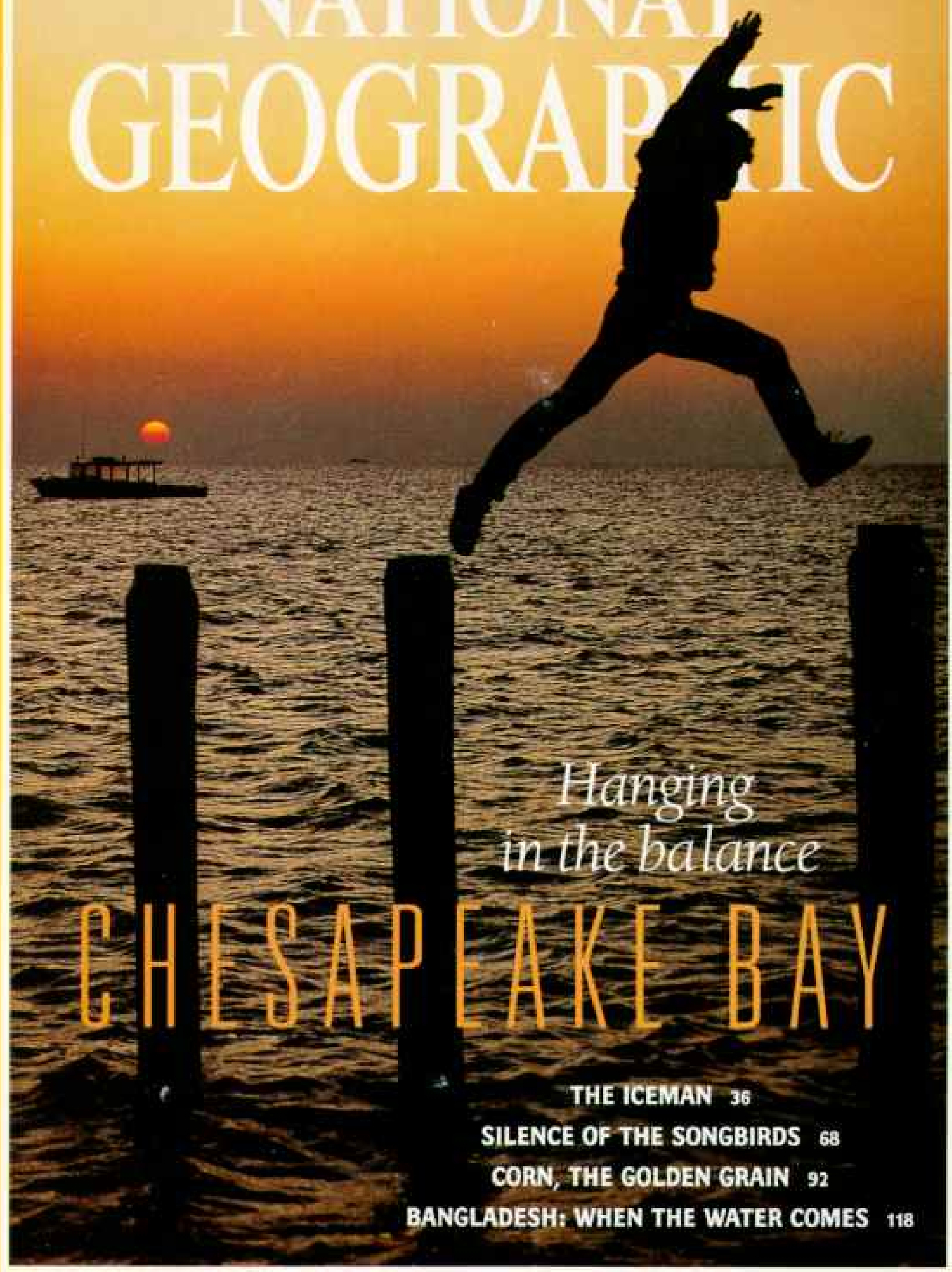

Hanging in the balance

CHESAPEAKE BAY

THE ICEMAN 36
SILENCE OF THE SONGBIRDS 68
CORN, THE GOLDEN GRAIN 92
BANGLADESH: WHEN THE WATER COMES 118

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NATIONAL GEOGRAPHIC

JUNE 1993

Chesapeake Bay—Hanging in the Balance

By Tom Horton
Photographs by Robert W. Madden

With oysters, crabs, rockfish—and the great estuary itself—at risk from overharvesting and pollution, the six states in its watershed struggle to save the bay.

2

The Iceman

By David Roberts
Photographs by Kenneth Garrett
Paintings by Greg Harlin

Discovered by hikers high in the Alps, a 5,000-year-old mummy reveals startling clues about Europeans of the Copper Age.

36

Silence of the Songbirds

By Les Line
Photographs by Scott Goldsmith

A spring without birdsong? As human development spreads and avian habitat shrinks, many of the 200 species of migratory birds that nest in eastern North America continue to decline.

68

Corn, the Golden Grain

By Robert E. Rhoades
Photographs by Peter Essick

Domesticated 7,000 years ago from a Mexican grass, corn sustained pre-Columbian civilizations, from Aztec to Zuni. Today corn products include toothpaste, fireworks, and garbage bags.

92

Bangladesh: When the Water Comes

By Charles E. Cobb, Jr.
Photographs by James P. Blair

Time and again, cyclones hurl wind and water at the densely packed Asian nation, with tragic loss of life. Yet monsoon floods bring silt, a key to growing rice in one of earth's largest deltas.

118

COVER: Greeting another day on the bay, Bo Hoppin navigates pilings off Great Fox Island in the Chesapeake. Photograph by Robert W. Madden.

Cover printed on recycled-content paper.

Hanging in the balance

A vast estuary teeters precariously between ecological collapse and a return to essential health. At Great Fox Island, a Chesapeake Bay Foundation education center, ecology instructor Bo Hoppin provokes students to rise early with a promised display of "walking the pilings."

CHESAPE


LAKE BAY

By TOM HORTON

Photographs by
ROBERT W. MADDEN
SENIOR ASSISTANT EDITOR

IT'S EARLY MAY, about halfway up the Chesapeake, where Maryland's Nanticoke River meets the huge estuary. Sunset burnishes the river, which is swollen by a tide thrusting up from the bay. The Nanticoke seems to hold its breath, ripe and expectant in the soft evening air. A single star peeps out, mirrored on the smooth water. Something bulges under the river's skin, shattering the starlight. Soon the wetlands echo with thrashing and splashing.

Great striped bass wallow on the surface, venting gobs of amber eggs. Smaller males attend the female fish, leaping, jetting clouds of sperm to fertilize the eggs. From Labrador to North Carolina the fish have converged here for another spring in the Chesapeake's riverine nurseries, where they join other excited migrants like shad and river herring.

Not so long ago the Nanticoke and other tributaries of the bay hatched up to 90 percent of the East Coast's striped bass—stripers, rockfish, or, as we call them locally, just rock. The rock sustained a sport and commercial fishery valued in the millions of dollars annually. Shad too were harvested by the millions of pounds, herring by the tens of millions.

Such numbers and economic multipliers were of scant interest to me as a boy growing up in the 1950s and '60s in Federalsburg on Marshyhope Creek, where the Nanticoke forks deeply into the farmland of the Eastern Shore. All I cared was that each spring, when the peepers began to chorus and the shadbush bloomed and the dogwood budded, I could get my fishing rod and walk down Bloomingdale Avenue to the willows behind Zaffere's Bakery, cast a shad dart into the Marshyhope, and hook into excitement and vitality from far beyond the confines of my little hometown. I have since caught sharks in the Red Sea, giant catfish in the Amazon, and Dolly Varden trout in Alaska. None was more thrilling than those spring shad of my youth.

And we nearly lost it all. From the early 1960s to the late 1970s, commercial harvests of American shad declined 35 percent in the Virginia portion of the Chesapeake and 95 percent in Maryland, where fishing for them was banned in 1980; in the 1970s, herring catches went down by 95 percent across the bay; striped bass fishing was banned in Maryland

"WHEN the time is right to crab, you go, even if you are tired, even if you feel bad," says Dwight Marshall of Smith Island, hauling crab pots in summer. That waterman tenacity has spread from oldtimers to newcomers; all sense "the time is right" to work for the bay's future.

TOM HORTON is the author of *Bay Country* and a co-author of *Turning the Tide: Saving the Chesapeake Bay*. A columnist for the Baltimore *Sun*, he won the 1988 John Burroughs Medal for excellence in natural history writing. This is his first assignment for NATIONAL GEOGRAPHIC.

in 1985, and Virginia soon had to follow suit. White perch, yellow perch, weakfish, and other species showed similar trends.

These enfeebled spring pulses of life were symptomatic of a decline throughout the Chesapeake, described by journalist H. L. Mencken in its happier days as a giant protein factory. In the past century more oysters have been harvested from the bay than anyplace else on earth. Yet takes have sagged to a few percent of historic harvests. Meadows of underwater vegetation, critical habitat for dozens of species of fish and waterfowl, have vanished over much of the bottom. Measurements in the bay's deep channels reveal that 15 percent of its 15-trillion-gallon volume has had little or no oxygen some summers.

Amid all the decline, though, the lusty rolling of the rockfish in the Nanticoke offers a ray of hope, a sign that, given half a chance, the bay will not die easily. Although pollution is still a threat, removing fishing pressure has let the rock's spawning stocks rebuild, and reproduction has been good enough in the past few years to allow a limited fishing season.

Also give credit to the rock. Several spawners out here this evening are nearing four feet and 65 pounds, in their third decade

now of carrying life back to their natal river. Biologists date some of these old grandmothers to the record spawn of 1970, the same spring the nation's first Earth Day celebrated a new era of environmental awareness.

If there is hope now in the boisterous regeneration we see in the water, there is irony too. How did we let such treasure almost slip away? Nothing in my native Maryland is more sacred than the bay. It is no accident that the state boat is an oyster skipjack, the state dog a Chesapeake Bay retriever, the University of Maryland's mascot a diamondback terrapin, or the state fossil a mollusk. Of course, the state fish is the striped bass. Indeed, during the long life of the oldest stripers there was scarcely a year when some state or federal environmental manager could not legitimately claim some example of progress in caring for the bay.

So many environmental battles waged and won, but how goes the war? A decade ago William Hargis, former director of the Virginia Institute of Marine Science, evaluated it this way: "We have been progressing nicely, moving upstream at three knots—but the current keeps running downstream at five."

WHEN MARYLANDERS cross the bay, they drive a few miles on a span between Annapolis and Kent Island; Virginians drive more than 15 miles on the bridge-tunnel between Norfolk and Cape Charles. The bay in Maryland has a cozier, riverine feel, but head south into Virginia and the shorelines fade from sight, the

water takes on a more marine coloration. It is big water, forbidding on stormy days.

Geographers say the bay stretches just under 200 miles, from around Norfolk, Virginia, at its mouth, almost to the Pennsylvania line 30 miles north of Baltimore. But if you were actually to slosh along its edge, following the intricate merges of land and water, you would be in for a hike of several thousand miles. And it would be a hike, seldom a swim. The broad Chesapeake waters that spread across thousands of square miles are astoundingly thin—little more than 20 feet average depth. I used to tell the kids that I took canoeing across intimidating stretches of open bay: "If we capsize, stand up!"

To see what unifies this vast body of water, what makes it at once so special and so especially vulnerable throughout its length, you need not put on a lab coat. Far better to lace up a pair of old tennis shoes for protection against oyster shells and broken glass and strike out, wading, from almost any point along the shoreline.

Something about *(Continued on page 16)*

***DEMAND FOR WATERFRONT** raises environmental concern. Chesapeake Harbour (upper left) at Annapolis was approved before setbacks from water's edge were mandated. In Baltimore's Inner Harbor, workers dismantle an AlliedSignal facility where chromium compounds, some carcinogenic, had been manufactured since 1845. Elaborate barriers will seal off toxics before the land is redeveloped.*

A PECKISH SQUABBLE doesn't amount to much between tundra swans that have flown together across the continent from Arctic nesting grounds. Like Canada geese, these swans have adapted to

feeding in farm fields. Other Chesapeake waterfowl, with habitats disrupted or food sources reduced, have fared worse. Among the victims: black ducks, redheads, wigeon, and canvasbacks.

The Chesapeake watershed

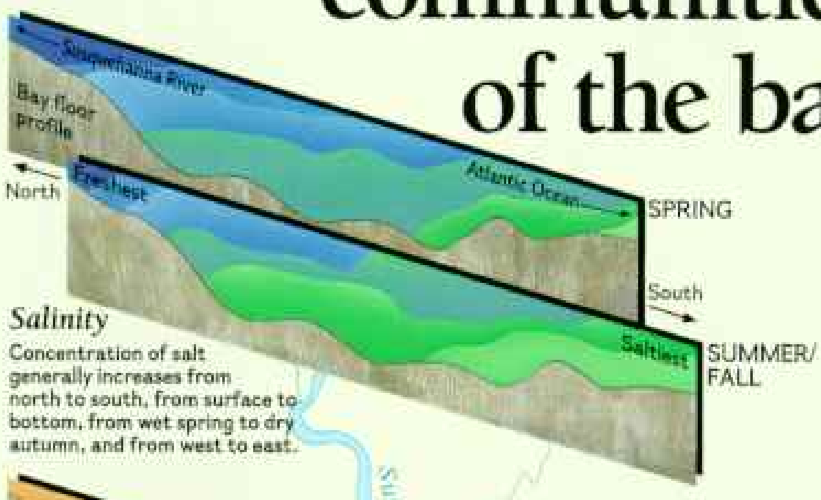
***THE BAY IS YOUNG** by the slow reckoning of geology. It was carved by a Susquehanna River engorged with meltwater from the waning of the last glacial maximum about 18,000 years ago. Since then sea levels have risen, as they are rising now, and the ancient river has continued to evolve as a tidal estuary.*

As a tree depends on its roots, branches, twigs, and leaves, so the bay depends on its rivers, streams, creeks, and drainage basins. This Greater Chesapeake stretches over 64,000 square miles in six states and the District of Columbia. The view below, a mosaic of six satellite images rendered in enhanced color, focuses in exquisite detail on the heart of Chesapeake country.

LANDSAT THEMATIC MAPPER, EOSAT CORPORATION. IMAGE PROCESSING BY EARTH SATELLITE CORPORATION, ROCKVILLE, MARYLAND

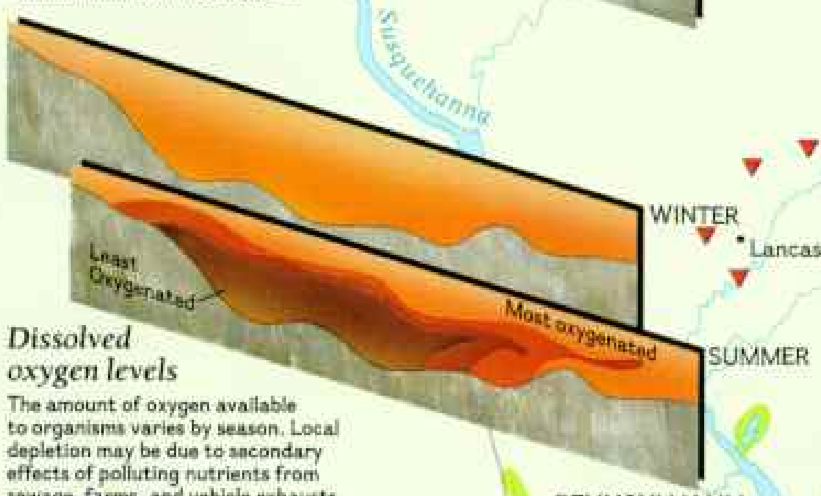
Diverse communities of the bay

Consider the sea nettle: pulsing, languid, diaphanous—and the biggest pain in the Chesapeake Bay. Its range, like that of many bay creatures, is governed by salinity. It cannot tolerate fresh water, so in a rainy year a swimmer might enjoy the upper bay until midsummer before being stung by nettles. The bay's natural communities vary with the interplay of salinity, dissolved oxygen, depth, bottom type, currents, pollutants, and other factors. Those shown are typical of the mid-bay, although, for example, the fish known as spot can live in most conditions.



Salinity

Concentration of salt generally increases from north to south, from surface to bottom, from wet spring to dry autumn, and from west to east.



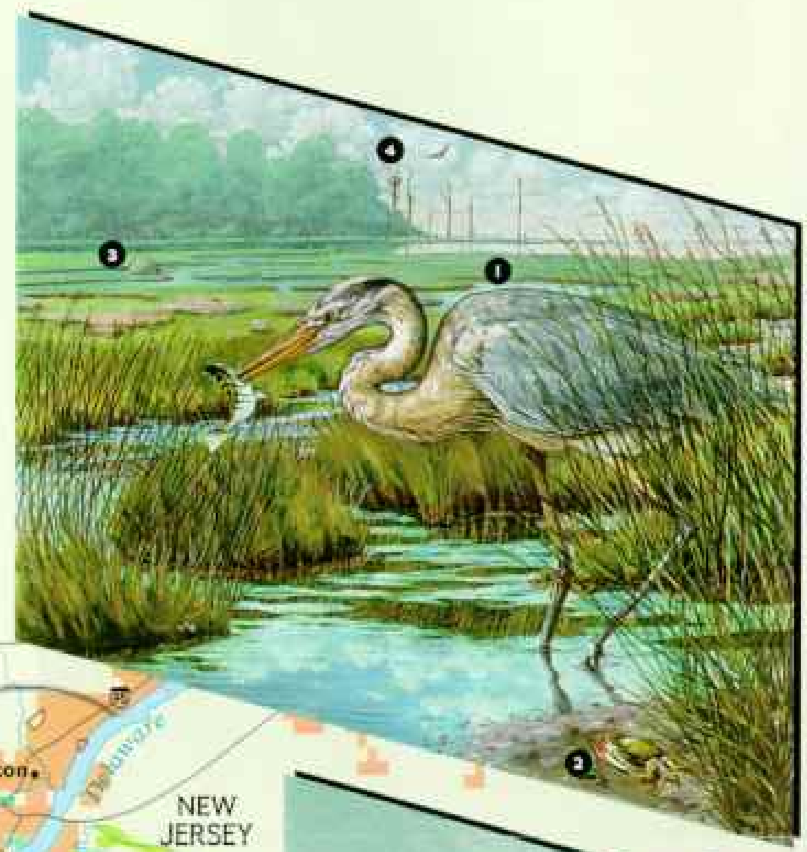
Dissolved oxygen levels

The amount of oxygen available to organisms varies by season. Local depletion may be due to secondary effects of polluting nutrients from sewage, farms, and vehicle exhausts.

Marsh and forest

Sometimes, as at Blackwater National Wildlife Refuge, all three types of bay marsh—fresh, brackish, and salt—grow in proximity. A great blue heron (1) has speared a fish, while a red-jointed fiddler crab (2) scuttles through salt-marsh cordgrass. Beyond, a muskrat lodge (3) rises from an expanse of three-square sedge. A dead tree in a mixed conifer-hardwood stand has been appropriated for a bald eagle (4) nest.

Marshes give many benefits: They buffer shorelines from erosive effects of storms and abnormally high tides, trap sediment, recycle nutrients, and serve as nurseries for crustaceans, fish, reptiles, birds, and mammals.

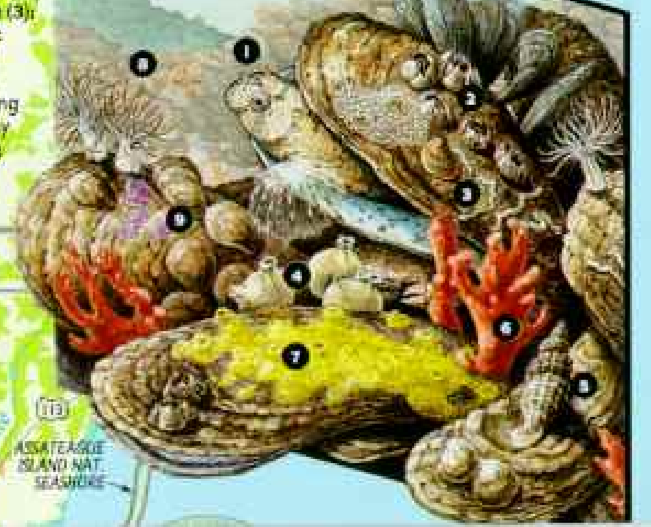


Aquatic plants

One of the most visible markers revealing the health of the bay is submerged aquatic vegetation (SAV). Widgeon grass (1) and eelgrass (2) stabilize bottom and provide cover for blue crabs (3) and young spot (4) and places to light for grass shrimp (5), bryozoan colonies (6), and snails (7). SAV is also feed for diving ducks (8) and, when it decomposes, for microorganisms that support the entire food chain.

Oyster beds

Now greatly depleted, oyster beds are not only the source of succulence on the half shell but also offer nooks and crannies where other organisms can flourish. Among these are the feather blenny (1); ivory barnacle (2); fan worm (3); sea squirt (4); Atlantic oyster drill, a natural oyster enemy (5); red beard sponge (6); boring sponge, another enemy (7); ghost anemone (8); and young oysters, called spat (9).



PENNSYLVANIA
MARYLAND
VIRGINIA
DELAWARE
NEW JERSEY
Chesapeake Bay
Susquehanna
Potomac
Patuxent
Choptank
Wilmington
Newark
Fair Hill
Elkton
Havre de Grace
Aberdeen
Bel Air
Reisterstown
Cockeysville
Westminster
Hereford
Frederick
Towson
Pikesville
Baltimore
Ellicott City
Dundalk
Columbia
Gaithersburg
Glen Burnie
Rockville
Laurel
Severna Park
Silver Spring
Bethesda
Bowie
Annapolis
Chestertown
Rock Hall
Centreville
Denton
Easton
St. Michaels
Oxford
Tilghman
Federalsburg
Cambridge
Washington, D. C.
Arlington
Alexandria
Fairfax
Vienna
Manassas
Upper Marlboro
Woodbridge
Waldorf
Prince Frederick
La Plata
Stafford
Dahlgren
Solomons
Leonardtown
Broomes Island
King George
Colonial Beach
Cobb Island
Coltons Point
Lexington Park
St. Marys City
Piney Point
Port Royal
Hooper I.
Deal
Wenona
Salisbury
Princess Anne
Conowingo Dam
Elkton
Susquehanna River
Bay floor profile
North
Freshest
Atlantic Ocean
SPRING
South
Saltiest
SUMMER/ FALL
WINTER
Least Oxygenated
Most oxygenated
SUMMER
Lancaster

Saltwater wetlands
Freshwater wetlands
Blue crab spawning grounds
Oyster beds, active or inactive
Submerged aquatic vegetation (SAV)
Park, refuge, or other protected area
Military installation
Built-up area
Site classified by the Environmental Protection Agency as major discharger of pollutants
24 Depths in feet

0 20
MILES
NGS CARTOGRAPHIC DIVISION

WETLANDS AND BLUE CRAB DATA PROVIDED BY NOAA; OYSTER AND SAV DATA FROM THE CHESAPEAKE BAY PROGRAM

PAINTINGS BY CHRISTOPHER A. KLEIN, NATIONAL GEOGRAPHIC ARTIST

Open water

The food chain is shown here at its most basic — what eats what. It begins with phytoplankton (1), eaten by tiny animals called zooplankton (2), which in turn feed sea nettles (3) and small fish such as bay anchovies (4) and Atlantic menhaden (5). The fish become food for predators like bluefish (6) and rockfish, or striped bass (7). The most lethal level is not shown: human beings.

Subtidal zone

Beyond the line that marks low tide is a world of worms and clams like the Baltic macoma clam (1). Clamworms (2) don't attack clams but are themselves prey for crabs and fishes. Others in the worm world include the common bamboo worm (3), parchment worm (4), and a milky ribbon worm (5), arching over a tube anemone (6) as it burrows through the mud.

(Continued from page 7) an edge attracts life. It is there that sunlight falling on the marshes and the rich muck of shallows can stoke a production of organic matter unequaled by human agriculture. In the nooks and crannies of the edges all kinds of creatures find food and refuge. Soft-shell crabs, minnows, and crayfish; bald eagles, canvasback ducks, and great blue herons; oysters, ospreys, and Canada geese; the young striped bass and speckled trout. So much of what we hold essential about the bay inhabits its edges.

Humans, too, increasingly have found the edges of the bay prime habitat—as waterfront real estate, marina space for pleasure boats, and the best place to find cooling water for power plants and dilution for sewage and industrial discharges.

It took more than three centuries following Capt. John Smith's 1607 Jamestown colony for the number of people in the bay region to reach eight million—and only the past half century to nearly double. And that understates the impact modern society has had. Automobile exhaust, garbage, energy consumption, pesticide use—these and other by-products of humankind all have increased more rapidly than the population.

Since John Smith produced his remarkably accurate map of 1612, the Chesapeake has been portrayed as a great body of water fringed by the lands of its tidewater counties. But, as seen from space satellites, the bay is in fact part of a drainage basin, or watershed, 25 times as large as the bay proper.

More than 40 significant rivers and thousands of streams root the bay intimately in lands stretching north nearly to Vermont, out across the Blue Ridge into West Virginia, and south almost to North Carolina. In such a context the bay seems no longer magisterial but, rather, a smallish skim of water on the receiving end of nearly 15 million peoples' activities that flow—as surely as rain and rivers run downhill—from every inch of the 64,000-square-mile Chesapeake watershed.

The implications of "seeing the bay whole" are far-reaching. Pennsylvania, for example, though it owns not a foot of Chesapeake shoreline, profoundly determines the quality of the bay's fresh water, half of which comes from a single river there, the Susquehanna.

It is this new and huge and devilishly interconnected concept of the bay that is now the focus of an unprecedented effort by scientists, governments, and citizens to halt the Chesapeake's decline and to restore it as closely as possible to the generally healthy conditions that existed in the 1950s.

That goal, the object of state and federal government programs for a decade now, is proving no less bold and difficult than John Smith's initial exploration of the estuary. Its outcome has implications felt far beyond even the sprawling boundaries of the watershed. The margins of land and sea, the coastal edges so attractive to us and to nature, are everywhere beginning to show the strains so well documented on the Chesapeake.

Nearly half of all Americans now live in the nation's coastal areas, including the Great Lakes, and growth in coastal counties continues to exceed the national average. Around the

***BAY TREASURE,** oysters by the billions once thrived in the Chesapeake. No more. Overfishing and parasitic diseases called MSX and dermo have all but ended the harvest. Diver John Volatile finds a few oysters at the mouth of the Tred Avon River but sees most die before they reach market size.*

To make up for lost income, many watermen have doubled or tripled the number of pots they set to catch blue crabs. Such intensive crabbing puts heavy pressure on what has been the bay's last reliable fishery.

country—Puget Sound, Galveston Bay, Pamlico Sound, Casco Bay—coastal embayments are struggling.

The fate of the Chesapeake, then, embraces notions as grand as whether humans can learn to live in a sustainable natural environment—and as personal as whether my son and daughter can ever hook a shad from the Marshyhope.

FROM MY HOME CREEK it is a 400-mile drive to where I'm walking in a crowd of summer visitors down Main Street in Cooperstown, New York. I'm one of the few who don't turn in at the National Baseball Hall of Fame. I want to see the top of the watershed, a few blocks down the street and unmarked by any sign. This is the source of the mighty Susquehanna, the place where, as much as anywhere, you can say the Chesapeake Bay begins. Maple-shaded and not 50 feet wide, the Susquehanna moves sedately, tentatively, beneath a little bridge at the foot of Otsego Lake, and begins its way to the bay.

At the Otsego field station of the State University College at Oneonta, Joe Homburger shows me specimens of a few tiny eels taken from Otsego Lake. They can have come from only one place—the Sargasso Sea, a thousand miles away in the North Atlantic Ocean, where all American eels go to spawn and die. How their young made it back into far-flung river systems they have never seen is mystery enough, but these eels at Otsego astound me: They must have come to New York by way of

SQUEEZING along a shallow gut at high tide, a powerboat threads a marsh of needlerush. Beyond rises a hummock called the Pines, once a homestead, now a rookery for herons and egrets. Closer to the

horizon lies Tylerton, one of three active Smith Island villages. Eroding with every storm, Smith and Tangier Island, a few miles south, are the last settlements without a bridge to the mainland.

the Chesapeake and the Susquehanna, somehow getting past more than a dozen dams, including a hundred-footer at Conowingo, near where the river enters the bay in Maryland.

Such migrations of fish once connected the bay vividly throughout its watershed, legions of shad and herring providing a glad countercurrent to what these days seems only a one-way flow of pollutants downstream.

At Otsego a scientist shows me an excerpt from an account of the spring of 1789, after a hard winter left many settlers near starvation. Then "a singular event seemed sent by a good Providence to our relief . . . unusual shoals of fish were seen moving in the clear waters of the Susquehanna. . . . In less than ten days each family had an ample supply," wrote William Cooper.

From the author's description it is clear that these were herring and shad, whose descendants I would hook and net in the Marshyhope and its tributaries nearly two centuries later.

Dams, roads, ponds, and other obstructions have in modern times effectively "amputated" thousands of miles from fish migration. But ambitious programs to restore fish passage in the District of Columbia, Maryland, Virginia, and Pennsylvania are beginning to reopen hundreds of miles of prime spawning habitat—and remind people as far away as New York and Virginia's Blue Ridge Mountains that they are linked to something greater downstream.

For the scientists at Otsego a main worry is the same water quality that is a primary threat to the Chesapeake far below. "Right now we are balanced right on the edge," says Bill Harman, director of the Otsego field station. He explains that sewage, farming, development, and erosion have been raising nutrient levels, threatening to deplete oxygen vital to the lake's fish.

ON MY WAY BACK DOWNRIVER through the agricultural heart of Pennsylvania, I recall John Smith's oft quoted description of the bay: "Heaven and earth never agreed better to frame a place for mans habitation. . . ." Seldom do you hear the rest of that sentence, "were it fully manured. . . ."

In his wildest dreams of a well-fertilized, bountiful land, Captain Smith could never imagine anything like Lancaster County, Pennsylvania. Famed for its Pennsylvania Dutch culture, it is a horn of plenty from which spills more than half a billion dollars annually in milk, eggs, pork, poultry, mutton, and related products. But each year from the horn's other end spills nearly ten billion pounds of cow, sheep, hog, and poultry manure.

The nutrient-rich runoff, washing downstream to the bay, has fueled mammoth increases in the growth of floating algae, denying vital sunlight to underwater plants. These aquatic plants, on which ducks, geese, and swans feed and in which crabs hide to shed their shells, have been wiped out across tens of thousands of acres. Additional damage comes when the algae die and decompose, using up oxygen from the water needed by the bay's other aquatic life.

"We do have a problem," says Sherman Haas, who raises cattle, hogs, grain, and hay in a valley that rolls between Nittany and Brush Mountains in central Pennsylvania. "But you wonder if your farm can be hurting Chesapeake Bay as bad as some say."

No single farm is—nor is agriculture the sole source of the bay's problems; but farmers, though they number less than 3 percent of the bay region's people, work a quarter of the 41 million acres in the watershed. They apply nearly 700 million pounds of commercial fertilizer annually. And today's farms also have far greater concentrations of livestock and poultry—and their manure—than they did 50 years ago.

Haas became a farmer in 1983, moving near the Centre County village of Rebersburg to get away from growing development around the city of York. It's easy to understand why, seated on the porch in the cool shade of his old stone farmhouse. The valley shimmers green-golden in the late summer heat. The corn is tasseling gold-to-brown, and a playful breeze blends barnyard odors with scents of alfalfa curing sweetly in the hayfields. It is difficult to reconcile such beauty and fullness of the earth with water-quality problems happening more than a hundred miles away.

In an effort not to add to the bay's troubles, Haas is trying to send out no more nutrients than he takes in. For that reason, he weighs every pig, every bag of feed and fertilizer, every truckload of hay, livestock bedding, and manure leaving and entering his operation. He works closely with Les Lanyon, a Pennsylvania State agronomy professor.

"We have changed the world," Lanyon told me, referring to the vast increase in

THOUSANDS OF TONS of Pennsylvania manure and millions of gallons of Washington, D. C., area sewage head toward the bay each day. The straw this Amish farmer spreads with manure (upper left) acts to slow nitrogen release; a proposed state law would require management plans for fertilizer and manure on large farms. The Blue Plains plant intercepts sewage before it reaches the Potomac River, producing compost (below) sold for soil conditioner.

modern fertilizer use, "and we wonder why things won't stay the same." With farmers like Haas, Lanyon is attempting to bring agriculture in the bay watershed into "nutrient balance," eliminating any excesses not needed to grow crops or animals—excesses that now end up in the Chesapeake. Haas, for example, has used government funds to build storage pits to hold his manure until it can be removed by a neighbor who has more land than animals. This has prevented polluted runoff from the Haas farm and cut the neighbor's use of commercial fertilizer by 30 percent.

Such heartening examples are becoming more common; but in Pennsylvania and throughout the bay's watershed, agricultural pollution control remains largely voluntary, and, in the context of millions of crop acres and billions of pounds of manure, progress is but a fraction of what it needs to be, bay environmental managers agree.

Still, things have come a long way from 1983, when officials from Pennsylvania first came down to Annapolis to explore bay pollution control. One of the Keystone State's top natural-resources officials seemed puzzled when someone from Maryland handed him a large oyster. The Pennsylvanian turned it over and over, handling it gingerly. "It's amazing that these things shed their shells every year," he said.

"No, no, it's crabs do that!" an aide hissed in his ear.

***CAPITOL PUDDLE** goes the way of all rainwater—trickling toward the Chesapeake and bearing whatever it gathers on the way: heavy metals, petroleum by-products, airborne acids, excess lawn-care chemicals, pet wastes, and other pollutants.*

Such "nonpoint" sources are notoriously hard to identify, much less to control. Their potential for damage is made worse when natural filtering systems—forests, grasslands, marshes, and beds of healthy oysters—are paved over, drained, or killed.

AGRICULTURAL POLLUTION by most measures is at least not getting worse, but the same can't be said for population growth. I'm thinking of this as I gaze up the Potomac River on a hot June afternoon. Plenty of time to gaze, because I'm caught on the Woodrow Wilson Bridge, just below Washington, D. C., barbecuing in some of the world's worst traffic congestion, inhaling fumes that are an acrid affront to the nation's Clean Air Act.

The river below us, the bay's second largest tributary, once supported oyster beds downstream so rich that dozens of Marylanders and Virginians have died in shoot-outs over the bounty in the past century. Sturgeon, measuring as long as 14 feet, once roiled the river here, where a caviar business operated until the mid-1920s.

While still not back to its historical levels of production, the Potomac is cleaner today than it was in the 1960s, when President Lyndon B. Johnson called the nation's river "disgraceful." Johnson's warning led to massive spending on sewage treatment, but as population grows in the Washington region, the pressures on the bay will continue mounting.

Bernie Fowler saw the crush of humans—and trouble—coming more than 20 years ago, when he was a new president of the Board of County Commissioners in Calvert County, Maryland, where the Patuxent River flows down to its junction with the Chesapeake. Bernie mystified many neighbors in his sleepy, rural county back then by saying that growth was the region's most pressing problem.

"All you had to do was look at what was happening around Washington, D. C., and look at the bridges and highways being planned," Bernie told me recently. "We had waterfront in Calvert County. We had low taxes. We had a beautiful countryside, and

everything we were doing was making it more convenient for people to come here."

Since 1950, population in the Patuxent drainage basin has more than tripled, while forests and fields have been given over to development, removing some of the natural buffers that keep pollutants out of the bay.

"You wonder how we let it go," Bernie mused. "You know, you hear people say the water seems cloudy, and I wonder what's happened to all the hardheads [croakers, a once plentiful bay fish]. The fishing fell off. The bay grasses disappeared. You notice all these things, but it comes so slow. I guess it's like setting in a room and the oxygen being consumed; you don't notice it until most of it's gone."

To stem the tide, Bernie and others joined in a lawsuit against Maryland and the EPA in 1978. The idea was to limit sewage pollutants from urban areas upstream. Bernie's side won, and that is why nowadays, every second Sunday in June, people from around the state of Maryland wade into the Patuxent on Bernie Fowler Day. They are hoping to see their toes in the river, just as Bernie did as a young man in the 1950s. He recalls how he would wade out into the river to hunt for soft crabs. The water was so clear that, even chest deep, he could spy the crustaceans hiding in pale green grasses that carpeted the shallows. Thus the unofficial goal: When Bernie Fowler can once again wade to his chest and see his toes, we will know the river is back.

With Bernie and a crowd of others, I link arms and wade out from the beach at Broomes Island, where flags flap and big fluffy white clouds race before a smart southwest breeze, wafting the smell of a fried-chicken picnic awaiting us on shore.

Shin deep now, I can still see my white tennis shoes clearly (it helps to have size 15 feet). Bits of aquatic grass float by. Better than it

LOPING ALONG near Point Lookout, Maryland, FA-18 jet fighters return to the Patuxent River Naval Air Station, home of the Navy's test-pilot school and proving ground for aircraft. The government restricts

air traffic near the base and reserves a one-mile-radius circle of open water for target practice with dummy bombs. The armed services control some 350,000 acres of bay watershed, much of it prime wildlife habitat.

used to be, a local tells me: Knee deep now. I don't think we're going to make it, although there is progress. Phosphorus from sewage discharge is down 75 percent since 1981; tens of millions of dollars have been allocated to begin removing nitrogen. Thigh deep and we're done—still looking for our toes, still hopeful.

I've heard Bernie speak many times, but his talk this year is more urgent, perhaps because of the quadruple-bypass surgery he underwent following last year's wade-in.

"When people like me grow old and die off, we risk leaving a whole generation that has no idea what this river really was. No memory banks in those computers at EPA can recall the ten barrels of crabs one person used to catch out there, and all the hardheads, and the thrill of the oyster fleet coming in at sunset, the shuckers in the oyster house all singing harmony while they worked. If we can't make some headway soon," Bernie added wistfully, "these children will never, never have the hope and the dream of bringing the water back, because they just won't have any idea how enriching it used to be."

Even if Bernie finds his toes eventually, in many regions of the river the look of the landscape, the mix of villages and tobacco barns, forest and field and rolling vistas that made southern Maryland unique—much of that is beyond recall.

Increasingly I look at the Patuxent and think of other bay rivers—Virginia's James and Rappahannock, where forested shorelines still predominate for miles at a stretch and you can see more eagles in spots than most places outside of Alaska; the Delmarva Peninsula's Pocomoke and Nanticoke, where you can canoe all day with scarcely a sight of human commerce. These rivers still have time to do it right, to plan for growth rather than react to it, to maintain the great green filters—forest and wetlands—that help cleanse runoff before it reaches the bay. Those riverside communities should send someone to Bernie Fowler Day.

FROM THE POTOMAC'S MOUTH it is only a dozen or so miles to Smith Island, but they are water miles, and water, even in the modern world, remains a blessedly effective buffer and insulator. Late summer on the island is high harvest season in the crab center of the universe. Bay and land and humans merge and blend in this, one of only two inhabited offshore islands in the Chesapeake.

Sunrise throws silver on the wave crests and blushes in the troughs as boats set out for the crabbing grounds, and the morning palaver on the marine radios flows as soft as a marsh creek, and here or there a word or phrasing harks back across three centuries to the West Country dialect of Smith Island's original English settlers:

"Hayeee Chaarruls."

"Out o'heart?" (Are you depressed?)

"That I warrr. Two jimmies 'n' a gnat." (Yeah, caught very little the day before. Jimmies are male crabs.)

"Swagger I am." (Me too.) "What I had was right sookeh." (Caught mostly mature females, or sooks, which fetch a lower price.)

"I'm gone." (That's enough of that.)

Kevin Marshall throttles back the *Maria Rose* and heaves his "scrapes," heavy iron rectangles dragging mesh bags large enough to enclose a man. Attached by a short, stout rope to either side of the boat, the scrapes bite into the bottom, trailing twin chocolate contrails in the water. After a "lick" of the bottom that lasts a few minutes, the young crabber hauls his first scrape, dumping glistening, thigh-thick rolls of green and olive sea grass onto the boat's washboards.

At first the heaps of grass seem inert, but on closer inspection I can see the surface wriggling with small grass shrimp, minnows, and the young of trout, flounder, spot, and a dozen other species. From deeper in the grass Kevin begins plucking soft crabs. No forest on the surface of the bay's watershed holds more life than these meadows that once stretched across 630,000 acres of its bottom and now hang on in only a tenth of that area, mostly around places like Smith Island, remote from mainland pollution.

We love our crabs in Chesapeake country—love to eat them steamed and fried, in crab cakes and stuffed into flounder and striped bass fillets. We catch them every month of the year, from the remoteness of Smith Island to the urban-industrial harbors of Baltimore and Norfolk.

Nearly half the national catch of blue crabs comes from the bay. Blue crabs can grow only by frequently shedding their shells, at which point they become known as soft-shell crabs, one of the world's great delicacies.

"It's a good living while it lasts, soft-crabbing, but it only runs May to October,"

IT'S A KEEPER—a largemouth bass a young fisherman caught in the Anacostia River, an urban tributary of the Potomac with a sewer's reputation. That is changing as volunteers and governments pitch in to make the Anacostia watershed safely swimmable and fishable.

Kevin tells me later, slumping wearily in his particleboard shanty. "It's about ready to wind up." The breeze ruffles his blond hair as we gaze out at a million-dollar view of the bay and marsh and sunset sky. Kevin's wondering what to do with the rest of his year, and maybe what to do with the rest of his life.

This time last year he rigged *Maria Rose* for oystering up the bay, around Annapolis, and spent nearly $5,000 adding a small but comfortable cabin for a place to sleep out of the winter weather. Bucking a storm on his first run, a wave smashed his windshield out and Kevin had to turn back for home. Then he came down with appendicitis. By the time he finally joined the oyster fleet, the best weeks of the season were gone, and his colleagues decided to call a strike to protest the low prices.

"Coulda been worse—I learned a lot," was Kevin's assessment of his first oyster season. And this year? "Dunno. The older men say it doesn't look good for oysters. I may end up comin' home and riggin' up for hard-crabbin' through December." His thinking is typical. Watermen see oysters, shad, striped bass, white perch, and other traditional quarry in decline, so they fall back on the only thing they know, the last great fishery of the blue crabs, in hopes that it will provide for their future. Scientists worry that the crabs, still plentiful, won't stand the pressure.

"It is harder now to make it than when I started," says Dwight Marshall, Kevin's father and one of the region's top watermen. Days can run from long before dawn until after dark. Only on Sundays do the islanders rest, in accordance with the teachings of the Methodist Church, which dominates life here. To chart the ups and downs of crabbing through the summer, one need not look at catch records. A reliable indicator is the amount of weekly collections published on the church wall.

"Kevin works as hard as most," Dwight says. "But to make it these days, you got to drive yourself, even when you are tired."

Kevin admires his father's energy—but he worries about it too. "I don't think anybody

does any better than Dad," Kevin says. "But Dad never stops. He'll have a heart attack."

"So many of the young ones are leaving," says Kevin's mother, Mary Ada Marshall, thrusting her hand into a huge tub of quivering, live soft crabs in Dwight's shanty. Quiver they might, because Mary Ada's big scissors make short work of preparing them for the freezer. SNIP goes a crab's face; SNIP, SNIP, go its gills; SNIP goes its abdominal cover. Then it goes to the freezer. It's 3:30 in the afternoon, and except for 20 minutes to swallow a tuna sandwich, Mary Ada has been going since 3 a.m. on this typical summer day.

She runs down the list of island youth who have left for the outside: "Charlie and Frances's five, there's one stayed; none of Fred's four; Ruth and Waverly's four, two gone; Connie and Bucky's two, both gone. . . .

"I believe there's enough left in the bay to see me and Dwight through, but we're established, our family's raised. It won't be the same for Kevin. I used to believe he'd be here till the last sea gull flies, but now I believe he'd take a job if he could get a good one."

The equation is more complicated than the biological health of the bay, which is complicated enough. I'll never forget what Mary Ada told me as Dwight and I began yet another conversation on the future of seafood harvesting.

"I'm not worrying about the crabs and oysters," she interjected. "Lord'll take care of them, one way or another. What I want to know is who's my boy Kevin to marry, with three eligible girls left here, and two of 'em his cousins."

That is the rub. It's bad enough for the Chesapeake to lose its water quality and abundance of seafood—but the traditional culture is going too. To be a citizen of the Chesapeake is not just to enjoy oysters on the half shell but to slurp them within thrilling sight of the century-old wooden skipjacks, North America's last working sail fleet, which harvests them; not just to dine on rockfish stuffed with crabmeat but on rockfish and crabmeat from tight-knit little communities that recall a time when nature called the tunes.

In a world of options—and uncertainties—their parents never had, the young people of the bay's traditional communities are seeking the outside world, and the outside world, in the form of tourism, is seeking and changing the places where they live.

***FISH OUT OF WATER,** spawning American shad take the elevator (upper left) to bypass Conowingo Dam near the mouth of the Susquehanna River. Tagged and sexed during a census, a large rockfish is released to reproduce. Their steep decline led to fishing bans in Maryland and Virginia, but rock have made a comeback, and limited fishing is now permitted.*

On Smith Island the population has fallen to around 450, from nearly double that 50 years ago; in Urbanna on the Rappahannock, sailboats and condos outcompete battered workboats for waterfront space. A high-speed ferry now sails direct from Baltimore across the bay to once remote Rock Hall, and in the narrows at Kent Island the crabbers most weekends are

dodging 300-horsepower (and up) speedboats heading for the bikini contests at Redeye's, a pandemonious waterside bar.

BACK ON THE NANTICOKE the short crisp November days prod catfish and largemouth bass to feed against the coming winter. Wood ducks have moved into the forested swamps. Any day, riding the skirts of winter's first big norther, chevrons of tundra swans will come sailing over, baying like lost hounds. Summer's life has decamped, rockfish to the ocean, turtles and crabs to the mud bottoms, warblers and egrets to the far south.

One constant remains, a silent observer of the river's edge, the splendid-plumed, pterodactylous great blue heron. If the bay, from marsh to mountain, shares a spirit, it is this bird. There is not a season of the year, nor a single county, where the great blue heron does not stand watch over the meeting of land and water. It sees the breaching of humpback whales and the surf crashing on Atlantic jetties; it knows the river otters' mud slides up wooded Potomac creeks; it watches the crimson-stippled trout in the limestone springs that feed the Susquehanna.

Soaring on six-foot wings, it has seen the rising sun work gold and silver filigrees on millions of acres of land and water, and grain by grain it has probed the sands and muds and rotting leaves of every beach and tideflat, every farm ditch and mountain creek and bog. The books say it feeds on small fish and frogs and snakes, but in freeze-up winters it does whatever it takes—swallows a muskrat whole or fights mother cats for their kittens in a Smith Island crab shanty, downing them, mewing. It seldom speaks, and when it does, it utters only a fractured croak, as if a hard crab has gone down its long gullet sidewise.

Now I watch it warm its spindly shanks in the last slants of November sun and wonder what kind of accounting we can make for the human stewardship of the Chesapeake. What of the ambitious program that aims not only to halt the bay's decline on all fronts but to restore it to conditions of 40 years ago? Are we finally moving upstream, not just making three knots against the five-knot current in Dr. Hargis's analogy?

"I have this gut feeling that just in the last few years we may be holding at four versus four, that we're at the point we've stabilized the patient," says William C. Baker, president of the Chesapeake Bay Foundation.

Christopher D'Elia, a bay ecologist at the University of Maryland's Sea Grant College, agrees: "It looks to me like we're at a stasis point; we have arrested the decline."

Neither man, however, underestimates how far there is to go. "Society is still in a stage of denial about just how extensive the human input is," says D'Elia. As an example, he cites the excessive amounts of nitrogen that still flow into the bay—from sewage plants and septic tanks, from farms and well-fertilized suburban lawns and golf courses—even from automobile exhausts and power-plant stacks, sources that may account for 25 percent of the nitrogen reaching the bay.

Of these major sources of nitrogen, it looks as if human sewage is the only one that will be reduced by the stated goal of 40 percent by the year 2000. Money, laws, and technology

***THE TOES TEST** is a ritual soaking for Maryland State Senator Bernie Fowler and friends. As a young man wading after crabs in the Patuxent River, he could see his toes in chest-high water. Then came scummy algal blooms and clouds of silt. Toes vanished.*

Senator Fowler, who has since chaired the Chesapeake Bay Commission, got together with citizens and legislators of Maryland, Virginia, and Pennsylvania to press for cleanup laws. "I'm optimistic that we've turned the corner," he says—but he still can't see his toes.

appear adequate to accomplish that. With agriculture such success appears farther off. Perhaps 90 percent of the eight million acres of crops under fertilization in the Chesapeake watershed lack comprehensive management plans to stop nitrogen and phosphorus from running into the bay. In the past ten years nitrogen from all sources actually increased about 2 percent.

Controlling pollution entering the bay is only one part of a three-point solution to the bay's future health. Limits on overfishing have helped the striped bass return to the bay, but governments in the region are well behind promised deadlines to carry out management plans. And fisheries management can turn out to be a nasty choice between preserving bay watermen and preserving the species that are their lifeblood. Consider the oyster: Until recently seen mostly as a tasty hors d'oeuvre and economic resource, the oyster is now regarded by many ecologists as a valuable filter because it removes excess algae and silt from the bay as it sucks water through its system. But decades of disease, poor fisheries management, and pollution have ravaged the bay's oyster colonies. Once they may have been capable of filtering a volume of water equal to the entire bay every week or two. Now it takes the reduced oyster population almost a year to accomplish the same cleansing.

The third part of the equation is maintaining and restoring the bay's natural resilience, the extraordinary capacities of aquatic plants, oysters, forests, and wetlands to buffer the bay against pollutants that otherwise would upset the ecological balance. Forests and wetlands cover only about half as much of the watershed as they once did. Both continue to decline in the face of sprawling suburban development that is consuming nearly four times as much open space for every new

STINGING THE COMPETITION, including entries from the U. S. Naval Academy, Yellow Jacket leads on a downwind leg of racing near Annapolis, one of the nation's busiest sailing centers. One lesson all

DICK SWANSON AND BILL THEAD

Chesapeake sailors soon learn: how to free the boat after running aground. On average, the bay is only half as deep as these boats' masts are high. Fortunately for skippers most of the bottom is soft mud.

resident as did the more compact housing patterns that prevailed through the 1950s.

Maryland has enacted a pioneering measure restricting development of most remaining natural shoreline in a thousand-foot buffer zone around the bay and its tidal rivers. But there is nothing comparable in Pennsylvania or in the other 90 percent of Maryland. And Virginia's shoreline protections are not nearly as strong. "Managing growth is absolutely the toughest challenge we face," says Will Baker of the Chesapeake Bay Foundation.

Will we succeed? Will the current someday run five knots upstream against three knots? I think we are on the right track—that success in restoring the bay begins by attending to the entire watershed and all the links that implies. But I do not think my generation, the baby boomers, and our elders will complete the task. Too many of us are still overreliant on technological solutions, more stopgap than sustainable, and reluctant to innovate alternatives to the "grow or die" economic notions that put so much pressure on our natural resources.

Sometimes looking at the troubles of the whole watershed can overwhelm you, and, then, maybe it's time to go home.

"LAST GUY, last house, last everything," jokes I. T. Todd about his return to Holland Island, where he was one of the last children born. Islanders were leaving by 1917, when his father dismantled the family home and rebuilt it in mainland Crisfield. The last house on Holland (left) is owned by hunters, and the island, like the community of 300 that once lived there, is dissolving into remembrance.

NO ONE in the Chesapeake watershed, it is said, lives more than a few minutes from some stream. The bay branches and branches again and again, rooting the estuary like a mighty tree in the lives of us all.

Recently I decided to go back for the first time in more than 30 years, to where the bay began for me. To a ravine behind my family's old home and a rubbishy little rivulet that was as much a drain for waste oil from a local trucking firm as it was a waterway. It meandered only a half mile or so before entering Marshyhope Creek, and eventually the Nanticoke, the Chesapeake, and beyond. Never mind its biological shortcomings, that little stream was flowing water, lending personality and attraction to an otherwise ordinary depression in the land. My playmates and I dammed it, channeled it, splashed in it, raced wood chips in it, swung across it on ropes. Such a humble thread in the grand web of the bay's drainage, yet what perceptions, memories, and emotions it still evokes for me.

Sliding down a steep bank into the cool, sun-dappled, and still trashy creek bottom, I heard voices—three youths of the town, armed with one rusty toy gun among them, out for a Sunday morning expedition. Their leader, Steve Faulkner, Jr., 12, described himself as the general of this group. He took me in tow and introduced his buddies Michael and Joey Keene. They offered me a turn on the slender rope they used to swing across the water. I declined. (When you weigh 220 pounds, some things are best left unrevisited.)

"It's a neat place, huh?" the general asked.

"Oh yes," I replied, and thought, just wait until you see what it's connected to.

In fact, I was impressed and pleased to learn, they knew something of the little stream's links to the bay. And they knew that cleaning up the bay was, in Steve's view, "one of the most important things we've got to do." They had discussed it in school. I wondered if they had ever caught a shad downstream in the river or dipped a herring in April or May.

"Nope," said Steve. It seemed they were wiser than I at their age, yet poorer. This brought to mind something a friend from one of the bay's tributary communities had told me recently.

"The difference between the bay I knew and the bay my daughter knows is this," he said. "She's 19 and never caught a rockfish, and I just think that is outrageous." □

THE ICE

LONE VOYAGER FROM THE

In a rocky hollow at the crest of a high mountain pass, the man stopped to rest. We may never know what drew him to these heights. Perhaps he was a shepherd, guiding his animals back to the southern lowlands for the winter. Perhaps he was an itinerant trader, a shaman, a prospector, an outcast.

Buffeted by cold winds along the pass, he gazed out over the two valleys below. The one to the north looked formidable—a vista of glaciers that led to a harrowing chasm and a thundering river. To the south beckoned a valley of safety, its larch

MAN

COPPER AGE

Overcome by fatigue and cold, a mountaineer lies down to die high in the Alps. Now, some 5,000 years later, the discovery of his well-preserved body, along with clothes and a copper ax, offers startling clues about how humans greeted the metal age in Europe.

ETÖMA

Entombed for millennia under a glacier, the Iceman emerged in September 1991, when hikers chanced on the mummified corpse in melting ice. Did he die while tending his animals? Nearby a modern shepherd guides a flock past Austria's Niederjoch Glacier toward a valley in the Italian Alps, where some experts guess the Iceman made his home.

Ötzi, the Iceman

By DAVID ROBERTS

Photographs by KENNETH GARRETT

Paintings by GREG HARLIN

trees a blaze of orange needles in the waning autumn, its stream spilling softly from one green meadow to the next. It was also a valley of comfort. It may even have led to his home.

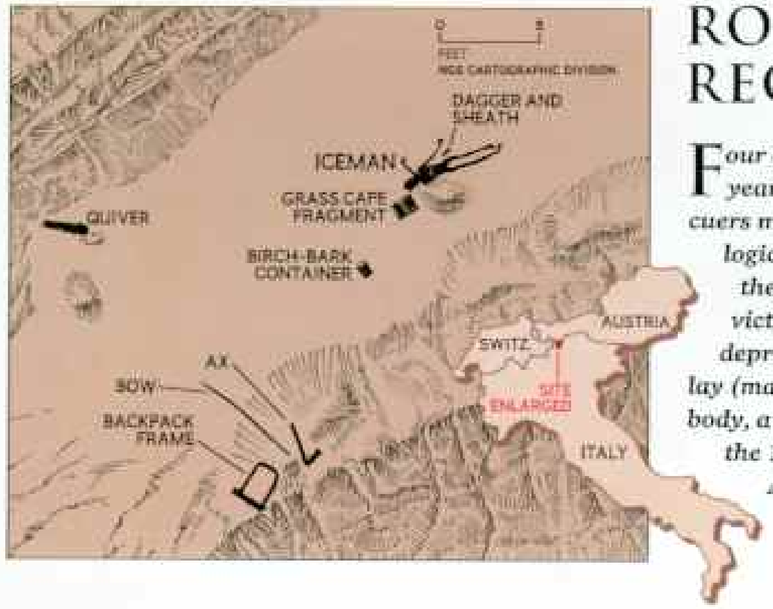
He knelt in the hollow and unpacked a birch-bark container. Inside, carefully wrapped in green leaves, lay a few pieces of charcoal. Had he not climbed so high, he might have built a fire with them, but now he was thousands of feet above any shrubs whose branches he might have used for kindling. A piece of meat, from an ibex he had killed earlier, and a few berries were all the food he had.

The man, in his late 20s or 30s, stood five feet two. His clothes of animal skins, cape of grass, and leather shoes stuffed with grass warded off the cold. Beneath his clothes his skin bore markings, perhaps tattoos—several sets of parallel blue lines on his lower back, a cross behind the left knee, and stripes on the right ankle. In his hand he clutched his ax, the most valuable thing a man could own.

He looked up at the mountains we call the Alps. Something was wrong. This skilled, solitary traveler, who knew these ranges as well as any man, was in trouble. Perhaps a sudden blizzard had surged over the jagged ridges and was engulfing the pass; perhaps the man had gone too long with too little food; perhaps some illness sapped his strength. One item at a time, he laid down the belongings that defined his life, propping them here and there among the rocks around him. Then he stretched out across a broad stone in the center of the hollow, reclined on his left side, and laid his head down. Sleep overcame him.

The man never awoke. Deep snows covered him. Through some 5,000 years, he lay in his tomb of ice, frozen in the posture of his last conscious moments.

On September 19, 1991, a German couple, Helmut and Erika Simon, hiking near the border between Austria and Italy, wandered slightly off the *(Continued on page 44)*



ROUGH RECOVERY

Four days almost undid 5,000 years of preservation as rescuers manhandled an archaeological treasure. Assuming they had found an accident victim, climbers trampled the depression where the Iceman lay (map, left). Trying to free the body, a policeman summoned to the 10,530-foot site on the Austrian-Italian border tore into the left hip with a jackhammer.

Finally a forensic team from Innsbruck, Austria, arrived. Workers digging with ski poles (right) scattered the Iceman's garments. The genitals were missing, possibly broken off when the coroner and an assistant lifted the corpse (far right). Not until archaeologists viewed the body and belongings in a lab was the Iceman's antiquity revealed. Despite the damage, the body, still wearing a grass-stuffed boot (below), was amazingly intact, virtually unharmed by the glacier that had slid over the trench where it lay.

SYGMA (ALL)

(Continued from page 38) trail. Suddenly Erika Simon caught sight of a small head and pair of shoulders emerging from the ice. The couple thought they had stumbled across a discarded doll. Instead, Frau Simon had found the solitary prehistoric traveler now known around the world as the Iceman.

He was quickly nicknamed Ötzi, after the Ötztal, the valley north of his death site. Not since Howard Carter unlocked the tomb of King Tutankhamun in the early 1920s had an ancient human so seized the world's imagination. Within months, T-shirts, postcards, jewelry, and pop songs celebrated Ötzi. Austrian schoolchildren described him as well as anyone could: "the poor man who died alone in the snow."

Everyone had a fantasy about Ötzi. One journalist insisted that the Iceman was a hoax—an Egyptian mummy stolen from the British Museum and somehow planted in the ice. A German woman announced that she was writing a book about her nightly séances with Ötzi. Other women declared that they wanted to be impregnated with his presumably frozen sperm!

Meanwhile, the Iceman had begun to excite archaeologists and anthropologists all over the world. Thought initially to be 4,000 years old, he ranked as one of the oldest and best preserved mummified humans ever found—King Tutankhamun, by comparison, lived nearly a millennium later.

The Iceman's was by far the oldest body ever retrieved from an Alpine glacier; his nearest rival was a mere 400 years old. And at 10,530 feet, the death site represented the highest prehistoric human find ever made in Europe. Not even the remains of a campfire had been discovered so high before.

The Iceman's body survived through topographic luck. Shortly after he died, the rocky hollow where he lay filled with snow, but it formed a stable pocket, detached from the glacier that flowed for five millennia a few yards above his head. Bodies caught in glaciers usually are crushed and torn by the movement of the ice, and tissues and organs are reduced to an undifferentiated mass. The Iceman instead was naturally mummified. The body emerged in such good condition that the man's eyeballs remain intact, glaring eerily at the modern world, and scientists may be able to determine what he ate for his last meal.

As a mountaineer who has spent many jubilant days in the Alps, I found myself engrossed the moment I heard about the Iceman. As a journalist who often writes about prehistory, I was doubly intrigued. And as the details of the chance discovery became clear, I realized that on a warm September afternoon in 1982—nine years almost to the day before Erika Simon stumbled upon the mummy—I myself had ventured within a mile and a half of where the Iceman lay.

I flew to Innsbruck to report on the Iceman, hoping to see him with my own eyes. It was too late: Already the scientists in charge had closed the door tight on press and public alike.

Their reaction made sense in light of the shocking tale of the botched recovery of the Iceman's remains that was beginning to unfold.

During the four days after the September discovery, a small horde of well-meaning hikers and officials, including the famed mountaineer Reinhold Messner, had taken their turns trying to free the wanderer from the ice. With ice axes and ski poles, the "rescuers" had hacked and prodded. One of them had seized a nearby stick to dig with, breaking it in the process; the stick turned out to be part of the hazel-wood and larch-wood frame of the Iceman's backpack, an artifact the likes of which had never before been discovered. In their haste the workers also managed to snap off the Iceman's six-foot-long bow. (The bottom end of it, frozen in the ice, was recovered a year later.)

Yanking and pulling on the Iceman's body, his saviors succeeded in destroying what was left of his clothing. Then, as they hauled their victim out of the ice, they realized that his genitals were missing. Once freed, the Iceman was

This much is certain: The Iceman stood five feet two inches tall, had wavy, medium-length dark hair and a beard, was between 25 and 40 years old, and died around 3000 B.C. Almost everything else about him is part mystery, part speculation.

ALL ICEMAN'S ARTIFACTS PHOTOGRAPHED AT RÖMISCH-GERMANISCHES ZENTRALMUSEUM, MAINZ, GERMANY

Anthropologists are intrigued by his secret markings, such as the parallel lines on his lower back (facing page). They wonder if a stone disk threaded with a leather thong (top) served as an amulet. A piece of fungus on a string (above) may have been a first-aid kit.

slung in a body bag and airlifted to Vent, the nearest Austrian village. There, his salvagers forced the body into a coffin for the car ride to Innsbruck. Some witnesses heard a cracking sound. (X rays later revealed the left arm to be broken.) And on the mortuary slab in Innsbruck, as a mob of photographers flashed away, a contaminating fungus began growing on the Iceman's skin.

Not until five days after his discovery did an archaeologist, Konrad Spindler of the University of Innsbruck's Institute for Prehistory and Early History, examine the Iceman. In all fairness, none of the salvagers had suspected the Iceman's antiquity. Even the knowledgeable Messner guessed the body might date, at the earliest, from the Middle Ages.

"I needed only one second," Spindler told me in October 1991, "to see that the body was 4,000 years old." Actually, it was the style of the Iceman's ax that inspired the archaeologist's confidence. That ax indicated to him that the Iceman lived around 2000 B.C. plus or minus 200 years.

At once a rigorous effort to stabilize his condition was launched. Under the supervision of Werner Platzer of the university's Anatomy Institute, the mummy was placed in a freezer, where the temperature was kept at a constant 21°F and the humidity 98 percent—the same conditions as the ice from which he had emerged. The Iceman could not be removed from the freezer, Platzer decreed, for more than 20 minutes at a time, and then only for the most compelling scientific inquiry. By then, the best press credentials in the world could not crack open that freezer door.

DURING THE NEXT FEW MONTHS the Austrians began divulging some of the Iceman's secrets. They did so slowly and cautiously, still embarrassed by early mistakes. For instance, the mummy's most prominent injury was a gaping hole in the left hip. In October Spindler had assured me that the hole was caused by some wild animal shortly after the Iceman's death, before the snows covered him. But a policeman who had helicoptered to the death site in September came forward with a confession. It

Eyes that beheld an ancient world stare from the head of the Iceman—one of the oldest, best preserved of all prehistoric corpses. Naturally mummified and sealed in an airtight pocket by glacial ice, the body survived with its brain and internal organs intact. Ice pressure disfigured the nose and lip, and pushed up the left arm. Stored in a freezer at the University of Innsbruck, the Iceman is removed only for brief examinations by scientists (below).

GAMMA LIAISON (FACING PAGE)

BRINGING THE ICEMAN TO LIFE

So real he seems—as if pausing in mid-sentence or catching his breath after a hard day's climb. Reconstructed for NATIONAL GEOGRAPHIC *by John Gurche, an anthropologically trained artist, the Iceman appears in a bust modeled from forensic data to suggest how the ancient traveler might have looked in life.*

Gurche began with published tables of measurements, three-dimensional computer images, X rays, and CT scans, all produced by the Anatomy Institute of the University of Innsbruck. Projecting computer images onto modeling plastic at the Denver Museum of Natural History, he sculpted a replica of the skull (top left). He then added clay to duplicate the Iceman's mummified face, complete with smashed nose and lip (second panel).

Like a magician reversing time, Gurche gave life to the Iceman. Using anatomical data for European males and his own interpretations, Gurche fleshed out the face with muscles and fatty tissue, following a map of numbered pegs. He reconstructed nasal cartilage and positioned glass eyes.

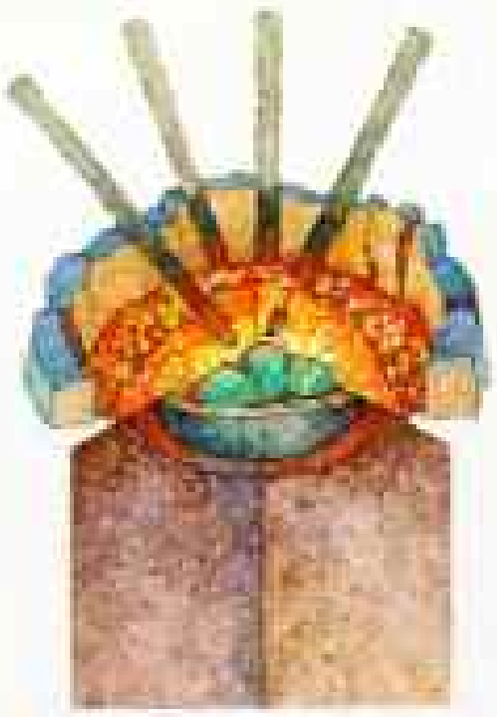
Finally he made a new model of the head with soft urethane, tinted to suggest windburned skin (right). Distinctive features emerged—a broad nose, a protruding lower lip, a prominent chin. Human hair was added.

In a telling gesture, his eyes are alert, as if noting with alarm the storm clouds gathering overhead that may have foreshadowed his death.

LEAVING THE STONE AGE

The first metal widely used in prehistoric times, copper came to prominence in Europe as early as the fourth millennium B.C. when artisans learned to extract it by smelting ore. Setting up operations near deposits in the Alpine foothills, the workers produced ingots that were later fashioned into weapons and tools sharper and more workable than stone.

To fan a fire hot enough to extract copper, early metallurgists fed oxygen into an underground hearth by rhythmically blowing through hollow sticks. When the temperature rose to 1981°F, copper's melting point, the molten copper separated from any impurities, or slag.



PHOTOGRAPHED AT CIVICI MUSEI, REGGIO NELL'EMILIA, ITALY (BELOW)

was he, wielding a pneumatic jackhammer, and not some predator, who had gouged the hip in his zeal to free the icebound body.

In addition, radiocarbon analyses from two different laboratories dated the Iceman between 3500 and 3000 B.C.—1,000 to 1,500 years older than Spindler's confident initial assertion. How had he made such a mistake?

At the vanguard of a new era, the Iceman carried a copper ax (above), the oldest ax found in Europe with its bindings and handle intact. It predates a blade from around 2700 B.C. (left), excavated from the Remedello Sotto burial site in northern Italy.

Spindler had based his date on the shape of the Iceman's ax blade. It looked like a relic from the Early Bronze Age, which began around 2200 B.C. The blade, however, turned out not to be bronze at all. Chemical analysis showed it to be nearly pure copper. (The two metals look quite similar.)

Thus the Iceman was far rarer than a voyager from the Bronze Age. He was, in fact, unique: a mummy from the Copper Age, which lasted in central Europe roughly from 4000 to 2200 B.C.

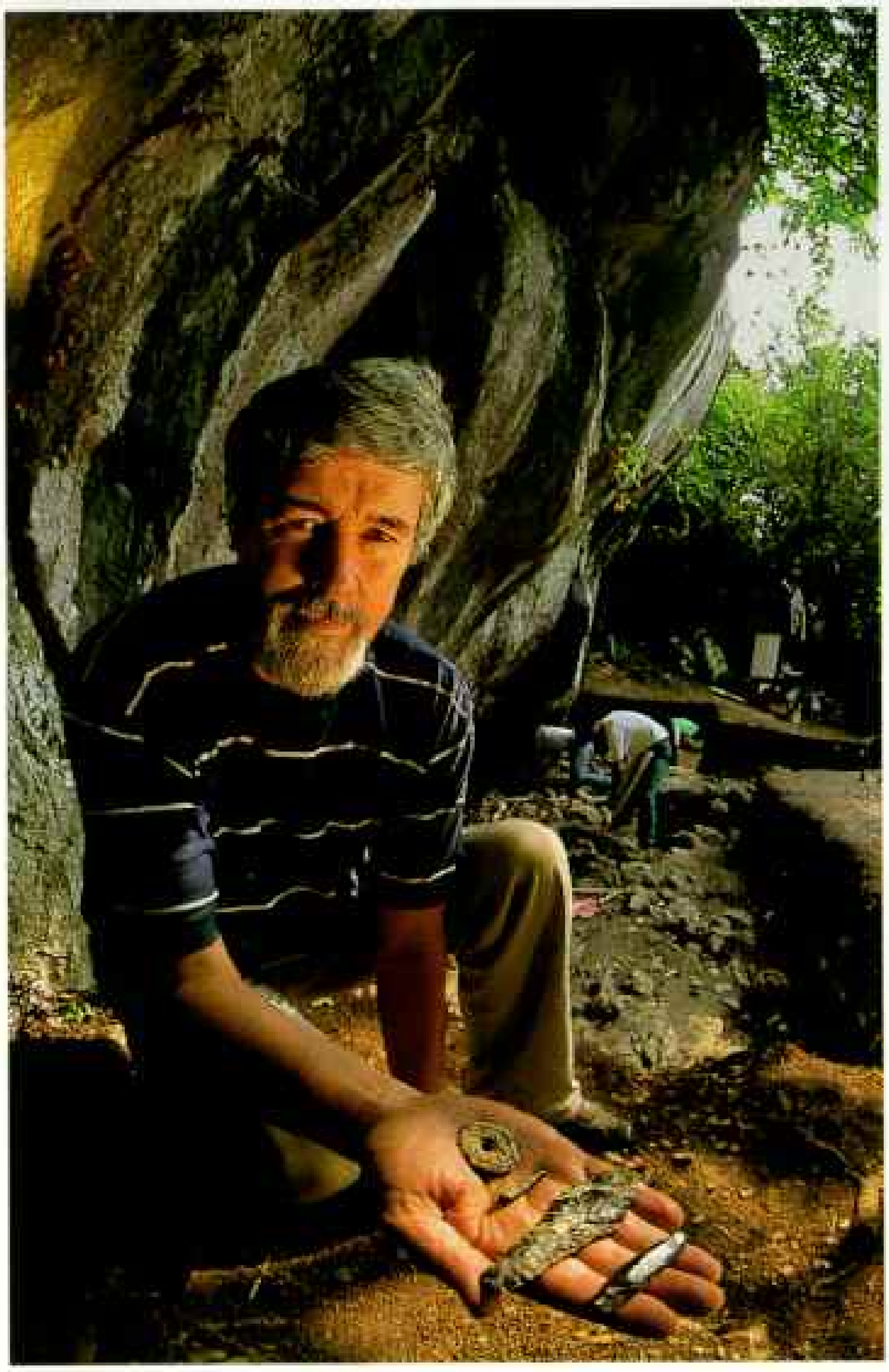
Meanwhile, the Iceman became the focus of an intense political dispute. Although Austrian police had retrieved the body, surveyors determined that the Iceman had actually died 303 feet inside the Italian border—in the autonomous district of Alto Adige, or South Tirol. Italy demanded that the Austrians turn over the Iceman. And South Tirol made its own claim. After lengthy negotiations the Austrians agreed—on paper at least—to return the Iceman to South Tirol by September 1994. Since then the South Tirol government has agreed that the body may remain in Austria until research is completed.

The Austrians' preservation efforts were fraught with problems. "To freeze the Iceman again is bad," explained an outspoken young archaeologist named Markus Egg. "It dries him out. Also the ice expands and breaks down the walls of the cells. Every time they take him out to check on him, he starts to melt again."

I met Egg, whom the Austrians had put in charge of restoring the Iceman's tools and belongings, at the Roman-Germanic Central Museum in Mainz. Unable to see the Iceman, I had determined to learn about his world. His possessions, many archaeologists believe, will eventually tell us more about that world than the body itself will.

Geographically, the Iceman's domain was

the Alps, stretching from the massifs of southeast France to the Swiss-German border, from the ranges of the Austrian Tirol to the lakes of northern Italy. Five thousand years ago these mountains that command the heart of Europe were a vast, fearsome wilderness. Yet in the Copper Age, or, as archaeologists call it, the Chalcolithic, hardy voyagers trekked through



these ranges, and the goods they traded traveled even farther. Whatever else he was, the Iceman was a mountaineer: His very clothing and his tools proclaim as much.

The Iceman's most provocative possession was his copper ax. With reverence, I watched Markus Egg pick it up and offer it to me. I grasped its yew-wood handle and swung the tool gently through the air. The handle ended in a gnarled joint where it bent to hold the blade. Perhaps the Iceman himself had seen the shape of the ax handle lurking inside a tree and had cut it free.

I traced the haft with my fingers to where it ended in a notch that held the blade. Dark birch gum held the blade firmly in position beneath a tightly wrapped thong of rawhide. I weighed the wedge-shaped blade in my palm and ran a finger over a pair of small nicks in the cutting edge. What swings had the Iceman made to dent that blade?

The ax blade that fooled Spindler continues to confound the experts. Surprisingly, it is a flanged ax rather than a more primitive flat ax. The flanges, or ridges, along its four edges hold the blade more stably in its haft.

Most Copper Age specialists in Europe now agree that the Iceman's blade is a classic example of what they call the Remedello style. Remedello Sotto was a cemetery just south of the Italian Alps, where 124 tombs were excavated in the 19th century. However, Remedello artifacts are thought to date back no earlier than 2700 B.C. Given the Iceman's radiocarbon age, how could he have owned a Remedello ax hundreds of years earlier? It was as if the tomb of a medieval warrior had yielded a modern rifle.

Egg walked me to a table where his assistant, Roswitha Goedecker-Ciolek, was trying to put the hundred-odd scraps of the Iceman's clothing back together. It looked like a hopeless jigsaw puzzle of pieces with stretched, soggy edges. Yet already the two researchers had made important observations. The patchwork garment had originally been finely stitched together with sinew by a skilled hand. Far cruder repairs had been made, probably by the Iceman

The Iceman's survival kit included an ash-handled flint dagger (above), its blade no larger than an arrowhead. The Iceman probably used it to cut leather or game. Found near his body, the dagger lay next to a grass sheath, the first ever discovered.

In addition to a bone needle, a hank of grass rope, and a mass of feltlike fiber that may have served as tinder, the Iceman also owned a four-inch-long stick (left) tipped with antler. Conservators believe it was a tool for sharpening flint, pieces of which the Iceman stored in a pouch.

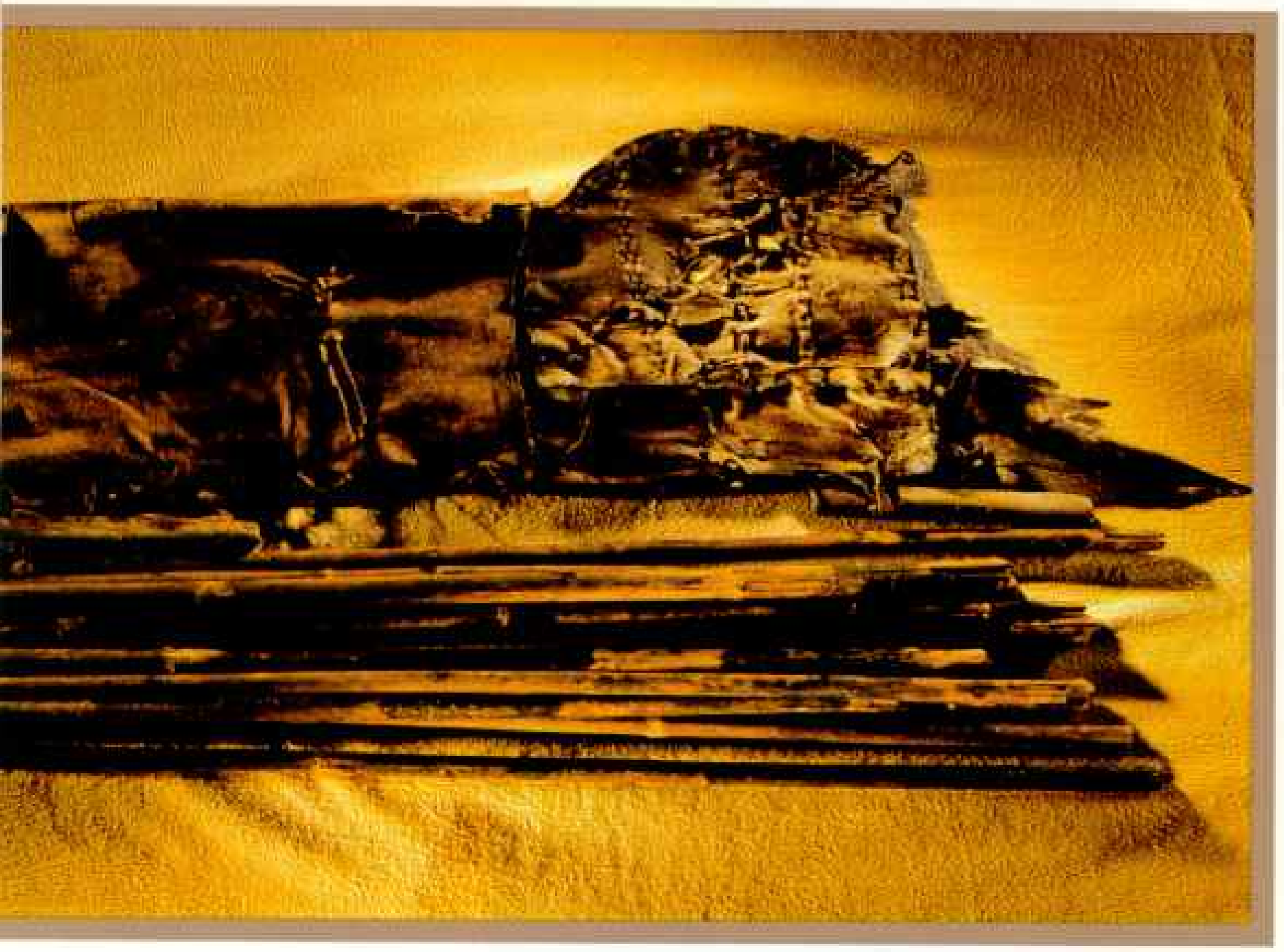
A common material, flint served toolmakers through the Copper Age and into the Bronze. The Iceman carried high-quality flint that he may have traded; Lawrence Barfield of the University of Birmingham in England believes it was quarried in the highlands east of Italy's Lake Garda. At a burial ground across the lake, Barfield (facing page) found items almost identical to the ones the Iceman possessed.

Twelve unfinished arrows and an unstrung bow raise the question of what the Iceman was doing alone and defenseless in the wild high mountains. His deerskin quiver (above) did contain two complete arrows, made of viburnum wood with flint heads and feathers. But the Iceman's longbow could not have fired them. The curved, six-foot-long piece of yew wood—taller than the Iceman himself—had not been notched or fitted with string.

Most experts speculate that the mountain traveler was a shepherd who had lost or damaged his weapons and was gathering material for new ones.

Others picture the Iceman as a shaman who, with tattoos, amulet, and magical ax, had climbed the mountain to do ritualistic battle with evil.

In the end what defeated the Iceman was probably the severe mountain weather. As his body shows no sign of broken bones or disease, scientists think he froze to death after falling asleep. A fragment of his plaited-grass cape (below) was found next to his head, having failed to ward off the fatal cold.



himself, sewing with grass. Thus they believe he must have had ties to a community, although he was used to fending for himself.

Also, as they sorted through the tatters of his clothes, Egg and Goedecker-Ciolek found two tiny spikelets of a primitive wheat. Later another researcher, Willy Groenman-van Waateringe of the University of Amsterdam, found pollen of the same wheat as she searched among the hairs fallen away from his fur clothes. This wheat grew only at low altitudes.

Meanwhile, University of Innsbruck botanist Sigmar Bortenschlager and his team analyzed the pieces of charcoal the Iceman carried. They came from a variety of trees found throughout the Alps. But one tantalizing piece of evidence allows us to speculate about the Iceman's homeland: One of the families of trees can be found a mere five or six hours south of the death site but at least two days to the north. This botanical evidence indicates that the Iceman may have come from the Val Senales in the South Tirol.

Egg showed me the rest of the Iceman's tools. A small pencil-shaped stick of linden wood with a tip of antler was first thought to be a fire starter; now Egg believes that it was a tool used for sharpening flint blades.

The beautiful deerskin quiver that held the Iceman's 14 arrows astonished the scientists, for no quiver from either the Copper or the Bronze Age had ever before been found. Some tools looked as if the Iceman had laid them down just yesterday. The bow, taller than the man himself, was unfinished, and scallops where he had shaped the wood with his ax looked freshly cut. A flint blade in his carrying bag still bore a burnish called sickle shine—left by the grasses he cut with the blade. Inside his quiver I saw scratch marks made by the flint tips of his arrows.

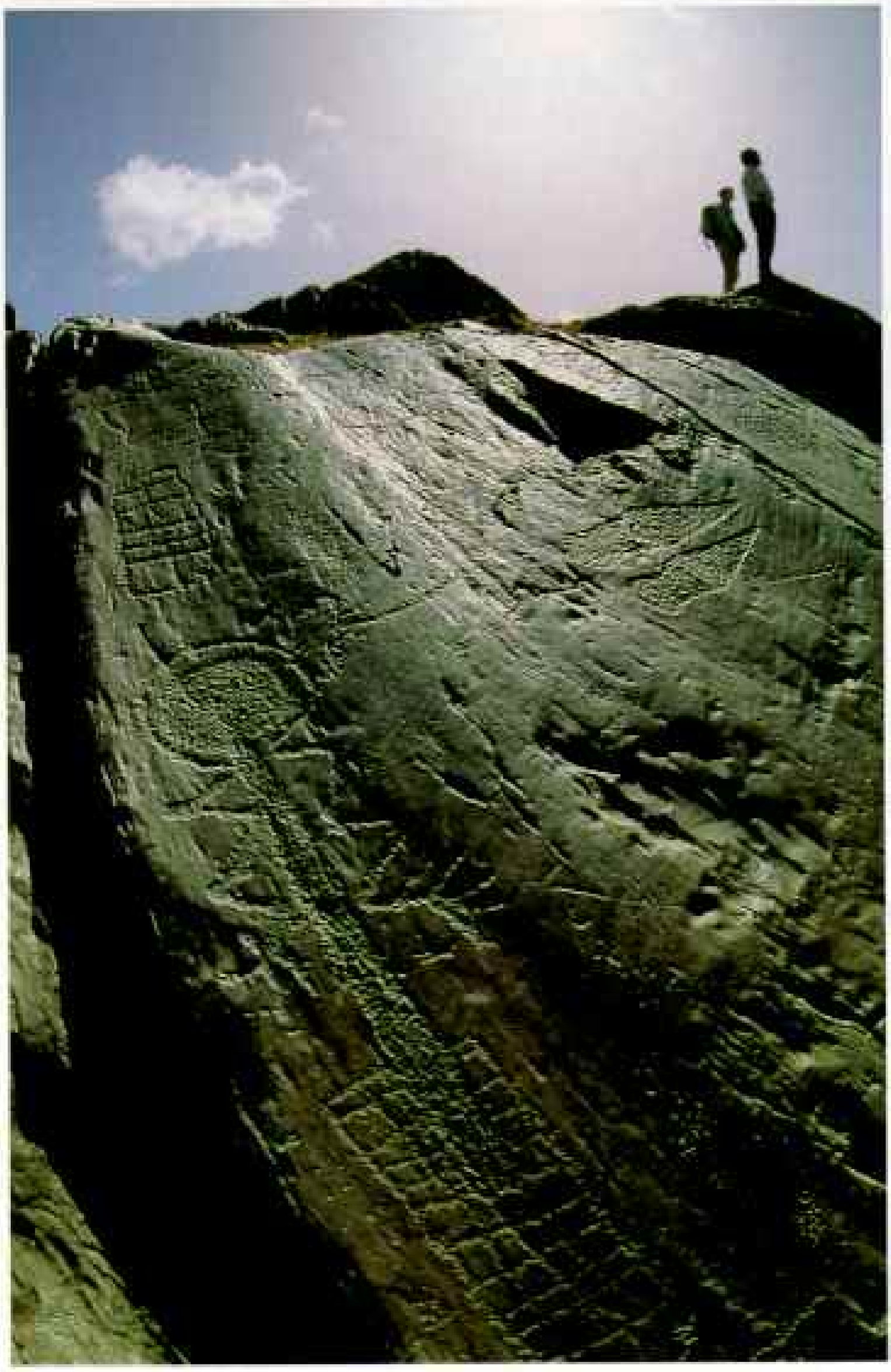
Some relics, such as a small flint dagger with an ash-wood handle, were similar to those found at other Copper Age sites. However, no one had ever seen the kind of delicately woven grass sheath that held the dagger.

These tools could not tell me who the Iceman was or what he was doing on a treacherous 10,530-foot-high pass. They did, however, evoke vivid images of a distant time.

The first half of the Copper Age was an era of climatic warming, when humans penetrated higher than ever into the Alps. The tree line climbed during the warming, and game followed the forests. Hunters followed the game.

Other motives drew daring adventurers to high altitudes. Because dense forests covered much of Europe, the meadows above the tree line offered the best pastures for sheep, goats, and cattle.

There was also this newly valued metal we call copper—great green veins of it bare to the sky, ready for the finding among the rocky crags. Copper was changing the Alpine world forever, stimulating the development of major trade routes between many isolated valleys.



"Before this moment," explained Markus Egg, "there were only two ways for a man to be rich. He could have a great mass of cattle or a great mass of wheat. But these are not good treasures—you cannot carry them around."

Egg took the Iceman's copper ax blade in his hand. "This is a good treasure!" he said. "Moreover, you now need men to be miners, smelters, axmakers, maybe even salesmen. Now people have a real profession, a specialty. Before copper, everybody did everything."

To turn raw chunks of copper-bearing stone into an axhead like the Iceman's is no easy feat. The ore must first be heated in a clay crucible buried in the ground to remove impurities, or slag. Blowing through pipes, several workers simultaneously direct intense streams of air into the fire, fanning it until it reaches 1981°F, copper's melting point. After the molten copper has separated from the slag, the entire mass is allowed to cool and the slag is carefully chipped away, leaving blocks of relatively pure copper. These blocks, or ingots, are later reheated, and the liquid metal poured into a cast.

The world's earliest known man-made copper objects—beads, pins, and awls—were fabricated about 8000 B.C. in Turkey and Iran. There is evidence of copper mining in the Balkans by around 5000 B.C. From there the technology probably spread west, reaching the Alps about a thousand years later.

Age-old destination, the slopes of Mont Bego in France's Maritime Alps abound with sacred rock art, some of it from the Copper Age. Pilgrims likely passed this 8,140-foot site, where a carving dubbed the Man With Zigzag Arms (above) appears amid daggers and grids.

OUR FULLEST PICTURE of life in the Copper Age comes from scores of villages painstakingly excavated over the past century on the shores of lakes in northern Switzerland, as well as lakes just across the border in Germany and France. As I traveled among these scattered sites and the museums that held their artifacts, I imagined the Iceman, perhaps as a trader, paying a visit to such a village in the late fourth millennium B.C.

The long approach through the dark forest had taken its toll on his spirit. He had sensed bears and wolves lurking unseen in the woods; because of the tangle of brush and trees, he had found his bow and arrows all but useless for hunting. Several times he had lost his way, finding it again only by carefully retracing his steps.

At last he came to a wooden palisade fence encircling a village. The strangers guarding the gate demanded to know who he was, but their language was alien to his ear. They stared at him hard, disdainful of his patchwork animal-hide clothing but impressed by his wonderful ax. Finally they let him pass inside.

The village was a pandemonium of domestic animals and people. The Iceman climbed a ladder to the floor of a terrace. It sat on great wooden stilts above the mucky shoreline of the lake. The rough-hewn houses of the villagers were crowded behind him.

Gradually the Iceman's welcome grew warmer. His hosts lent him a linen tunic, embroidered with colorful designs, to wear while his fur clothing dried out.

As he relaxed, the Iceman saw how superbly placed the village was. For days he had traveled under the dense canopy of pines, oaks, and elms, with only the occasional clearing to give him a glimpse of the landscape. Now, as he rested on the terrace, he could look southeast across a huge sheet of water to the spectacular mountains.

His new friends fed him well. One night he ate beef, great bloody joints singed on the fire; another night, fish from the lake; yet another, steaks from a dog they had slaughtered that afternoon. Their berries and nuts he knew almost too well, but the food he craved was the soft, greasy stuff farmers had recently learned to make from milk.

At last the Iceman pulled out of his backpack the goods he had come to trade: pieces of unshaped flint, ruddy, cream-colored, gray,

COPPER AGE IN THE ALPS

Advancing technologies helped usher in the Copper Age (4000-2200 B.C.) in central Europe. Agricultural inventions like the plow and wheeled cart came into common use. Traders and prospectors, stimulated by the demand for copper, traversed mountain passes, exchanging ideas and toolmaking skills between the lakeshore villages of the north and valley settlements of the south. Drawn together by trade and technology, and sharing common rituals, the peoples of the Alpine region gradually merged into a single culture, before diversifying again during the Bronze Age.

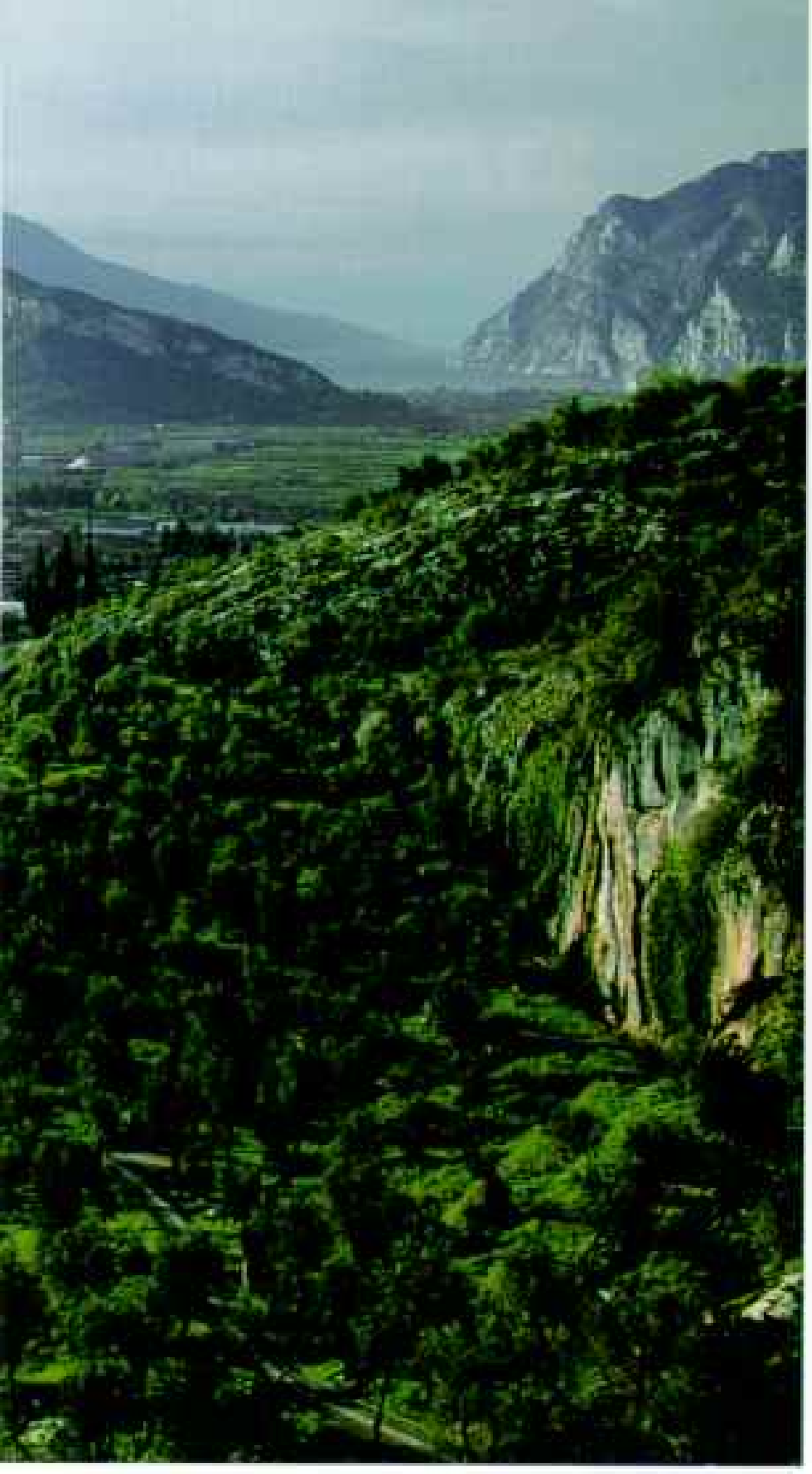
and dark brown. They were from a famous quarry far to the south, he bragged. They were the finest flints anyone had ever seen, so much better for making knives and daggers than the pitiful stuff found north of the mountains. His lakeside friends turned the flints over and over in their hands.

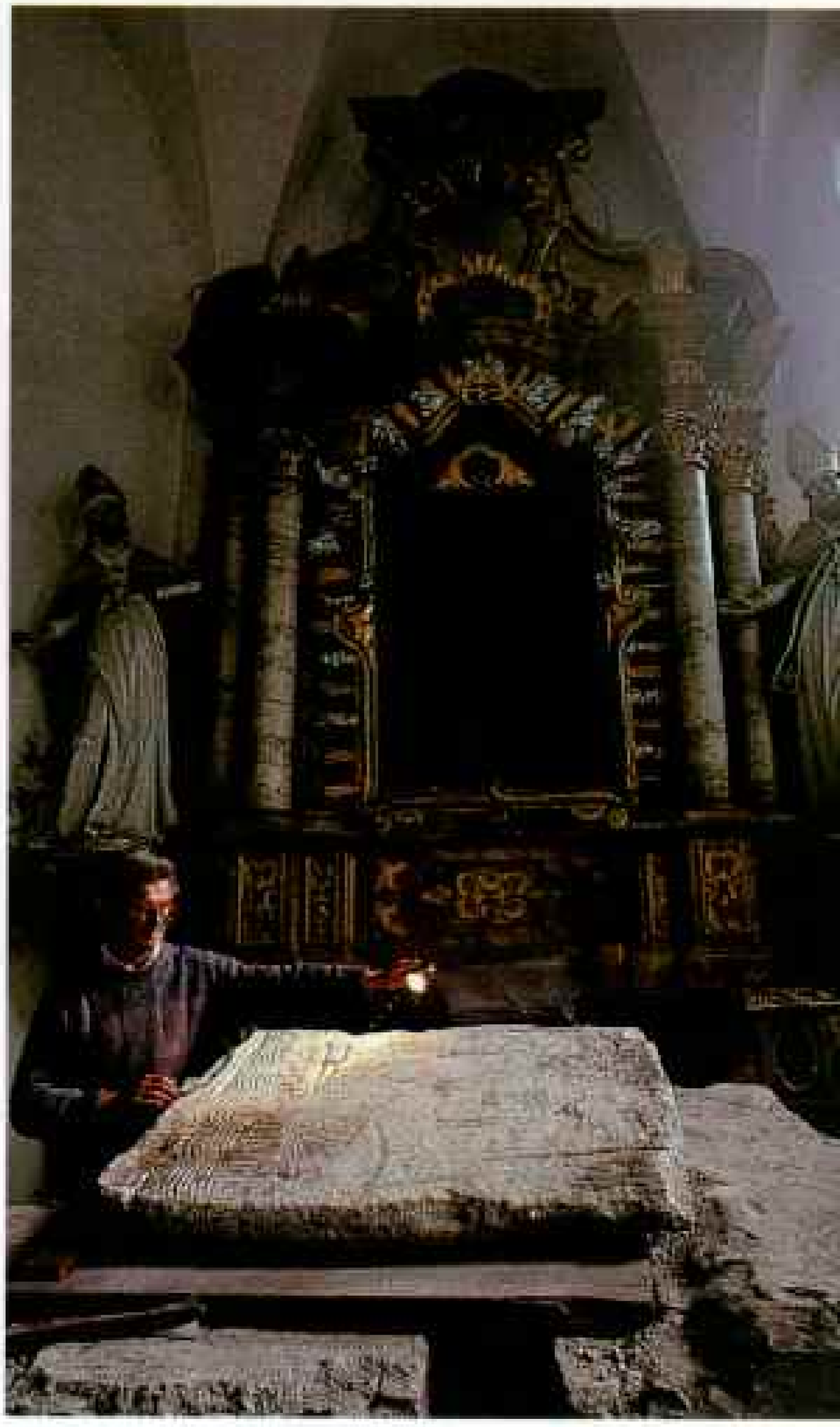
But it was his ax they kept staring at, and when the Iceman slept at night, he held its smooth handle in his hand and tucked the blade close to his chest.

One day it was their turn to dazzle him. They took him to a field outside the palisade, where he saw two extraordinary objects. He had heard stories about both but had never been able to picture either. On the edge of the field a cow had been attached to a great open box loaded with firewood. The Iceman had seen such sledges laboriously dragged by cattle across the earth, but this box, two feet off the ground, glided through the air. As the Iceman stared, he saw that a pair of solid, round slabs of wood rotated beneath the sledge. He had seen his first wheels.

And there, in the middle of the field, two cattle were yoked to a strange, forked wooden device; a man walked behind the device, guiding it. As the cattle moved, the device dug into the soil, cutting it loose and spilling it to the side—the kind of work that had always taken men infinitely longer to perform with wooden hoes. The Iceman had seen a plow.

My vision of the Iceman's visit to a northern lakeside village is based on the work of many researchers over the past 30 years. For instance, excavated bones tell us that by around 5000 B.C. Alpine man had domesticated five animals: dogs, which were originally more important for food than companionship, cattle, sheep, goats, and pigs. Horses were still





unknown in the Alps. Chickens were not introduced here until the Iron Age, around 600 B.C., cats not until Roman times.

In the Copper Age, villagers grew wheat and barley and made linen clothes from flax. They had only recently discovered how to milk a cow and how to make cheese and butter. Their sheep may have been used for meat but not yet for wool. Many staple foods of today were still unknown, including potatoes, onions, and oats.

At the Swiss National Museum in Zürich, I saw probably the oldest wheel ever found in central Europe—and maybe in the world. It was discovered in downtown Zürich in 1979 by a Swiss team led by archaeologist Ulrich Ruoff. Made from a single piece of maple, it may date back as far as 3200 B.C.

Central Europe's oldest known plow is more than a thousand years younger than the

Surely the Iceman knew of the fertile valley at the head of Lake Garda, inhabited long before the Copper Age. Today olive groves and castle ruins overlook the town of Arco. He may have even worshiped at the carved stela (above) that archaeologist Hans Nothdurfter discovered below an altar in Laces, Italy, 11 miles from the Iceman's camp.

Iceman. Yet Copper Age artists cut images of plows on rock surfaces. Italian archaeologist Franco Mezzena has found many rows of furrows preserved at a major Copper Age religious complex excavated in the town of Aosta in northwest Italy. He believes the plowing was ritualistic rather than agricultural.

What language did the Iceman speak? We don't know: Words cannot be dug out of the

On its formidable coat of arms, a Copper Age stela (right) brandishes seven copper daggers, plus halberds and axes—proof of the sacred significance of early metal implements. A stylized human figure that may have represented a god or ancestor, the seven-foot-high sandstone

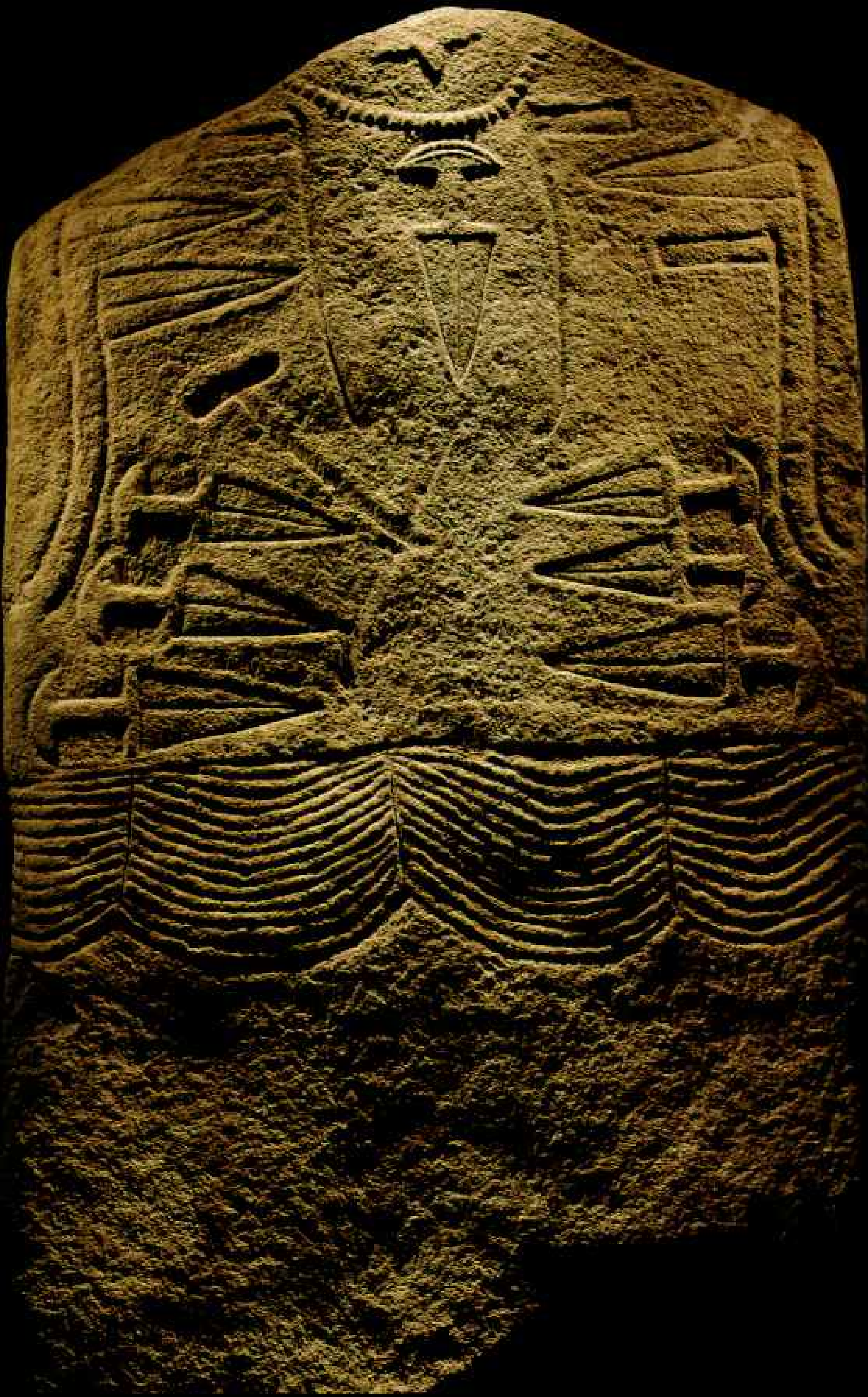
PHOTOGRAPHED AT MUSEO CIVICO DI SCIENZE NATURALI, BRESCIA, ITALY

slab wears a corded belt and necklace. Its T-shaped pin, possibly a cloak fastener, resembles the rare silver piece (above) found at the Remedello burial site. The stela belongs to a "family" of six stones uncovered near Arco, with a child-size figure and a mother made of marble (left).

PHOTOGRAPHED AT UFFICIO BENI ARCHEOLOGICI, PROVINCIA AUTONOMA DI TRENTO (ABOVE AND FACING PAGE)

soil. Almost all modern European languages belong to the same family, which is called Indo-European after a hypothetical common parent language. Until recently, most experts thought that Indo-European tongues arrived in Europe around 2500 B.C. However, British archaeologist Colin Renfrew has recently argued that the Indo-European languages reached Europe much earlier. If the Iceman indeed spoke an Indo-European tongue, linguists believe he would have used a word like *kwekwlos* for wheel, *dhwer* for door, *deiwos* for god, and *sneigwh*, meaning to snow.

While words cannot be excavated, pottery can. And different styles may point to different cultures—and presumably to different languages. In Switzerland sharply contrasting pottery styles seem to define a dramatic barrier between two cultures during the Iceman's era. Some specialists think this barrier, which bisects present-day Switzerland, marked the collision of two currents of thought and art—Mediterranean ideas sweeping up from the south and eastern European notions moving in from the north and east. Trade and perhaps warfare ultimately broke down the barrier. Toward the end of the Copper Age, around 2200 B.C., a single culture—called the Bell Beaker people, after the shape of its pottery—had unified the Alps and most of Europe.



Once prized like gold, a four-inch copper disk must have awed villagers when it appeared on the German shore of Lake Constance. Archaeologists unearthed the ornament from a village that burned around 3900 B.C., making it the oldest copper artifact found in the Alps.

PHOTOGRAPHED AT ARCHÄOLOGISCHES LANDESMUSEUM, KONSTANZ, GERMANY

LAST SEPTEMBER, just before the first anniversary of the Iceman's discovery, I flew back to Innsbruck, still hoping somehow to see the man. His scientific guardians, Werner Platzer and Konrad Spindler, told me that a special viewing remained out of the question. However, Spindler flew with me by helicopter to the site where the Iceman was found. After we reached the hollow, Spindler stooped, then ran a finger across the snow.

"Do you see this?" he said, showing me a fine dirt now coating his fingertip. "Dust! This is why we found him."

In March 1991 a huge Saharan dust storm blew tons of fine particles all the way to the Alps. Over the warm summer of 1991 the dark grit absorbed the sun's rays, spurring an unprecedented melting of the glaciers.

"We think he was found only three days after he had melted out," said Spindler. "And three days later, the snow fell again—enough to have buried him. He was out of the ice, then, only six days, at maximum. So we are very lucky. I think it is easier to break the bank at a casino."

I looked at the rocky slab where the man had lain and wondered again what he had been doing up here. I asked Spindler.

"I think he was a shepherd," he replied.

I heard that belief echoed the next day. Rather than take the helicopter back with Spindler, I hiked down to the Ötztal Valley. The next morning I met a group of modern shepherds tending a flock of 1,600 sheep. Struggling in German, I questioned the three sturdy young men and a woman about the Iceman. At nine in the morning they were drinking wine straight from the bottle.

Of course he was a shepherd, they assured me. Like them, he had been on his way from the north, across the glaciered Ötztal Alps to the Val Senales, the safe valley on the south.

"To his house," one nodded.

As I sprawled in the grass, envying the shepherds their tipsy camaraderie, I realized I might be witnessing a trek that sprang from an unbroken tradition stretching back 5,000 years to the Iceman himself.

Through these blithe shepherds I seemed to glimpse not only the Iceman but also inklings of his elusive soul.

The Iceman's tattoo-like markings might imply something about his spiritual life. They intrigued scientists, who had no evidence that tattooing was practiced until about a thousand years later. The Iceman's markings are not like those of a modern sailor or biker. Located in normally hidden places—his lower back, behind his knee, and on his ankle—they were not done for show. They may have been designed to give him some sort of supernatural power or protection.

So might the pair of fungi he carried, each pierced by a leather thong. Archaeologists have never seen anything like this arrangement from this period. The fungi contain chemical substances now known to be antibiotic. If the Iceman used them to counteract illnesses, perhaps they seemed magical to him.

In the weeks ahead I tried to learn what else had animated the man. What were the gods he worshiped? What were the beliefs that held the cosmos of his people together? I found windows to his soul in a series of recent Copper Age excavations across northern Italy. The evidence is recorded on three types of artifacts. One type is engraved stone slabs, called stelae, which were erected at sacred sites.

An astonishing set of six stelae was accidentally discovered only a few years ago at Arco, near the city of Trento, as bulldozers were

clearing land for a new hospital. Earthmoving for new construction is, in fact, what has brought many Copper Age sites to light.

These stelae, known as Arco I through VI, are kept in a warehouse in Trento. I was taken there by two energetic young archaeologists, Franco Marzatico and Annaluisa Pedrotti. Arco I, a sandstone slab standing seven feet tall and weighing seven tons, is shaped like a human torso. The chest is crowded with carvings: seven copper daggers, halberds, a necklace, a richly detailed belt, and an object Pedrotti called a scepter. Three copper axes are identical to the Iceman's.

Axes are found on other Copper Age stelae. What do they mean?

Scientists believe that stelae represent gods, venerated ancestors, or cultural heroes. Perhaps the Iceman, when he saw a stela such as Arco I, knew exactly which warrior or deity the stone proclaimed, as a Roman Catholic might recognize the saint in a medieval fresco. Perhaps he had even prayed before this stone or made a pilgrimage just to touch it. In a mystical sense, each swing of his ax partook of the sacred. To chop down a sapling was to be linked to some god whose own ax had helped bless the world, to some hero whose weapon had rid the land of evil.

The spiritual importance of stelae endured among the Iceman's descendants. Only last summer Hans Nothdurfter of South Tirol's Department of Archaeology in Bolzano found a Copper Age stela beneath an 18th-century wood altar in a church in the small South Tirolean village of Laces. It was covered on both sides with mysterious engravings, including an ornamental belt, radiant sunlike objects, and a copper dagger just like those depicted on Arco I. The practice of invoking the spirits honored on monuments for good luck and fertility must have persisted well into Christian times. Even 4,000 years after the Iceman died, Roman Catholic bishops were threatening "worshipers of stone" with excommunication.

Laces lies only 11 miles by air from the high pass where the Iceman perished. The stela

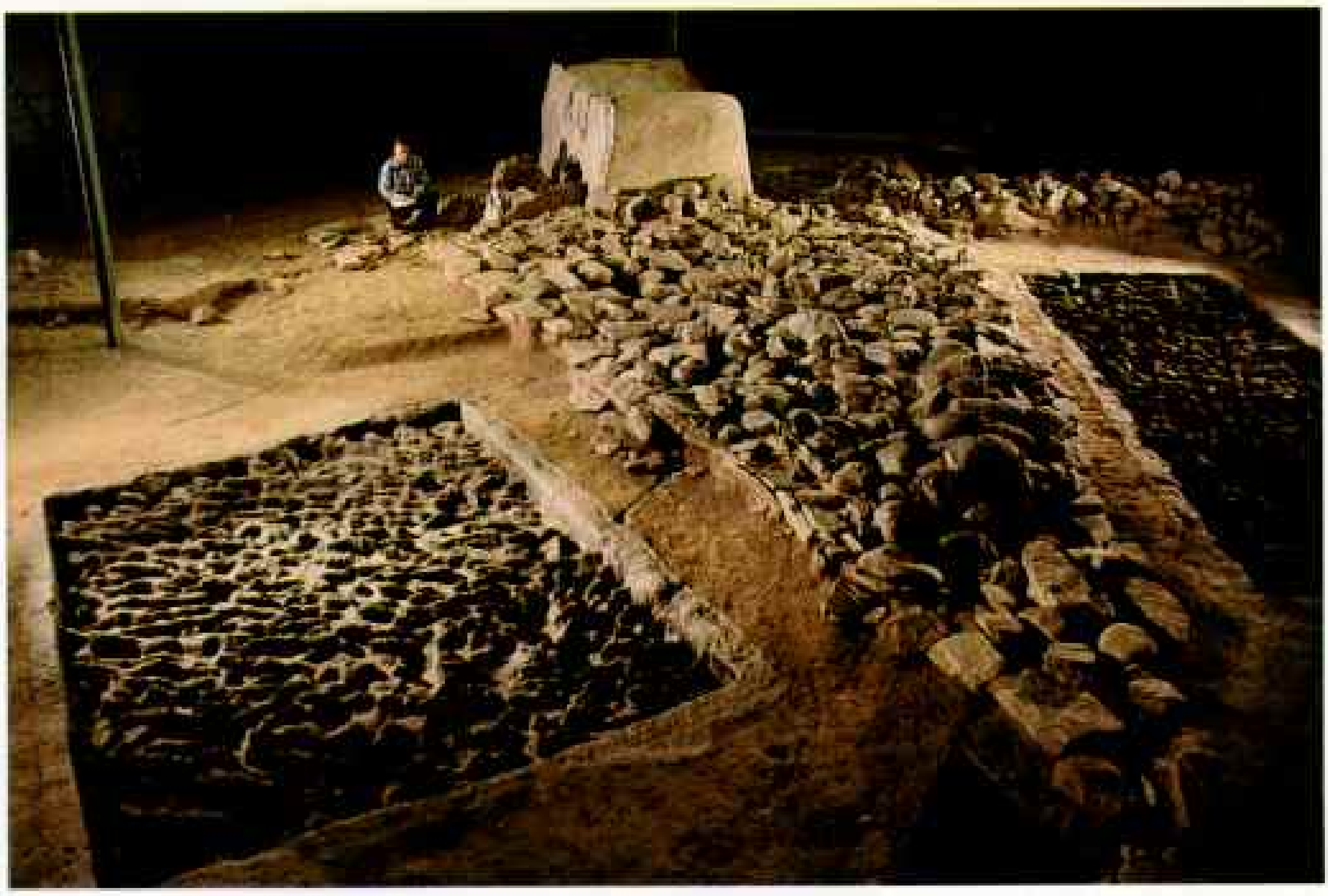
The turning of an ungainly solid wood wheel constituted a true revolution during the Copper Age, when wheels were first used in Europe. Excavated in Zürich, Switzerland, the 20-inch wheel from 3200 B.C. appears beside a model of an early cart.

PHOTOGRAPHED AT SCHWEIZERISCHES LANDESMUSEUM, ZÜRICH, SWITZERLAND

cannot be carbon-dated. But if the monument is as old as he is, the Iceman probably knew of it. He might even have worshiped before it.

STELAE GIVE US one window on the spiritual life of the Copper Age; burial sites afford another. The most famous is Remedello Sotto, south of Brescia. Its 124 separate graves provide us with a wealth of artifacts, including beautiful flint blades, probably made just for the burials. An unusual silver pin and numerous arrows and metal weapons suggest to some scientists that no common men were buried here. The Iceman's Remedello-style ax could indicate he was a big man in a hierarchical society.

It was long thought that such single burials were the norm across most of northern Italy. However, in 1981 British archaeologist Lawrence Barfield of the University of Birmingham uncovered a startling Copper Age burial site, called Rocca di Manerba, on the western shore of Lake Garda. At this site Barfield found no carefully arranged individual graves. Instead the cemetery was a chaotic mass of human bones. The skeletons had apparently been ritually defleshed. Barfield



A triangular platform and plowed earth speak of ancient rituals at a cemetery excavated by Franco Mezzena, above, in Aosta, Italy. A stone dolmen housed bones.

speculated that the bodies had been exposed to the elements or buried for a time. Then the skeletons had been taken apart and burned. Finally they were deposited in a mass crypt. All the individuals at Manerba were so buried. If the Iceman had belonged to a community like this, he would have been an ordinary man in an egalitarian society.

The third window into the Iceman's soul is rock art—the figures that Chalcolithic artists etched into cliffs and other rock surfaces. Some 300,000 rock figures, many of them carved by Copper Age artists, have been discovered in a narrow northern Italian mountain valley called Val Camonica. Only 50 miles from the Iceman's resting-place, the valley must have been known to him.

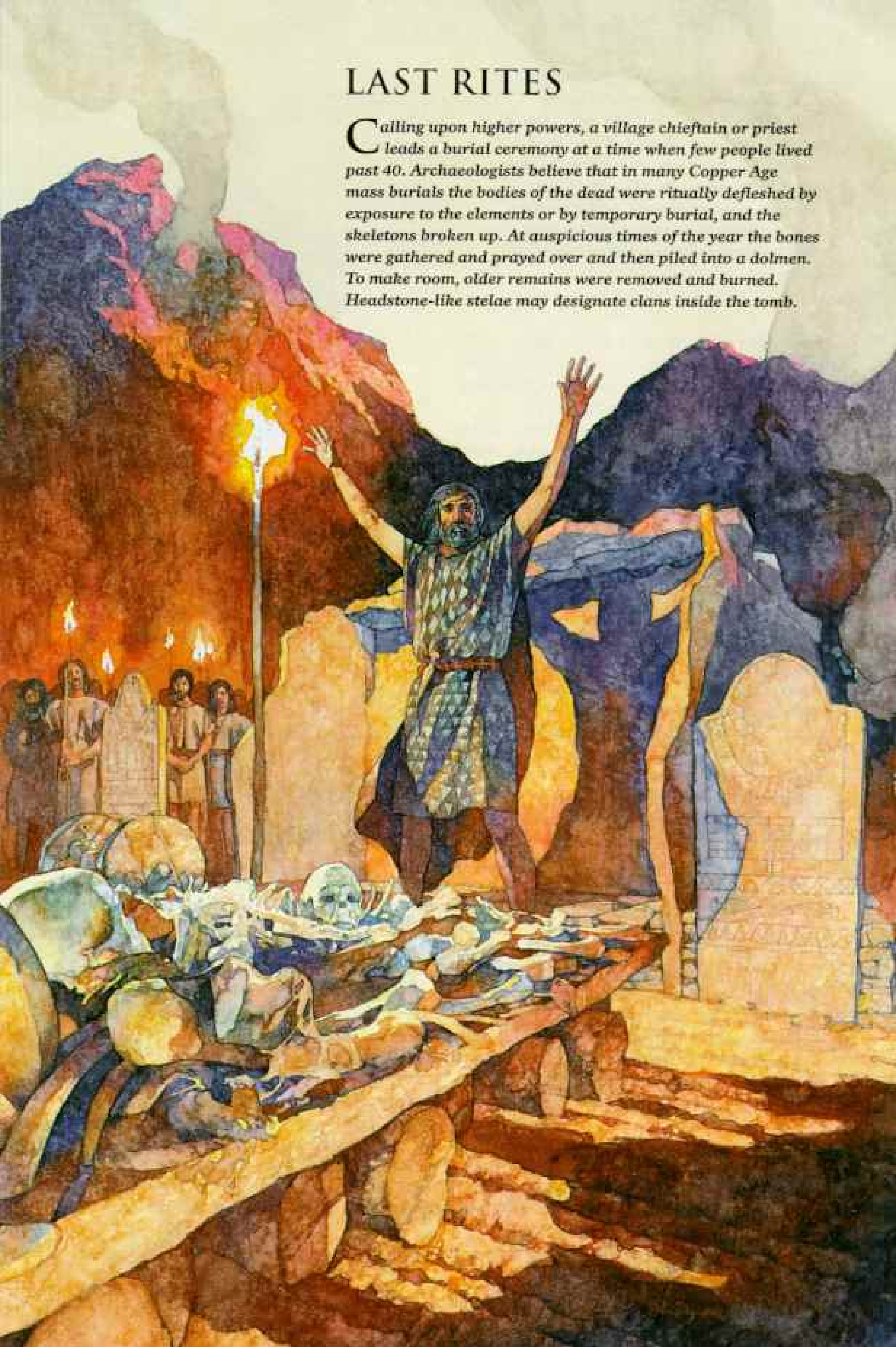
I wandered for two days among the dazzling and perplexing petroglyphs, guided by archaeologist Angelo Fossati of the Footsteps of Man Archaeological Cooperative. One recurrent image was a circle with radiating spikes. It was as if some Copper Age visionary had once seen the setting sun framed by the antlers of a great stag on the horizon. Had the image become his people's sign for revelation?

Fossati showed me a chain of humans linked arm in arm, encircling a stela. Here surely was a rite of celebration, a life-affirming dance. Row upon row of chamois, deer, and boars invoked a hunting magic. And countless daggers and axes once more declared the supernatural power of a tool or weapon made of copper.

From Val Camonica I drove west to Aosta. Here the Iceman's contemporaries built a religious complex so grand that he might well have made a pilgrimage to it. Some 45 stelae

LAST RITES

Calling upon higher powers, a village chieftain or priest leads a burial ceremony at a time when few people lived past 40. Archaeologists believe that in many Copper Age mass burials the bodies of the dead were ritually defleshed by exposure to the elements or by temporary burial, and the skeletons broken up. At auspicious times of the year the bones were gathered and prayed over and then piled into a dolmen. To make room, older remains were removed and burned. Headstone-like stelae may designate clans inside the tomb.



Approaching the past on its own terms, archaeologist Pierre Pétrequin crosses Lac de Chalain in eastern France toward pile houses built in the style of Copper Age dwellings. In summer he and his students adopt the life-style of the Iceman—making pottery, gathering food, and chopping trees with primitive axes. Concludes an assistant, "I think life was not easy."

have been unearthed at Aosta since 1969, mostly under the direction of archaeologist Franco Mezzena. The finest of these features a bow, several arrows, and a copper ax.

The site also displays structures called dolmens—large tombs that resemble stone houses. In one Mezzena found the jumbled bones of 70 skeletons. Two Aosta dolmens are built on raised stone platforms, one of which is shaped like a huge wedge and points northwest. Some researchers believe this form represents the magical blade of the copper dagger.

An equally stunning complex of dolmens and stelae has been found in the Swiss town of Sion by archaeologist Alain Gallay of the University of Geneva. The engravings in Sion look exactly like those of Aosta. Moreover, the dolmens are built on similar dagger-shaped platforms, also oriented to the northwest.

Clearly there was regular traffic between these sites. They shared the same spiritual tradition. And they did so despite being separated by the Great St. Bernard Pass, which until the recent opening of a tunnel required a slow drive on a road contorted with hairpin turns.

As I wandered among the sites where Copper Age communities had interred their dead, I saw how much emphasis they placed on a proper burial. Whatever people the Iceman came from, they must have been deeply disturbed by his disappearance. It was not a just closure with the gods. It was against the order of things for him to die as he did. The ones who cared for him were cheated of the purgation of their mourning. He had simply vanished, and no one knew where he was.

LAST DECEMBER, 14 months after my fascination with the Iceman first took me to Innsbruck, an unexpected phone call summoned me back. Werner Platzer had invited four of the world's leading experts on naturally mummified humans to examine the Iceman. Each had seen the body months earlier. Now they would evaluate how well Platzer's efforts to preserve the body were working. After their examination I could get a four-minute look at the man.

At noon on December 17 the experts entered his chamber. Later they would tell me that the Iceman had dried out perceptibly during his stay in the freezer.

"Given the present state of the science, there's nothing more you can do to prevent desiccation," said Elsebet Sander-Jørgensen of Denmark's Silkeborg Museum.

An all-out effort to stabilize and preserve the man, they all concurred, was more vital than any further research on the body.

After the experts finished their examination, Platzer ushered me into the Iceman's

10-by-20-foot chamber. He ordered me to stand on a carpet just inside the door. Then I saw the Iceman, just 15 feet away, lying on his back inside a plexiglass box with regulated air flow. The experts were still discussing anatomical details. All I could do was stare and struggle with a tumult of emotions.

How thin and frail he looked, his limbs like sticks! His ribs protruded against his skin, taut and brown, like tanned rawhide. The head, staring upward, had a fierce, angular dignity.

Platzer was saying that the Iceman's upper left arm had been broken. The injury may have occurred in Vent as workers forced him into his coffin. It had snapped rather than bent, I thought, as if repudiating the science that would wrench him from his world into ours.

My gaze fixed on the Iceman's other arm, resting at his side. The hand lay in an open clench. The hollow between palm and fingers had exactly the shape of his ax handle. Even the careless workers who had hacked him out of the ice had noticed this, giving rise to a rumor that he died clutching his ax.

The rumor was false. On the day he died, the Iceman had propped his ax against a stone 12 feet away. But then, as he stretched out across the rock slab and drifted toward eternity, his fingers had closed halfway, as if he were clasping the memory of his ax. If so, it was the last thing his body had to say.

I had a hundred questions to ask the ancient voyager, but my four minutes were up. I turned and walked out of his chamber, leaving the Iceman for the ages. □

Silence of the Songbirds

By LES LINE
Photographs by
SCOTT GOLDSMITH

"THIS IS THE ROBIN STOP," says biologist Sam Droege as we unfold from his subcompact at 5:19 a.m. and are greeted by a clamor from North America's best known songbird. "They're so noisy at this time of the morning, you can't hear anything else."

Well, not exactly. Over the insistent caroling of robins claiming possession of the shadowy lawns and churchyards in a still slumbering community, Droege's keen ears register a mourning dove, house finch, catbird, mockingbird, and chipping sparrow. And one second before the three-minute alarm sounds on his chronometer, a drowsy cardinal chirps a halfhearted call note.

Singing a sweet solo, a prairie warbler adds to the chorus of migrant songbirds in decline across the United States. As the scale of losses comes to light, alarmed experts ask: Can we save our birds of summer?

PRAIRIE WARBLER (DENDROICA DISCOLOR); ARTHUR MORRIS, BIRDS AS ART

W. CODY, WRITER-PHOTOGRAPHER

RICK ARTIST WILLIAM H. BOND

Forest fragmentation
Redstarts prefer intact woodlands for breeding. Human activity, especially in the eastern U. S., has carved up forests, leaving birds near the edges more exposed to predation.

STATUS OF BREEDING POPULATIONS OF NEOTROPICAL MIGRANT SPECIES, 1982–1991

- Significantly more than half of species decreasing
- Slightly more than half of species decreasing
- Half or slightly more than half of species increasing
- Significantly more than half of species increasing

AMERICAN REDSTART

- Breeding range
- Winter range
- General migration route

TROPICAL RAIN FOREST

- Existing forest
- Area of deforestation

Man-made obstacles
Transmission towers, windows, cars, aircraft—even golf balls—take a toll on all species of migrants. Such hazards may kill 62 million birds annually in the U. S.

Sea crossings
Powered by reserves of body fat, redstarts wintering in the Caribbean brave ocean storms on their return flight. Exhaustion over open water can be fatal.

AMERICAN REDSTART (*SETOPHAGA RUTICILLA*)
H. DOUGLAS PRATT

WILLIAM H. BOND

Natural enemies
Raccoons, crows, and black rat snakes fare well in degraded U. S. forests—and love to raid songbird nests. Migrants also lose young to pets and nest-invading cowbirds.

MICHAEL MELFORD

Tropical deforestation
The destruction of rain forest has left many songbird species without wintering habitat. Redstarts, however, appear to make do with second-growth forest.

A perilous passage

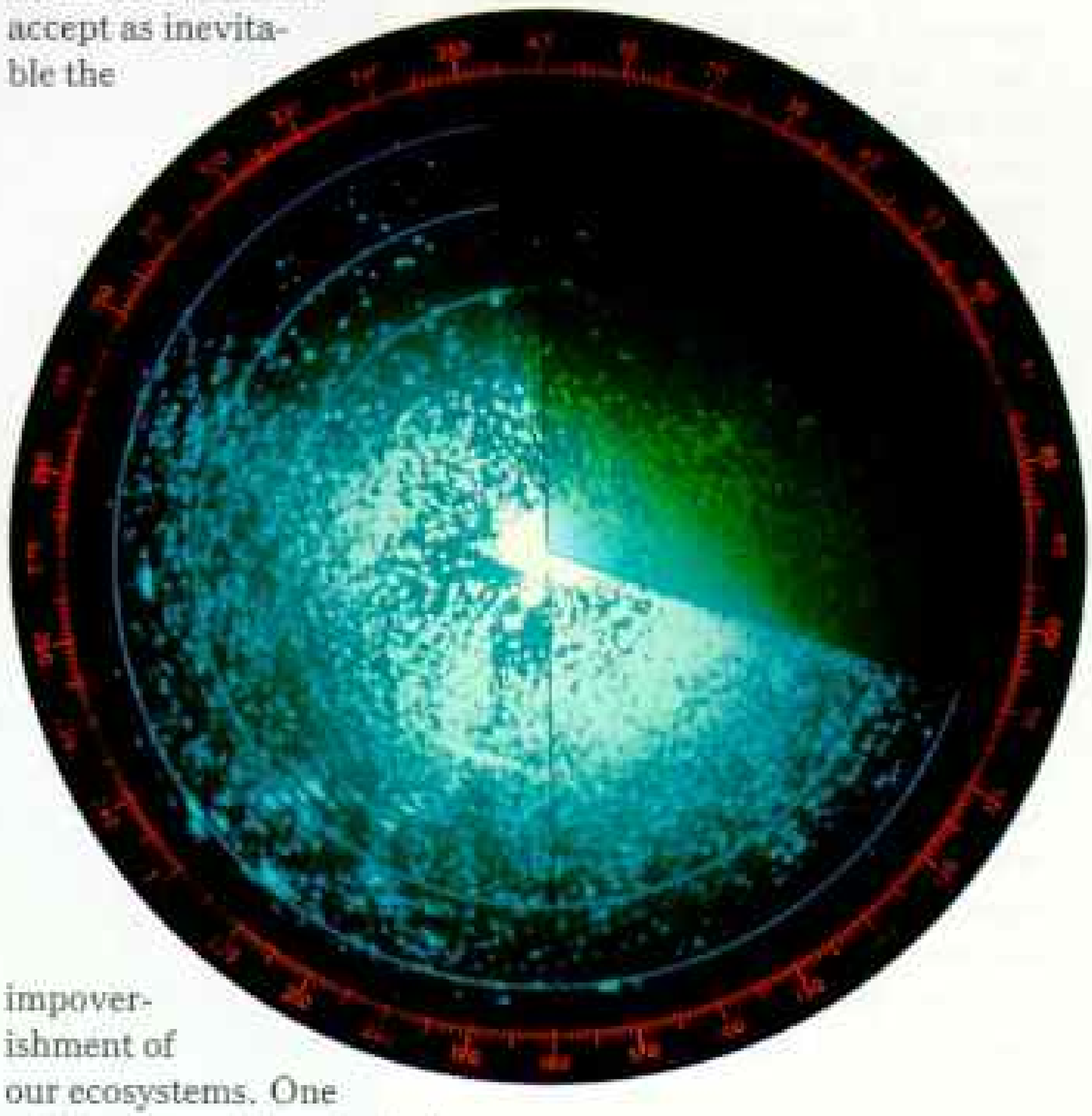
The annual flight of one abundant songbird, the American redstart, reveals the dangers contributing to many species' decline. Like more than 200 other Neotropical migrant land birds, redstarts breed during the summer in North America and spend the winter south of the U. S. border. With each passing migration, more forests are cut, more predators thrive, and more human obstacles clutter the landscape. Some species adapt. But since 1980 one in six redstarts has quietly vanished.

We pile into the car and dash for the next of 50 stops on our 24½-mile-long circuit of Calvert County, wedged in the tidewater region of Maryland between the Chesapeake Bay and the lower reaches of the Patuxent River. What a difference a half mile makes! Woodlots and meadows have replaced suburbia, and the wood thrush with its boldly spotted chest has overshadowed its red-breasted cousin. "The thrush alone declares the immortal wealth and vigor that is in the forest," proclaimed Thoreau. Few who have heard its ethereal song would disagree.

It is June 18, height of the nesting season hereabouts, and this is the month when 2,200 amateur ornithologists—from desert borderlands to treeless tundra—join in the annual North American Breeding Bird Survey (BBS). Organized in 1966 by the U. S. Fish and Wildlife Service, the BBS tracks changes in bird populations by yearly roadside counts along permanent routes. And if a sense of urgency now attends the exercise, it springs in large part from recent readings of BBS data showing major population decreases of migratory songbirds that nest in forests east of the Mississippi but winter in Mexico, Central and South America, and the Caribbean. Many of our birds of summer appear to be in decline.

To find out why they are disappearing and what is being done to save them, I traveled to their summer homes in the deciduous forests of northern New England and the Midwest and to their winter haunts in the mangrove swamps and rain forests of the Caribbean and Central America. For several months I spoke with people who are studying the lives of songbirds and searching for ways to slow the most destructive influence on them—loss of habitat. I would come to know the black-throated blue warbler as intimately as the everyday cardinal that nests in my front-yard spruce, and I would discover many other causes for the birds' decline but no simple way to stop it.

Saving our migratory songbirds may be the most daunting task ever faced by American conservationists. But everyone I met agreed that the effort must be made, even if success is elusive, because to allow them to decline further is to accept as inevitable the impoverishment of our ecosystems. One might reasonably ask whether we couldn't live without these birds. But why would we want to? They are worth attempting to save for no other reason than the pleasure people find in watching them, listening to them, studying them.



Reflecting fowl weather, a National Weather Service radar in Slidell, Louisiana, picks up clouds of songbirds migrating across the Gulf of Mexico in April. Each dot represents about 20 birds. Analyses of 25 years of radar data show dramatically emptier skies over the Gulf.

A lifelong passion for ornithology often begins with an encounter with a special bird. Roger Tory Peterson, the bird-watching legend, calls it "the spark." He tells a story about John Burroughs, one of the 19th century's most famous naturalists. One spring day in the late 1840s when Burroughs was a boy, he spied a tiny bird neatly patterned in blue, black, and white. It was a black-throated

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LES LINE was the editor of *Audubon* for 25 years. He has written, photographed, or edited some 30 books on natural history and conservation. SCOTT GOLDSMITH's photographs have illustrated several Society books and TRAVELER articles.

blue warbler, as he would later learn. "How the thought of it clung to me, afterward!" Burroughs remembered. "It was the first intimation I had had that the woods we knew so well held birds that we knew not at all."

My spark happened more than 40 years ago as I grew up with a pair of Baltimore (northern) orioles that nested each spring in the great elm shading our yard in Michigan. On Saturday mornings when schoolmates were choosing sides for sandlot baseball, I would lie on my back and watch the male's spirited defense of his kingdom with flashing colors and melodious song. Meanwhile, his mate—hanging upside down from a slender branch—wove horsehair, strips of bark, sundry plant fibers, and bits of yarn and string into a soft but incredibly strong bag, eight inches deep, that would soon hold a quintet of nestlings. My passion for birds has never waned.

SCIENTISTS call them Neotropical migrants. They are the more than 200 species that fill our city parks, suburban yards, rural woodlands and grasslands, and wilderness forests with melody and color. Among the true songbirds, or oscines, are the thrushes, orioles, tanagers, grosbeaks, catbirds, vireos, buntings, and warblers. Especially the multitude of wood warblers, many of them with vivid nuptial plumage that is mirrored in names like bay-breasted, chestnut-sided, golden-winged, and black-throated green. But if you consider a songbird any bird that sings, then also count flycatchers, cuckoos, whip-poor-wills, and hummingbirds.

Each spring, from mid-March to mid-May, they come north across the Gulf of Mexico in great waves, riding flows of warm humid air on a flight launched shortly after sunset from staging areas like the Yucatán Peninsula. Under the best conditions the vanguard—larger, faster fliers like tanagers, thrushes, and kingbirds—will reach the coast by mid-morning after a 600-mile journey; smaller birds like warblers lag behind. The travelers' goal is to make a rest stop in the first line of extensive forest on the mainland, perhaps 30 miles inland. But if they are buffeted by head winds or storms en route, they will drop exhausted into remnant scrub woodlands along the coast, festooning groves of live oak and hackberry like bright Christmas ornaments.

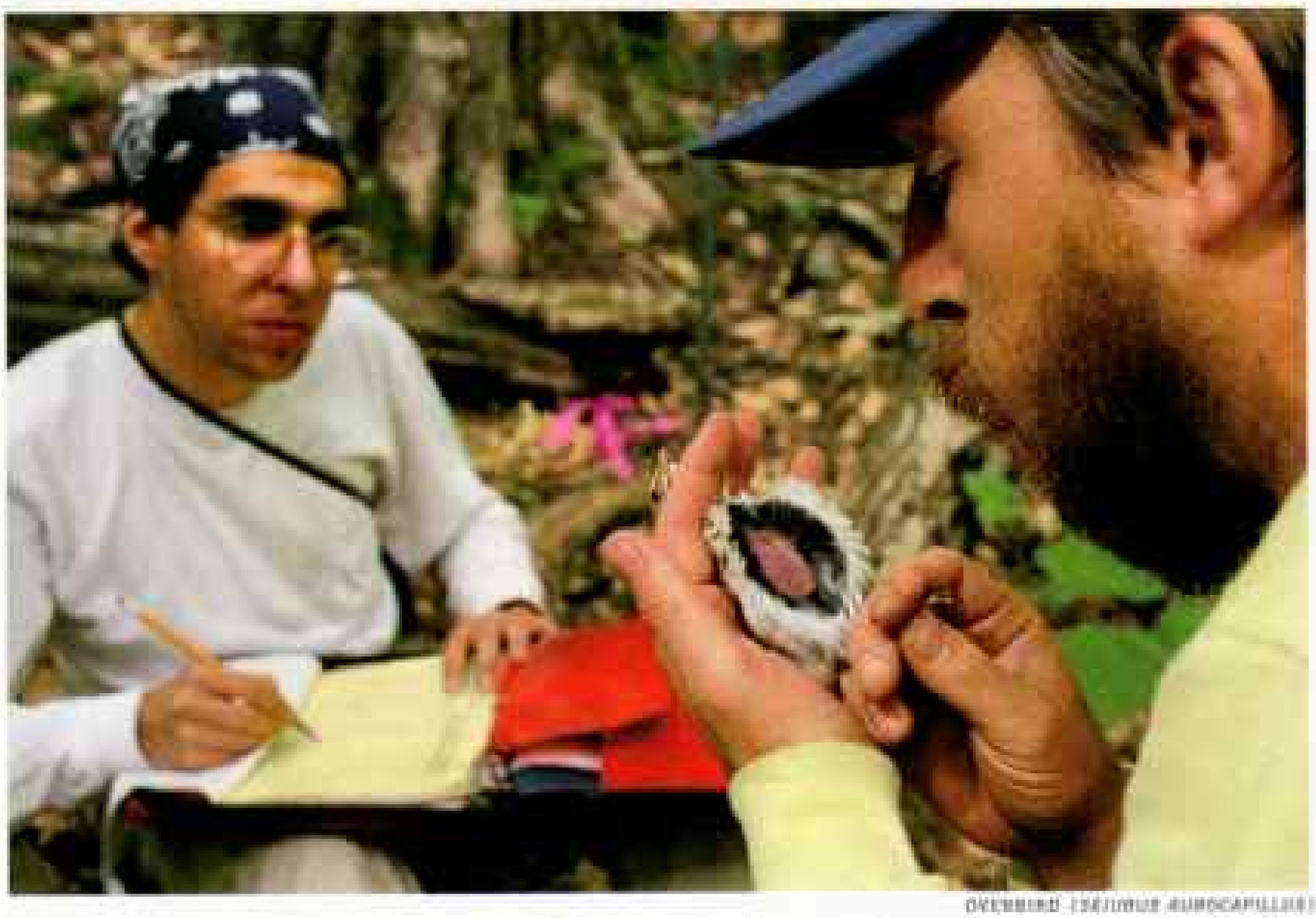
Snared for science, a Kentucky warbler dangles from a "mist" net set by ornithologists in Illinois. All but invisible, the delicate mesh gently traps forest birds for banding. Sometimes live decoys or taped bird

KENTUCKY WARBLER (*OPORORNIS FORMOSUS*)

songs act as lures. Since the 1960s, experts have cast the nets of research far and wide to explain the growing scarcity of scores of U. S. species. So far, simple answers remain as elusive as the birds that get away.

Sidney Gauthreaux, a biologist at Clemson University, has monitored the trans-Gulf migration. I asked him to calculate the number of birds in one wave, or "pulse," at peak migration in late April. Jotting figures on an envelope, he told me that 30,000 migrants would cross a given mile of coast between Corpus Christi, Texas, and Lake Charles, Louisiana, every hour for five hours. "That's 150,000 per mile along a 300-mile front, or 45 million songbirds. I'd call that a conservative estimate. And in the 1960s there was a major pulse every day!"

Not a few bird-watchers fly south as the birds fly north, to witness the spectacle at landfalls like High Island near Galveston or Grand Isle south of New Orleans. While others travel, I stay at home by my postage-stamp wood in the Hudson Valley of New



OVENBIRD (SEIURUS AUROCAPILLUS)

Bird biologist Tony Leukering (above, at right) checks an ovenbird's breeding status at New Hampshire's Hubbard Brook Experimental Forest, one of the few U. S. woodlands not losing songbirds. "It's painful," Leukering says, "seeing all the birds you know replaced by house sparrows and starlings."

York, 1,200 miles to the northeast, waiting anxiously for flights that are delayed by cold, wind, and rain. Will the wood thrush return this spring? Where are my Baltimore orioles?

Then one sunny morning around the first of May the air, gently scented by flowering spicebush, is filled with song. And the budding maples and birches overhanging my brook are alive with black-and-white warblers creeping over tree trunks to glean larvae burrowed in the bark and yellow-rumped warblers darting from twig to twig in a frantic search for early insects.

Day by day the cast changes as some birds stay to nest and others depart, their energy recharged, for more distant places. A catbird mews from the barberry hedge. *Drink-your-tea-ee-ee-ee-ee*, demands a rufous-sided towhee, rattling parchment leaves. A rose-breasted grosbeak shows off its red-white-and-black plumage against a curtain of cherry blossoms. And perhaps a week after my first birds arrive, I am awakened by the glorious piping song of a male oriole that has repossessed the sugar maple by the lane.

But this May there is an essential character missing from the cast: the wood thrush, of whom Thoreau also wrote, "Whenever a man hears it he is young, and Nature is in her spring." The thrush has not returned, and my spring is an unfinished symphony.

There were warnings in the 1980s of a calamity in the making, notably the well-documented disappearance or increasing rarity of once abundant birds—among them the Kentucky warbler, American redstart, ovenbird, hooded warbler, and red-eyed vireo—from such densely wooded sites as Rock Creek and Glover-Archbold Parks in the heart of Washington, D. C. Over the past ten years BBS reports reveal a sizable decrease in three-fourths of Neotropical migrants in the eastern U. S.

With the exception of a very few, very rare species, no one has hazarded an estimate of the continental population of any forest migrant. But among the many birds perceived to be in distress, wood thrush numbers have dropped by 40 percent in 25 years according to BBS data, the olive-sided flycatcher by 48 percent, golden-winged warbler by 46 percent, eastern wood-pewee by 33 percent, orchard oriole by 29 percent. This trend is often confirmed by local studies. Moreover, Sidney Gauthreaux's comparison of radar images from National Weather Service stations in Louisiana and Texas suggests a 50 percent falloff since the 1960s in waves of spring migrants.

Thus an army of ornithologists has taken to the wilds of North, Central, and South America and the Caribbean, probing the lives of songbirds whose auras are well-known to birdwatchers but whose natural histories have only been sketched.

There is an air of crisis that has not

been felt since the early 1960s, when the indiscriminate use of pesticides such as DDT decimated fish-eating birds like the bald eagle, osprey, and brown pelican. When robins by the thousands died trembling on lawns after shade trees were sprayed to combat Dutch elm disease. When Rachel Carson, an eloquent scientist and author of the best-selling book *The Sea Around Us*, stunned the nation with images of a silent spring.

"The tradition of wildlife management in this country is to wait until the critters are a basket case before doing anything," says Amos Eno, a seasoned conservationist at the National Fish and Wildlife Foundation. "By taking action early, we hope to come up with management options that will avoid the legal conflicts of a spotted owl." (That endangered bird has become the focus of a battle between loggers fighting for jobs and environmentalists trying to save old-growth forests in the Northwest.)

There might appear to be clear explanations for the plight of our birds of summer—loss and fragmentation of breeding habitat in North America to suburban sprawl, for one. And destruction of the Latin American forests where many species winter.

Consider the cerulean warbler, whose population has plunged by 49 percent in just ten years. This sky-blue inhabitant of mature floodplain forests is of special interest to Chandler Robbins, the veteran Fish and Wildlife Service biologist who conceived the Breeding Bird Survey. "We've lost thousands of square miles of cerulean warbler habitat to reservoirs, stream channelization, highways, power lines, housing, and commercial development," Robbins says. "If that weren't enough, now its wintering ground—temperate forest high in the Andes—is being cleared for coca plantings."

Take the case of the painted bunting of the Sunbelt, a favorite visitor at bird feeders because of the male's dazzling purple-green-and-scarlet plumage. "A lot of people think the painted bunting's scrubby habitat is wasteland, so it's being turned into pine plantations or cleared for beachside condominiums," said Sam Droege, a researcher with Fish and Wildlife's Office of Migratory Bird Management and former national coordinator of the BBS. And every winter thousands of these gaudy finches disappear into Mexico's cagebird trade. Their numbers have plunged by 58 percent in less than 30 years, reports Droege.

But as the scientists reiterate, explanations for the decline often are far more complex and elusive than simply loss of habitat. Each species, they emphasize, occupies its special niche in both summer and winter and is vulnerable to natural or human-caused changes in its surroundings. "There could be 20 different reasons why 20 Neotropical migrants are declining," says Droege.

What that means is that two different species of forest-nesting songbirds could flourish or fail, depending on

Life in miniature, a four-day-old warbler awaits measurement at the Hubbard Brook study site. By checking changes in leg and wing lengths, researchers can assess the chick's food intake—a gauge of survival in a world increasingly hostile to songbirds.

BLACK-THROATED BLUE WARBLER (DENDROICA CAERULESCENS)

Birds of a feather rest in peace together at the Smithsonian Institution's 600,000-specimen collection in Washington, D. C. "Research here saves hours in the field," says ecologist Mercedes Foster, noting that biological data accompany many specimens. Another collection includes a palette of painted buntings (left), birds now vanishing into Mexico's pet trade.

the needs of each. Dan Niven, an energetic doctoral student at the University of Illinois, has been studying the hooded warbler, which nests in dark, dank lowland woods where its golden feathers sparkle like a firefly on a black June night. "For a tract of forest to be right for hooded warblers," Niven explains, "it must have tree-fall openings, like those caused by a windstorm, which encourage dense vegetation. That's where the parent birds will tend their fledglings." Yet when aging or diseased trees topple and create sunlit gaps in the forest canopy, the least flycatcher, a diminutive scourge of insects and spiders, will abandon a favored breeding site.

To further complicate matters, several Neotropical migrants are segregated by sex on their wintering grounds. Niven has followed the hooded warbler to Yucatán, where males occupy mature forests while their mates prefer open scrubland. "We can't expect to save all these places in pristine condition," he says. "We need to find out what impact different levels of disturbance, like logging, will have on the birds' survival rates over winter."

Many factors also influence whether birds raise their young successfully. As Vickie McDonald has discovered in her studies of Kentucky warblers at the National Zoo's Conservation and Research Center in Virginia, overbrowsing by white-tailed deer destroys critical cover for birds that nest on the ground or in the forest understory, leaving them vulnerable to predators or even homeless. Survival of nestlings can be jeopardized by insect shortages or by an increase of nest-plundering blue jays. And always lurking is the brown-headed cowbird, a vagabond of the blackbird tribe that furtively leaves its eggs in another bird's nest, where its young are raised by unwitting surrogate parents.

Because the situation is so complex, there is no quick fix such as regulations banning the use of persistent pesticides, which eased the earlier crisis. As I was told time and again, staying or reversing the decline of the songbirds calls for profound changes in how we manage our public and private landscapes—plus a major effort to restore lost habitat.

Although no one predicts mass extinctions in the foreseeable future, ornithologists say that many Neotropical migrants like the cerulean warbler and wood thrush will continue to fade from places where they had been common. Some believe a few species could become exceedingly rare. John Terborgh, director of Duke University's Center for Tropical Conservation, warns that the last unprotected rain forest in Central and South America could disappear within 40 years, with grave consequences for birds tied to mature habitat. Terborgh claims, "We are as helpless as bystanders at a car crash."

SAM DROEGE cocks his head from side to side like a great horned owl listening for scurrying mice. "Three wood thrushes, at least," he says, jotting numbers on his clipboard. A pewee whistles its name. A field sparrow trills. The watch beeps. Time to move on. There are strict rules for Breeding Bird Survey participants. Starting time, for example, is exactly 30 minutes before sunrise. Stops are exactly one-half mile apart, and the observer counts every bird heard or seen from a stationary point in exactly three minutes.

Drive, stop, count birds. Drive, stop, count birds. Four hours of driving, stopping, counting birds. Boring? Not to serious birders, who crave the challenge of identifying hundreds of species from snippets of song or a flash of color.

Droege navigates by detailed topographic maps with landmarks noted in orange. At stop 18, for instance, nature is reclaiming an old drive-in movie theater, and trumpet vines twining about rusting lampposts have lured our *(Continued on page 82)*

Blinded by instinct, a mother blue-winged warbler feeds a brown-headed cowbird chick that has hijacked the nest (facing page). Brazen imposters, cowbirds foist their fast-hatching eggs on the unattended nests of other species, duping countless songbirds whose own young then suffer from neglect and starvation. Surveys show cowbirds are on the rise: In some Illinois forests, virtually every wood thrush nest has been saddled with their telltale speckled eggs (above). At Fort Hood, Texas, biologists have killed thousands of captured cowbirds with auto fumes (below) in a bid to save the heavily parasitized black-capped vireo from extinction.

BROWN-HEADED COWBIRD (MOLOTHRUS ATER)

BLUE-WINGED WARBLER (VERMIVORA PINUS) FEEDING CHICK, STEVE AND DAVE MASLOWSKI

NGS CARTOGRAPHIC DIVISION

1 Olive-sided flycatcher

CONTOPUS BOREALIS

Widespread in North American coniferous forests and bogs, the olive-sided flycatcher may face its greatest human threat in the heavily logged foothills of the Peruvian Andes, where some populations winter. In the U. S., sightings of this acrobatic insectivore have dropped by 22 percent since 1980.

2 Golden-winged warbler

VERMIVORA CHRYSOPTERA

After expanding into abandoned U. S. farmlands for more than a century, the golden-winged warbler has retreated as northeastern forests retake the shrubby fields and clear-cuts it prefers for breading. The species is also declining through interbreeding with genetically similar blue-winged warblers.

3 Wood thrush

HYLOCICHLA MUSTELINA

Its honeyed song has inspired poets — and made the wood thrush among the most beloved of Neotropical migrants. Cowbirds have invaded patchwork forests in the Midwest, sabotaging its nests. With Middle American wintering grounds also under pressure, numbers have shrunk 23 percent nationwide since 1980.

4 Cape May warbler

DENDROICA TIGRINA

This migrant winters in the remnant rain forests of the West Indies and breeds in black spruce forests in the U. S. and Canada, where it feasts on budworms. Though U. S. statistics show a sharp drop, budworm infestations can boost numbers locally; Maine sightings have more than doubled since the 1950s.

5 Rose-breasted grosbeak

PHEUCTICUS LUDOVICIANUS

This fruit-and-insect-eater can tolerate disturbance in its Latin American wintering grounds, so its decline may result from factors in the U. S. Aging New England forests, for example, could be squeezing it out of second-growth breeding habitat. Sightings in the U. S. have slumped by a third since 1980.

From species at risk, a

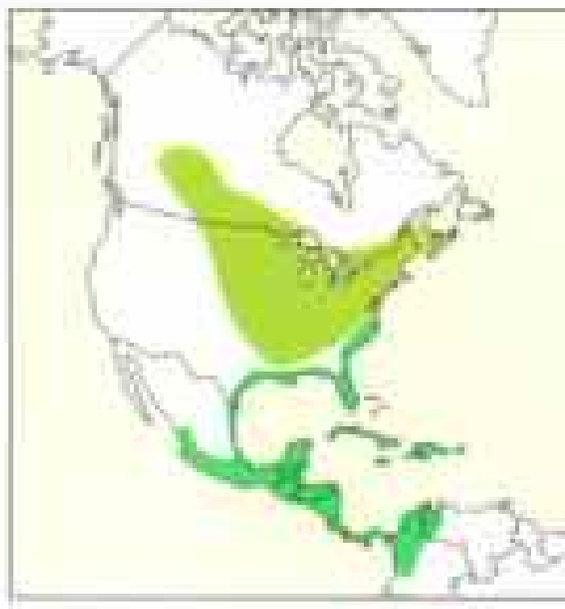
"It was a spring without voices," naturalist Rachel Carson wrote some 30 years ago, warning of the dangers of pesticides. "On the mornings that had once throbbed with the dawn chorus of robins, catbirds, doves, jays, wrens and scores of other bird voices there was now no sound. . . ." Today the waning melody of many migrant birds—including the sampling

PAINTING BY H. DOUGLAS PRATT

6 Northern oriole (Baltimore)

ICTERUS GALBULA GALBULA

This plumed dandy of the nation's backyards adapts well to human disruption in its nesting grounds. While the northern oriole is declining only slightly, the eastern subspecies — the Baltimore oriole — has dropped 27 percent in ten years. Little is known of its sojourn in Latin America.



7 Yellow-billed cuckoo

COCCYZUS AMERICANUS

A sharp *kuk-kuk-kuk* announces the yellow-billed cuckoo in woodlands across the U. S., but it has grown increasingly rare in the East. This bird tolerates various breeding habitats, so its decline could be linked to predators or disturbance to its winter range in South America.

8 Cerulean warbler

DENDROICA CERULEA

At risk in both its northern and southern ranges, this blue-jacketed migrant requires large, mature forests for breeding and wintering. Its bottomland woods have been replaced by farms in the Midwest, while in the Andes, climax forests are under siege. Declines since the 1960s have been severe.

9 Summer tanager

PIRANGA RUBRA

This fire-feathered tanager is plagued by cowbirds in the Midwest. Though found in a variety of breeding habitats, the bird winters in the tropical woodlands of Mexico and Central and South America — regions undergoing extensive development. Populations have diminished 17 percent since 1980.

fading medley of song

above—suggests that habitat disruption is an even greater culprit than toxics. Measuring bird declines is a complex and imperfect art. But a recent survey of a hundred migrant species confirms what avid birdwatchers have been saying for years: Most of the nation's losses involve forest birds, mainly in the East during the past decade.

10 Whip-poor-will

CAPRIMULGUS VOCIFERUS

Famous for its namesake lyric, the whip-poor-will is a shy ground nester acutely vulnerable to predation when humans cut into its woodland strongholds. Though statistics show a long-term national decline, reliable data are scarce because most bird surveys overlook nocturnal species.

first ruby-throated hummingbird.

Today, however, there's a new landmark at stop 23: a sign proclaiming the residential community of Deerfield II. Eighty-three acres of forest carved into 32 lots of varying sizes. It's not that all the trees will be felled. Homeowners, after all, have paid to live in the woods. But as driveways are bulldozed and understory is cleared—for lawns, swimming pools, tennis courts, or simply for the sake of neatness—the songbird habitat deteriorates.

New developments pop up like mushrooms along this Maryland survey route every year, Droege tells me, and like much of the Northeast corridor from Boston to Richmond, the area is fast becoming what he bluntly terms a "Neotropical desert."

But how do you weigh the value of bird habitat against the profits from developing a tract of forest for a subdivision? There will always be birds around, but greening woods where no song is heard except the voices of cardinals, chickadees, and robins would be a desolate place indeed. And the silence would be further evidence, if any were needed, of the rapid deterioration of the natural world.

One could also stress the role of songbirds in controlling destructive insects, but in truth their importance to humankind is largely aesthetic. To hear the mellow song of a rose-breasted grosbeak or to glimpse the fiery plumage of a scarlet tanager gladdens the heart and heightens one's appreciation of nature.

I asked Sam Droege for his plan of action if he were made national songbird czar. "We've got to identify and limit development of landscapes that these birds need for long-term survival," he responds without hesitation, "areas like the New Jersey Pine Barrens that will soon succumb to population pressures. Forestry practices can be changed to leave large, unbroken tracts to accommodate Neotropical migrants. Agricultural lands can be bought and left to revert to scrubland or forest. But once you've built houses, it's lost!"

Exporting bananas—not birds—is a priority for plantation workers toiling near Costa Rica's border with Panama. The region once pulsed with a tropical salsa of forest-dwelling orioles, vireos, and tanagers. About 60 songbirds that nest in the U. S. prefer undisturbed rain forest for their wintering grounds.

Hubbard Brook Experimental Forest is a 7,800-acre natural laboratory in the White Mountain National Forest of New Hampshire, embracing a valley that has been largely undisturbed since it was logged between 1905 and 1915. Richard Holmes, professor of biology at Dartmouth College, leads a scramble up a steep slope shaded by 90-foot beeches, sugar maples, and great yellow birches with their jagged plates of burnished-bronze bark. Holmes is tall and lean and accustomed to this vertical landscape, leaving me huffing to catch up. He stops by a hobblebush where a wicker nest, the kind used by cage-bird fanciers, is filled with quail eggs. A trip wire leads to a flash camera, which catches nest robbers in the act, providing researchers with mug shots of the offenders.

For more than a decade Holmes and Tom Sherry, a Tulane University ecologist, have studied the population

dynamics of American redstarts both at Hubbard Brook and on their wintering ground in Jamaica. The redstart is one of the most abundant warblers in North America. (The male is a black-and-orange bundle of animation that countryfolk from Canada to the Caribbean call the butterfly bird.)

Holmes and Sherry are outspoken in arguing that some of their peers as well as the popular press have been too hasty in blaming events in Third World countries for declines of forest migrants. For most species, they insist, the more immediate problems lie in our own backyard. "When you fragment forests into small islands surrounded by logging clear-cuts, farmland, and suburbs," explains Holmes, "nesting songbirds are left vulnerable to predatory grackles, raccoons, snakes, and house cats that haunt the woodland edge. Plus, of course, cowbirds." Cause and effect: Fewer nests succeed, fewer young birds return the next spring to replace adults lost to natural mortality, the population declines and may eventually crash.

"It's a rare event to see a cowbird in the deep forests of Hubbard Brook," says Sherry. Still, redstart numbers there have fallen by 48 percent in 25 years. Most of the blame, Holmes and Sherry say, falls on a host of predators. They show me color photographs of a blue jay with a quail egg in its mouth and a black bear with its snout in a nest. There are snapshots of raids by fishers (large relatives of the weasel) and by flying squirrels, red squirrels, and chipmunks. "Most losses," Holmes emphasizes, "are to mammals, although it's not clear which is the worst culprit."

Predator numbers rise and fall from year to year, and destruction of redstart eggs and broods in pristine Hubbard Brook has soared as high as 70 percent in a summer.

The implication is this: In landscapes where habitat has been severely altered by human activities, it is a small miracle whenever a pair of songbirds fledges a complement of nestlings under relentless pressure from predators—and the intrusions of parasitic cowbirds.

THESE NATIVE buffalo birds, as they were called long ago, followed those immense herds of wild bovines over plain and prairie—and then accompanied the cattle drives that replaced the roaming bison. Ever on the move, feasting on insects stirred by thousands of hoofs and undigested seeds in piles of dung, the pregnant females left their eggs in whatever unattended nests were handy. Then the mother cowbirds hit the trail, leaving their young to be tended by the owners of the nests.

As the country was settled, and farms, pastures, and ranches (with their inviting livestock) replaced forests, marshes, and native grasslands, cowbirds abandoned their nomadic ways. Expanding their

A homesteader's fire sends a grim smoke signal to the birds of Costa Rica: Flee for your lives. Some 160 square miles of Costa Rican jungles are cut each year. "In five years the last exploitable forests outside of our national parks will be gone," says a government biologist.

range east and west, they invaded the breeding grounds of many birds that had never been duped by alien eggs and were often defenseless. The number of cowbirds exploded; more than 200 species have had cowbird eggs foisted on them. But not every songbird is a pushover. Yellow warblers will build two, three, as many as five stories of nests to bury cowbird eggs, even when that means laying a new clutch of eggs in each.

Scott Robinson of the Illinois Natural History Survey has been studying the impact of forest fragmentation on the birds of summer, and nest parasitism by cowbirds in particular, for more than ten years. "Forest" in Illinois usually means a small woodlot in a sea of corn and soybeans—a patch of scarce habitat with an extensive agricultural edge that provides easy

Pioneering conservationist Shirley Briggs watched as Glover-Archbold Park in Washington, D. C., lost three-quarters of its original Neotropical migrant

bird species over three decades. Now the urban oasis is being crowded by a new housing development. "They've just scalped a whole hillside," sighs Briggs.

Robinson found that 90 percent of the wood thrush nests are commandeered by cowbirds, and the output of thrush fledglings has fallen far below the level needed to sustain the local population. "The wood thrush is remarkably defenseless," Robinson tells me with a measure of awe. "They have blue eggs. Cowbird eggs are white with brown speckles. Yet they can't recognize a cowbird egg in their nest and chuck it out. It's perfectly normal for a wood thrush to sit on a clutch of five or six cowbird eggs with none of her own left."

There is more bad news. In the Shawnee research area, 80 percent of the nests of scarlet tanagers, summer tanagers, and other canopy-nesting species such as the yellow-throated warbler contain cowbird eggs or young. A notable exception is the eastern wood-pewee, which is aggressive in defending its lofty nest.

ALTHOUGH the Shawnee spreads from the Mississippi River on the west to the Ohio River on the east, it hardly fits the popular image of a national forest as a blanket of green. What Robinson calls his "laboratory of fragmentation" consists of hundreds of small woodland tracts splintered by private inholdings—farms, pastures, pig feedlots, orchards, backyards, all places where cowbirds congregate to feed. "The area is utterly saturated with cowbirds," Robinson laments, "and there is no forest here that is large enough for songbirds to escape them."

He describes his project as "brute-force science—inelegant, labor-intensive. I hire skilled bird-watchers to find every nest, and undergraduates to check them every two days. And then I get graduate students to study the species of greatest interest, like the wood thrush."

Brute-force science, as I learned one morning following two students, also means crashing through grasping brambles and tangles of poison ivy in sopping heat, with a sharp eye for

access to songbird nests for skulking cowbirds and abundant predators like the black rat snake. "We don't have large parks and preserves in Illinois," says Robinson. "Our research provides a warning for other parts of the country. This is what could happen to your birds."

What has happened to the birds in the Shawnee National Forest of southernmost Illinois is sobering.

BLUE JAY (CYANOCITTA CRISTATA), TERRENCE DOFFY

"How many little dramas are enacted in the depth of the woods at which man is not present," Henry David Thoreau wrote while pondering blue jays—the roguish robbers of oriole young (left). Predation is a violent hurdle to successful nesting in the U. S., where jays, crows, raccoons, and squirrels all feed on migrant songbird eggs and hatchlings. Forest fragmentation only worsens the carnage. Fattened on birdseed or garbage, predators boom wherever suburbia meets woodlands. "Nice cuddly chipmunks can be aggressive raiders," notes ornithologist Richard Holmes, who has placed decoy nests in New Hampshire forests to study predators such as the mink-like fisher (above). His work shows that nesting losses for one migratory songbird, the American redstart, can reach 70 percent. Resident birds like woodpeckers or chickadees fare better against nest piracy—they fight off attackers more often, and they lodge in safer tree holes.

Altruistic arson: A forester in Michigan burns a plot to promote the growth of young jack pines—crucial nesting trees for the endangered Kirtland's warbler. The warblers faced habitat loss and cowbird parasitism until biologists intervened—a rare reprieve for songbird survival.

both nests and venomous snakes. But Robinson's students seem oblivious to the dangers as they keep note of cowbird eggs and chicks in the nests of other species.

By the end of this summer—their fifth season in Shawnee National Forest—Robinson's team will have compiled data on the impact of cowbirds and predators on more than 2,000 nests. The next phase of the study will try to answer some specific questions. "Why," Robinson asks, "are there wood thrushes in some ravines and not others?" Another riddle: Do foster parents expend so much extra energy feeding larger cowbird young that it leaves them so weakened that they die?

Is there any relief in sight from the cowbird? On the jack pine plains of Michigan a cowbird-control program helped save the Kirtland's warbler, perhaps North America's rarest songbird, from extinction. Each nesting season more than 7,000 cowbirds are trapped and humanely killed. The rate of nest parasitism has dropped from 69 percent to 5 percent since 1972, and the Kirtland's warbler breeding population has rebounded from a low of 167 pairs to 397 pairs in the latest census.

But trapping on a national scale would be impractical. "The cowbird population in the U. S. is at least 50 million at the start of the nesting season and 125 million by midsummer," says Richard Dolbeer, a blackbird expert at the U. S. Department of Agriculture.

I ask Scott Robinson for his solution to the cowbird conundrum, and he gives a familiar response: "We've got to manage our landscapes properly," he says. "In an area like the Shawnee that means buying inholdings to pull together the forest fragments."

Robinson and I drive into an empty Forest Service campground. Wood thrushes harmonize in the treetops while their nemeses search for seeds in the close-cropped grass. I glance up at the branch of a hickory and see a female thrush, ever dutiful, bringing a juicy caterpillar to a plump cowbird chick.

IT IS 1,800 MILES, as the warbler flies, from the cool mountain forests of New Hampshire to a steamy swamp on the southeastern coast of Jamaica. It is late October, the rainy season on this tropical island is nearing its end, and beaches soon will be crowded with tourists from the north. Songbirds from the north, however, already are ensconced for a long winter stay, and it is disorienting to see familiar species doing familiar things in this exotic setting. An ovenbird scuffles through leaves beneath a thorny logwood tree, and a northern parula warbler gleans insects from a scarlet bromeliad.

There is an occasional burst of melody from a Jamaican oriole, and the wheezing of local bananaquits, but the prevalent sounds this morning are the sharp call notes of assorted

warblers whose courtship songs are rarely heard in winter. Jamaicans call them, collectively, "chip-chips." Or simply "Christmas birds," to distinguish the winter visitors from their familiar resident species.

Tom Sherry, whom I last saw at Hubbard Brook in New Hampshire, sloshes from the swamp with a male redstart in hand. Using a stuffed redstart and taped songs of the species, it had taken him only minutes to lure the bird—outraged at the idea of a competitor for its turf—into a "mist" net virtually invisible to birds. As in previous years, Sherry and colleague Richard Holmes aim to capture and band every redstart and mark its territory on this 13-acre study plot at the edge of one of the few large stands of mangroves left on the island.

"Many Neotropical migrants are aggressive in defending their winter living space," Sherry explains, "and individuals will occupy the same territories year after year. If you destroy their habitat, displaced birds may not be able to find suitable places to forage in an ever-shrinking and increasingly crowded environment.

"The good news, at least for the redstarts, is that they will remain in their territories even after slash-and-burn agriculture, providing some trees are left." Here, then, is more evidence that the ebb of redstarts and other songbirds is linked to problems in the north.

Across the Caribbean Sea, more than 600 miles southwest of Sherry's study area, ornithologists in the forests of Costa Rica are also searching for clues to the decline of songbirds.

"*Nube loca*," says Daniel Hernández, a scientist from the National Museum of Costa Rica. "Crazy cloud." One cloud the size of a silver dollar hangs overhead in an otherwise unblemished sky, and for the past three minutes rain has been pouring on us and nowhere else along this reach of Caribbean coastline.

The deluge ends as unexpectedly as it began, and a trogon celebrates the sun's return with a prettily whistled song. We are on the bank of Caño Palma, a canal whose flow is so imperceptible that its surface is an uncracked black mirror. Buttresses of silk-cotton trees and the massive fronds of yolillo palms, real and reflected, merge in perfect symmetry. I am reminded of a cypress and tupelo swamp in South Carolina, and to complete the picture there is a flash of gold as a prothonotary warbler, a summer resident of those more northerly watercourses, flits from one green wall of the canal to the other.

The trail beyond is submerged, and we retreat to a corridor cut through the forest edge where mist nets are strung. Hernández is one of the half dozen Costa Ricans who are working ornithologists. And this site near Tortuguero National Park, on the northeast coast, is the first of three banding stations recently established to monitor habitat use and behavior of migrants. "The breeding

Back from the brink, Kirtland's warblers (below) have doubled their ranks to 397 mating pairs since the mid-1980s. Few other migrants face extinction —yet—although one species, the Bachman's warbler, is already thought to be doomed, partly because of Cuban sugarcane farming.

KIRTLAND'S WARBLER (DENDROICA KIRTLANDII); RON AUSTING

habits of most Neotropical migrants are well documented, but we know very little about the other half of their lives," says Chris Wille, representative in Central America for the Rainforest Alliance, an organization dedicated to saving tropical forests and their wildlife. "It's like trying to understand the human race by reading the Kinsey Report."

Tortuguero National Park together with Barra del Colorado National Wildlife Refuge to the north on the Nicaraguan border encompasses 428 square miles of tropical wet forest, where the annual rainfall exceeds 150 inches. In species it is one of the richest areas in the country, and probably the most threatened—by banana growers, loggers, ranchers, family farmers, and squatters.

The country's thriving banana-growing industry employs 100,000 workers and is consuming more and more rain forest—prime habitat for Neotropical migrants. Some Costa Ricans are pessimistic about their countrymen coming to the forest's defense. "Nobody loves a woman he doesn't know," says Julio Sánchez, curator of ornithology at the National Museum of Costa Rica. "Costa Ricans don't even know our own parks. They think the forest is dangerous, full of jaguars and snakes."

NOT ALL COSTA RICANS. At La Selva Biological Station, a rain forest reserve along the roaring Río Sarapiquí, Alexander Martínez rumbles up on his pride and joy, a beautifully restored 1940s Harley-Davidson motorcycle. Martínez is a fruit grower and grass-roots activist who is eager to tell me about his organization, the Association for the Environmental Well-being of Sarapiquí. He describes many of its members, himself included, as "ex-poachers who have abandoned their bad habits" to protect the forest and its wildlife, especially the spectacular birdlife that lures busloads of foreign tourists to the region.

"It is dangerous being a conservationist in Costa Rica," Martínez says. "I have been threatened with a machete, and my dog was poisoned," so he packs a pistol. He and his colleagues are gadflies to the banana growers, demanding that they comply with seldom enforced regulations, writing letters to newspapers, protesting on television. He slaps the handlebar of his Harley. "We must awaken the people. Bananas are not the best thing to happen to Costa Rica. There must be a limit."

It is a week before Christmas and my last day in the rain forest. As I near the end of La Selva's trail, elated to have seen the elusive rufous motmot with its long racket-tipped tail, there is a familiar burst of flame in the canopy. I focus my binoculars on an old friend from home, a male Baltimore oriole.

That flash of color sent me back to my boyhood in Michigan. I cannot imagine a summer without orioles. □

Dazzling our eye with the hues of a painted bunting (facing page) or enchanting our ear with the silver music of a thrush, migrants face a destiny as fragile as their song. "Try to imagine a world that's silent," says Carlos Quijano, a Bethesda, Maryland, bird-watcher (above, at center). "I'm not sure I'd like to live in a world like that."

PAINTED BUNTING (PASSERINA CIRIS); GILES DELISLE

THE GOLDEN GRAIN

CORN

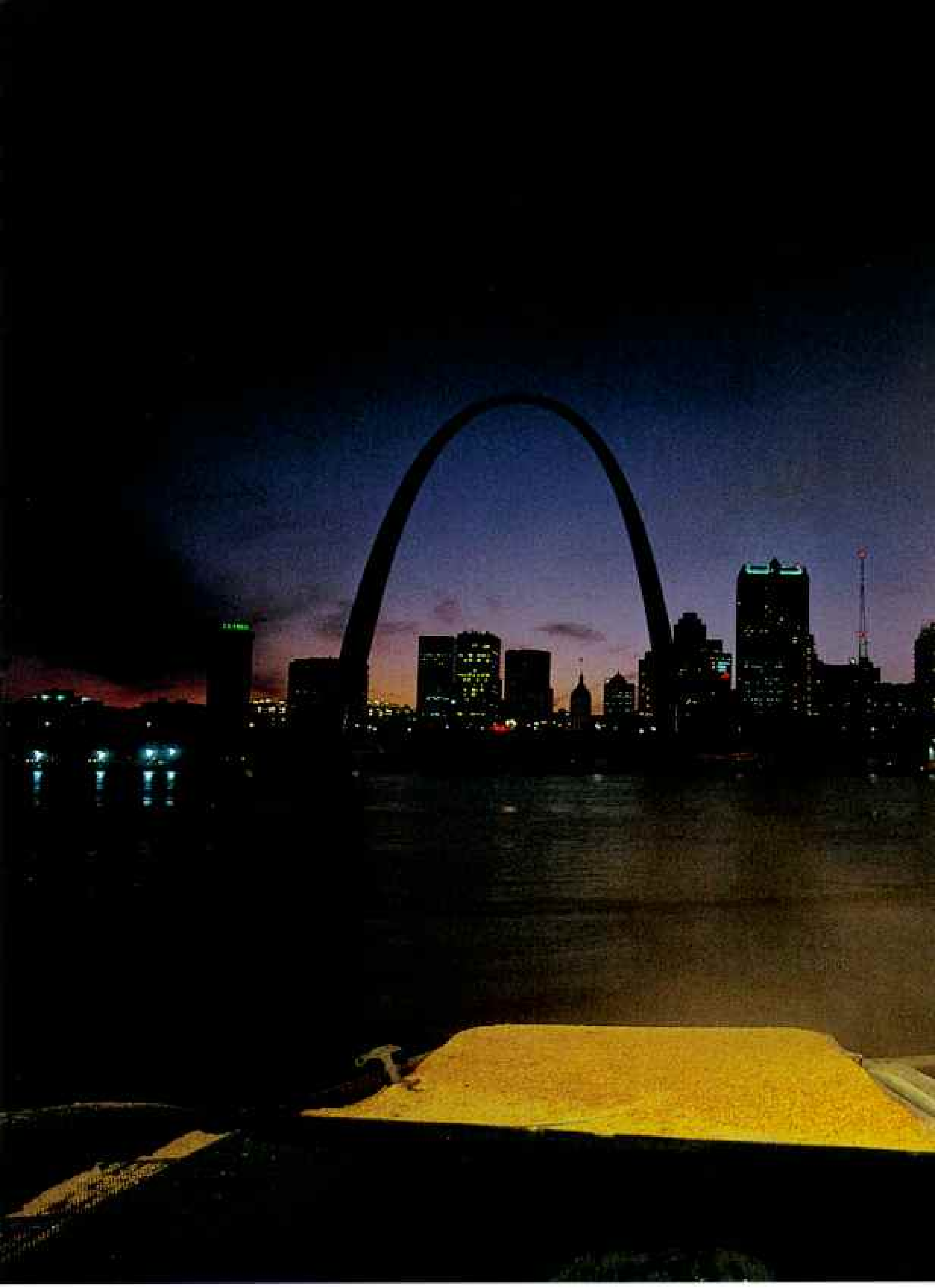
By ROBERT E. RHOADES Photographs by PETER ESSICK

Gleaned after the harvest, cornstalks are salvaged for animal feed at the Guatemalan town of Sololá, near Tolimán Volcano. Sprouting from a prehistoric Mexican grass, corn, also called maize, grows in thousands of varieties on six continents.

Geneticists group the world's corn into races, some 300 at last count. The rainbow of variations results from centuries of breeding for traits such as size, flavor,

CHRIS JOHNS

and pest resistance. Among the oldest types in the collection of Carl "White Eagle" Barnes is pod corn, with plumelike sheaths around each kernel.



Pillar of gold fills a barge across the Mississippi from St. Louis, Midwest gateway for corn exports. After loading at the Continental Grain Company facility, floating

convoys with as many as 30 corn-laden barges are pushed to New Orleans.
Cornhusker to the world, the United States exported 46 million tons in 1992.

VULTURES circled in a turquoise sky as we emerged from the cactus forest in the Tehuacán Valley of central Mexico. Nothing else moved. The squat figure of Narciso Tejeda Cabanzo stood silhouetted against the midday sun. He reached back, took my hand, and we scrambled up a worn goat path to a shallow cave.

A shaft of sunlight illuminated several depressions from old excavations and a few potsherds scattered about the cave floor. I sat on a rock and let my eyes adjust to the shadows. "This is where we discovered the oldest corn known to science," Narciso recalled, scanning the ground. "It was just a little shriveled cob, but we all jumped with joy as if this were the golden tomb of a great Aztec king." He leaned down, brushed aside some debris, and delicately picked up something too small for me to see. Then he handed me a wispish fragment about an inch long, an ear of wild corn. From diminutive plants such as these, Indians began domesticating corn as early as 5000 B.C.

I looked out over the thorn scrub and cactus that stretched to the horizon and imagined what it must have been like when the first Americans roamed these lands, migrating with the seasons, hunting small game and gathering food.

But the simplicity of the cave, the scene of one of the most extraordinary prehistoric finds ever made in the New World, caught me off-guard. There were no tourists here, no markers to signify its importance. "The cave has been looted and forgotten," said Narciso, shrugging as we hiked down through clusters of prickly pear and *jiotilla* cactus. "No one cares about this cave and what went on here."

Although the exact origin of modern corn has been passionately debated among botanical experts, most agree that it sprang from a grass native to Mexico, similar to some of the tiny plants from the cave.

"Prehistoric Indians living near the caves gathered tiny four-rowed ears of wild corn for

"Husking gloves cost me 88 cents an acre," says Amish hog farmer Robert Slabaugh. They are his sole expense for 46 days of hand harvesting 60 acres near Lagrange, Indiana.

food," says Richard S. MacNeish, an archaeologist who discovered the progenitor of modern corn here with Narciso 30 years ago. "It took only a thousand years for the Indians to transform wild corn into a primitive, domesticated corn. Prior to Columbus's discovery of the Americas, no event in the New World was more significant. This was the crop that made possible the great Indian civilizations, from the Aztec to the Zuni."

Through all the years since, corn has remained the grain of the Americas. It sustained the pioneers pushing westward. Today it nourishes millions of people in developing nations. The United States grows nearly half the world's corn, which feeds most of the livestock here and in Japan and South Korea. With an annual harvest worth 40 billion dollars, corn grows in more countries than does any other crop. In the U. S. alone the annual value of the corn crop (20 billion dollars) exceeds that of wheat, oats, rice, rye, barley, and sorghum combined. Without corn, millions of people would starve, and the U. S. economy would falter.

Any modern American would be hard-pressed to find a way to live without corn. Consider a typical day: You put on a cotton shirt, which has fibers strengthened by cornstarch. The eggs you eat for breakfast were laid by a corn-fed chicken. At lunch you drink a cold cola sweetened with corn syrup. In the afternoon you read a NATIONAL GEOGRAPHIC —the paper fibers are bound with cornstarch to keep them together as they race through high-speed presses. You drive home in a car powered, in part, by ethanol, a fuel derived from corn. When you get there, you feed your dog pet food containing cornmeal. You mix yourself a Manhattan with bourbon distilled from corn. For dinner you eat a steak that was once a steer fattened on corn feed. You take out the garbage in a trash bag derived from corn. Finally, you brush your teeth with toothpaste containing traces of sorbitol, a sweet powder processed from corn to make the paste tasty.

And that's not all: Corn's by-products turn up in such items as glue, canned goods, shoe polish, fireworks, lotions, crayons, ink, batteries, marshmallows, mustard, ice cream, aspirin, paint, and cosmetics.

To follow the story of corn, I visited the future of new technology, where people make golf tees from cornstarch in New Jersey and transfer insect-resistant genes to corn cells in a laboratory in Iowa. I also journeyed back to the past, where a Peruvian farmer makes an offering of corn beer to the ancient gods of the Inca. And in between I saw Illinois farmers rising before dawn to tend hundreds of acres and Hopi Indians planting the blue corn they consider sacred in ancient Arizona fields.

CHRISTOPHER COLUMBUS, seeking exotic spices and elusive gold, hardly took notice when Indians of the Caribbean gave him a gift of grain in 1492. He dubbed the strange crop *panizo*, or "panic grass," for an Italian millet he knew. The Indians called it *mahiz*. (In 1737 Linnaeus christened the species *Zea mays*, from the Greek *zeia*, for grain or cereal.) In 1493 Columbus carried seeds of the unusual plant back to Europe, where it was considered a curio by botanists. Before a hundred years had passed, corn had spread across Europe, Asia, and Africa.

Although a year's crop contains enough calories to nourish a billion people, only a fraction is eaten by humans. Because it's inexpensive and convenient for farmers, more than half the U. S. crop is fed to cattle, pigs, and chickens. Every day the average American ingests three pounds of corn in the form of meat, butter, milk, and cheese.

Whether they're devouring corn on the cob at a picnic, eating grits in a soul-food restaurant, or munching popcorn at a ball game, Americans are enjoying centuries-old culinary pleasures. The Pilgrims at Plymouth Rock would have starved in 1621 had it not been for the Pawtuxet Indian Squanto, who taught the settlers how to grow corn.

"Indians were not just the first corn breeders, they created the plant as we know it today," says Walton C. Galinat, a professor of botany at the University of Massachusetts. "Native Americans created all the types still in use: pop, dent, flint, flour, and sweet."

Since those days, of course, the humble American plant has taken on a variety of forms and uses. Galinat actually bred a patriotic red,

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ROBERT E. RHOADES, chairman of the anthropology department at the University of Georgia, was nominated for a National Magazine Award for "The World's Food Supply at Risk" (April 1991). Photographer PETER ESSICK's last assignment for NATIONAL GEOGRAPHIC was "The Bolshevik Revolution" (October 1992).

"Corn is my religion, and this laboratory is my church," Walton C. Galinat tells pilgrims to his University of Massachusetts greenhouse. He holds his genetic representation of corn's 7,000-year evolution.

white, and blue type for the 1976 Bicentennial. Corn might even help America reduce dependence on foreign oil and clean the air. An acre of corn yielding 125 bushels (a bushel averages about 56 pounds) makes more than 300 gallons of ethanol, an alcohol distilled from cornstarch that, combined with gasoline, helps fuel burn more efficiently, reducing carbon-monoxide emissions by as much as 30 percent. Ethanol helps power the city fleets of smog-plagued Los Angeles, Denver, and Phoenix.

No other grain converts energy from the sun more efficiently than corn. While a few varieties may take a year to mature, most can be harvested in fewer than 120 days, even sooner in warm climates.

In spite of its tropical origins, corn grows from Canada's Yukon Territory to Chile's Tierra del Fuego, from more than 12,000 feet in the Andes to the steamy jungles of the Amazon basin. In the deserts of the Southwest, where temperatures often reach 115°F and annual rainfall is less than eight inches, adapted varieties cling to life and bunch into two-foot-high bushes. In the Jala Valley of Mexico cornstalks receive a yearly average of 47 inches of rain, tower as high as 15 feet, and must be harvested from horseback.

"It's our symbiotic partner," says Galinat. Without humans to care for it, corn could not survive. Protected inside the husk and crowded together on the cob, any sprouting kernels will choke to death if they are not removed and planted. Corn is a cultural artifact, the product of a marriage from the distant past, strengthened over centuries. Few societies recognize this mutual dependence as well as do the Hopi Indians, who have farmed the same Arizona fields for centuries.

A HOT AUGUST WIND blew across the Third Mesa of Arizona, near the village of Moenkopi. Harold Dawavendewa, a 42-year-old Hopi, and I hoed his ancestral cornfield while our wives pulled weeds and the children played along a willow-framed stream. Except for Harold's pickup truck parked above a red rock overhang, nothing alien intruded on this timeless scene.

Blue corn is the symbol of the Hopi people. Harold explained their tradition: "Yaapa, the Mockingbird, placed many different kinds of corn before the tribes. The Navajo took yellow ears, Sioux picked the white, Havasupai wanted the red, Ute selected the flint, Apache chose the longest ears. My people picked up the last and smallest ear, the blue corn. This

Corn of Plenty

Ten pounds of corn feed yields one pound of beef in Kearny, Nebraska (above) —three pounds makes a pound of chicken. Burning calories at 100 mph (center), a South Dakota racer cuts emissions with ethanol, a corn-alcohol fuel. High-octane corn spirits mellow into bourbon under the care of Maker's Mark Distillery chief Bennie Miles (bottom). The distillery uses mostly Kentucky corn: "In good bourbon, water and grain come from the same soil," says its president.

CHRIS JOHNS

Embracing a hemisphere

From its Mexican cradle, corn was adopted and adapted by native cultures.

GENERAL DISPERSAL ROUTES OF CORN

Pre-Columbian
Columbus's return voyage, 1493
After 1800

Dispersal centers shown as circles.

0 1500 MILES

INFORMATION PROVIDED IN PART BY WALTON C. GALINAT, UNIVERSITY OF MASSACHUSETTS

NGS CARTOGRAPHIC DIVISION

Average Annual U.S. Usage

Man, beast, and industry share some eight billion bushels produced each year.

0.2% Seed
High-yield hybrids are planted annually.

1.4% Food
Americans eat little whole kernel or processed corn.

1.8% Starch
This extract thickens foods and industrial products.

3.7% Alcohol
Ethanol from corn powers both engines and bourbon.

5.8% Sweeteners
More costly sugar has been replaced by corn syrup in most sweet drinks and snack foods.

44.7% Animal feed and residual
Cattle, hogs, and poultry thrive on corn. "Residual" is the unrecorded part of USDA estimates.

16.8% Exports
Japan and Russia are the top corn customers.

25.6% Ending stocks
Corn held at year's end can be a buffer against a bad crop.

The kernel
Extract from the germ (1) is used as cooking oil. Versatile starch (2) can be food, a component of building materials, or an ingredient in intravenous solutions. The hull, or shell (3), is combined with protein from the germ to make animal feed.

PAINTING BY NATIONAL GEOGRAPHIC ARTIST WILLIAM H. BOND; STATISTICS PROVIDED BY U. S. DEPARTMENT OF AGRICULTURE

Plying a sea of maize, Lloyd Nelsen's combine brings in the harvest, bound for a grain elevator that looms like a cathedral over Ringsted, Iowa. The Midwest yields more than one-third of the world's corn.

meant the Hopi would have a long-lasting but hard life."

The Hopi use corn in several of their ceremonies as the symbolic representation of life. All Hopi children receive their name from their paternal aunts in a ceremony where a perfect ear of white corn, *tsotsmingwu*, is passed four times over a 20-day-old baby while it is fed a blue corn mash holy to the Indians.

"Every year my mother selects the strongest kernels for my husband to plant," said Harold's wife, Linda. "The right to select seed is passed on through the woman's family."

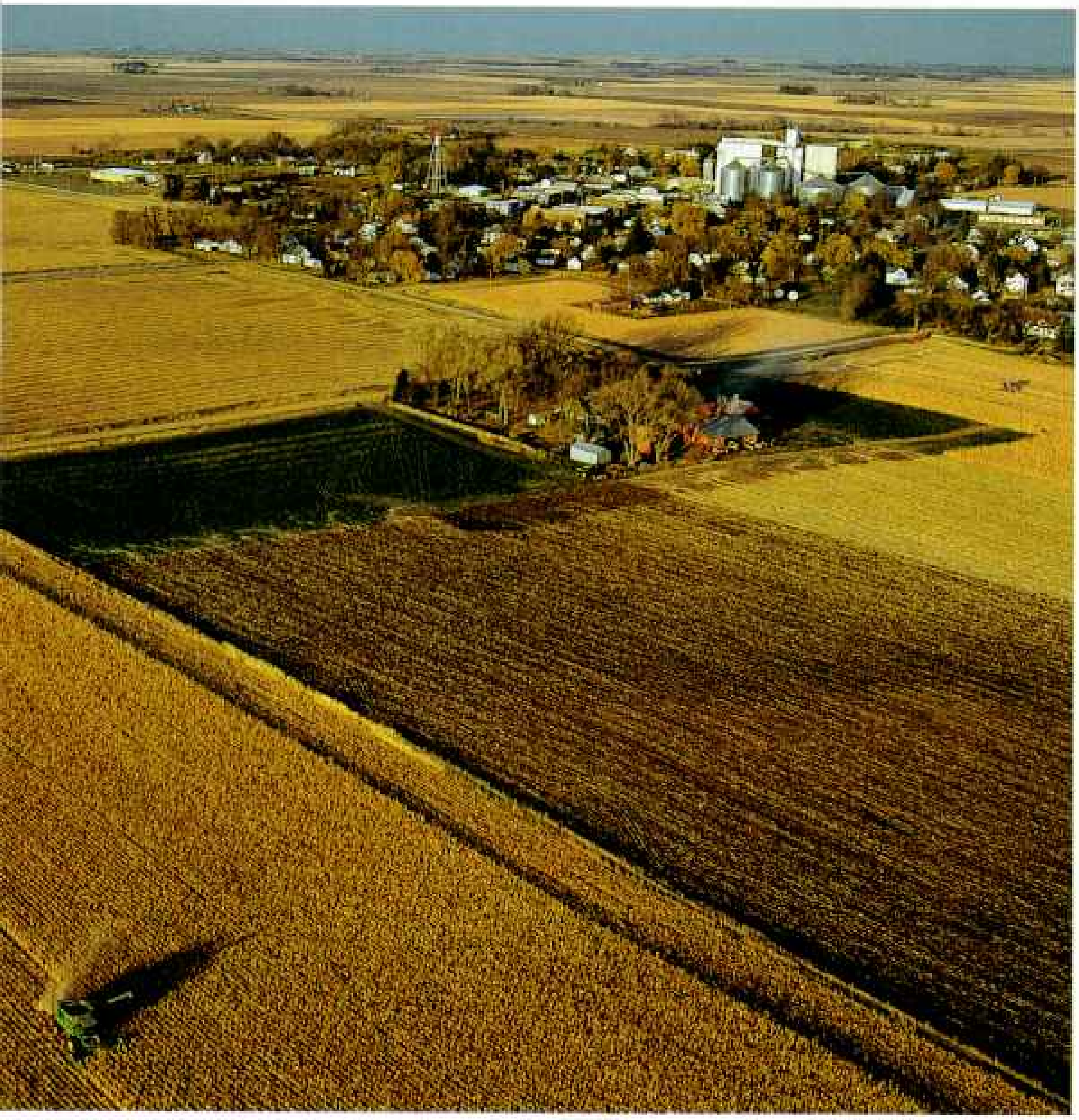
I TRAVELED A WORLD AWAY from the fields of the Hopi to visit a corn refinery in Decatur, Illinois. At the 410-acre facility of the A. E. Staley Manufacturing Company, millions of tons of corn are mashed, soaked, spun, dried, and separated into starch, oil, and meal. Mike "Slim" Slimbarski, the plant manager, shoved a hard hat and protective glasses in my hand and led me down a corridor of gleaming pipes and hissing steam valves.

"They call me the Corn God around here because it's my job to get angry if we don't grind corn—lots of it," Slim said. The smell of corn permeated the air. Slim explained wet milling, the process by which corn is broken down into its component parts.

First, corn kernels are soaked in warm water in huge steeping tanks for 30 to 40 hours. Then the softened kernels are coarsely ground and spun in silver-colored, water-filled separators, where the oil-laden corn germ rises to the top. The remaining starch, gluten, and fiber are ground and separated again; then the starch is dried and set aside or converted into corn sweetener.

From each bushel of corn, Slim's millers can separate 31.5 pounds of starch, 1.6 pounds of corn oil, and 15 pounds of animal feed. The hulls, gluten, meal, and steepwater also go for feed. The germ provides oil for margarine, mayonnaise, salad dressing, sauces, and soups. Cornstarch has become a mainstay of America's food and industrial economy and is used for plugging up the pores in paper and textiles. It is also processed into dextrin for adhesives, syrups, beer; dextrose for peanut butter, canned peaches, hot dogs, baby food; and lactic acid for leather tanning and paint removers.

After I rode a tiny platform elevator 11 stories up through the center of the Staley compound, I could see huge railcars guided by men in hard hats. For wet millers the contents of the tanks are as valuable as gold—each contains 25,000 dollars' worth of a clear, sweet liquid



called high-fructose corn syrup, destined for Smucker's preserves, RC Cola, and Coca-Cola. Converted from cornstarch with a special enzyme, the high-fructose syrup is sweeter than sugar. Its extra sweetness and its price—just below sugar's—have led all the major soft drink companies to use it. High-fructose corn syrup is a multibillion-dollar business and the main reason corn sweeteners control 53 percent of the U. S. sweetener market.

To see Maya Indians working hardscrabble corn plots as they have for centuries, I traveled to Chiapas in southeast Mexico. Newspapers in Mexico City had recently announced, "Mexico Is Self-Sufficient in Maize After 20 Years!"

But in the mountainous rain forests this self-sufficiency is exacting an environmental price. Large ranches and agribusinesses have forced landless peasants from the flatlands onto fragile mountain slopes. With no other recourse, the peasants depend heavily on maize. "Maize is our blood," says Miguel Solis, a 26-year-old farmer from the village of Salto de Agua. "Without it we cannot live."

The farmers' reliance on maize often puts them at odds with a government caught between either feeding its own people or saving

the remaining forests. The peasants slash and burn the forests and sow small fields, or *milpas*. After the protective forest canopy is removed, torrential rains cut deep gullies, washing away topsoil. Only dead, black tree stumps remain.

"Blaming maize for deforestation and soil loss is far too simplistic," says Donald Winkelmann, director of the International Maize and Wheat Improvement Center in El Batán, Mexico. "Population pressure and poverty are the real culprits, and small-scale corn production is the only chance of survival for many Third World populations."

For more than 200 million people in developing nations in Latin America, Africa, and Asia, corn is a staple. Because they cannot afford milk, eggs, or meat and because maize grows in almost any soil, it becomes their main source of protein. But maize, like all cereals, is low in key amino acids.

Scientists knew what a blessing a more nutritious corn could be for those hungry millions. In 1963 researchers at Purdue University stumbled across a naturally occurring mutant with about twice the normal amounts of lysine and tryptophan, two essential amino acids the body needs but cannot make itself.

Named opaque-2 because it was the second mutant found whose kernels were not translucent, it galvanized researchers worldwide. They transferred the opaque-2 gene into local varieties and rushed the crops into production.

But opaque-2 had its problems: Low yields, small ears, and a vulnerability to disease and pests turned farmers against it by the late 1970s. Undaunted by these setbacks, researchers from the El Batán research center eventually developed improved forms of the plant. By the late 1980s successors to opaque-2 were being tested in 40 countries in hopes that they would someday improve nutrition in the developing world.

"We don't need to create a miracle corn; the plant is already a miracle," says 78-year-old Norman E. Borlaug, who developed high-yielding wheat varieties in the sixties. "We simply need to help it realize its potential."

Borlaug won the 1970 Nobel Peace Prize for igniting the green revolution, the era of the 1960s during which improved crops yielded increased tons of grain far beyond researchers' expectations. He believes high-yielding varieties of corn can stimulate a similar food revolution in Africa.

Following in Borlaug's footsteps, corn scientists have developed a broader and straighter leaf to catch more sunlight and a drought-tolerant variety that will increase yields in tropical regions of Africa and Central America. Researchers dream of creating a perennial corn to reduce soil erosion and save farmers the cost of replanting each year and a variety with a gene inserted from a legume to return nitrogen to the soil, which will enrich the earth and reduce the need for fertilizers.

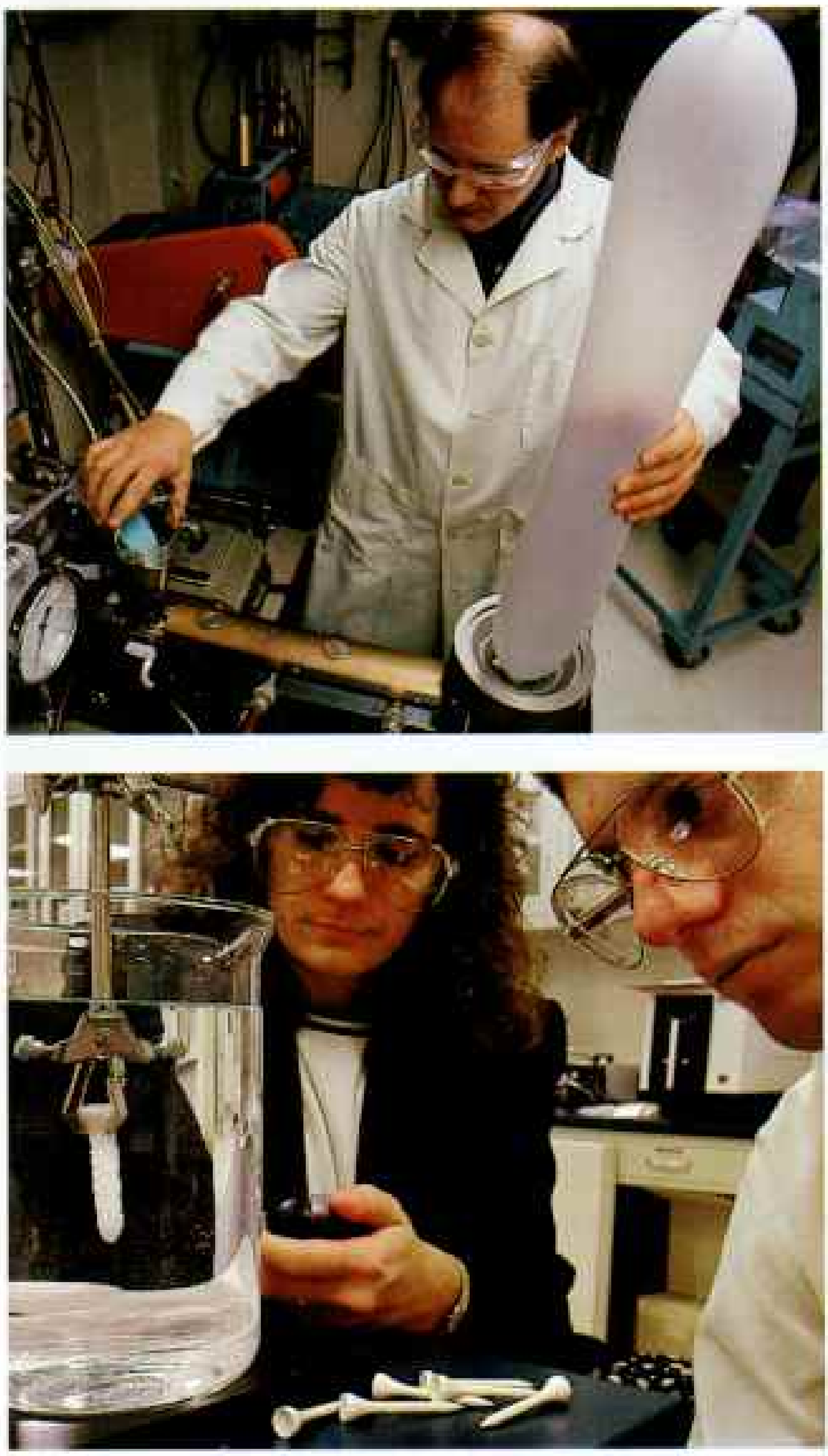
NEAR URUBAMBA, a town close to the Inca city of Machu Picchu, I joined a group of Quechua corn farmers. Eighty-year-old Marcial Querillo, his face wizened from years of working sunbaked hillside fields, offered me *chicha*, the corn beer and royal drink of the Inca. I accepted, my hands cupped and clasped together, my head bowed to show proper respect for *Mama Sara*, or Mother Corn.

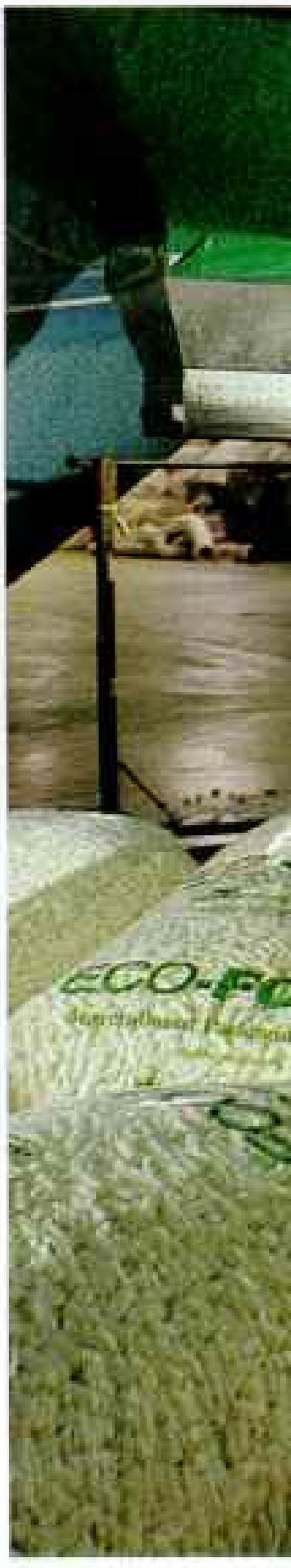
Señor Querillo then performed the *tynka*, an offering to Mother Earth for a bountiful harvest. As he chanted, he lifted his face to the sky and sprinkled the chicha from his cup in the cardinal directions: "To Mother Earth, to the god of wind, god of the mountains, and god of snow. . . ." He ended by pouring the chicha—the Inca's symbolic daughter of the sun—onto the freshly turned soil.

Although the Inca perfected an alcoholic drink that they considered sacred, others with more secular concerns recognized that corn whiskey is cheap and potent. Between 1790 and 1830 the United States was a nation of corn whiskey drinkers, each adult guzzling an average of six gallons a year compared with less than a quart today.

Distillation of white lightning on the early frontier got so out of hand that in 1794 Treasury Secretary Alexander Hamilton joined Gen. Light-Horse Harry Lee (Robert E. Lee's father) and 13,000 troops to put down a backwoods rebellion of tax-defying whiskey makers, the Whiskey Boys of western Pennsylvania. President Thomas Jefferson persuaded Congress to lift the whiskey tax in 1802, dealing a tough blow to rum, which had been colonial America's number one hard liquor. Today's most popular liquor in the U. S. is vodka, followed by Canadian whisky, then cordials. The corn-based drink, bourbon whiskey, has fallen to number four.

As corny as it gets, a mascot named Cornelius (above) cheers on South Dakota's Mitchell High School Kernels (6-4 last year). "It's one of the healthiest foods we've got," says popcorn magnate Orville Redenbacher, whose 85 birthdays make a good case. The former county agent took 24 years to breed his gourmet strain, offered by Samantha Haller at the annual Valparaiso, Indiana, popcorn fest.





A few new tricks

Biodegradable packing made of cornstarch (right) could challenge petroleum-based polystyrene—if production costs can be reduced. Cornstarch golf tees (bottom left), tested in the New Jersey labs of Novon Products, dissolve in rain. On the horizon are disposable cornstarch eating utensils. Corn-based products need additives for strength and flexibility. At a USDA lab (top left), technician Richard Haig makes an experimental film for use as mulch.

DRIVING ACROSS the wheat fields of Kansas, I catch myself singing a Rodgers and Hammerstein line, "I'm as corny as Kansas in August." Why is it that our noble corn, the Native Americans' deity of old, is always getting the put-down? Why is someone a "cornball" and not a "wheatball," and bad jokes are "corny," not "ricey"?

During the 1930s "corny" and "corn-fed" cropped up in American slang as pejorative designations for unsophisticated, corn-eating folks. Jazz critics began characterizing out-of-date music as "corn-fed." Later W. H. Auden castigated "minor devils . . . Grown insolent and fat / On cheesy literature / And corny dramas." It's been said that "corny" comes from "corn-fed," like the rural audiences that traveling musicians found to be hefty and easily pleased.

In the late forties as a child growing up on a farm in Oklahoma, I remember running for cover through make-believe trenches between cornstalks, barely escaping turkey-feathered corncob darts lobbed with deadly accuracy by my older brother. In calmer moments we would head for the fishing hole, where we'd bait our hooks with kernels and use a broken cob as a bobber.

Partly for nostalgic reasons, certainly it wasn't wise economics, I bought a farm in Oklahoma a few years ago. The place was still eroded and washed-out from Dust Bowl days. It came complete with a John Deere tractor,

vintage 1947. Cleaning out the storm cellar in the spring, I discovered a canning jar containing red corn seed. It looked as if it had been sealed for decades, left behind, perhaps, when a family sold out and headed for California in the 1950s.

With the old tractor I broke up the better part of an acre to plant the old seeds—the first corn crop on the old place in years. The rains came, smelling sweet as they soaked the red earth. The corn sprouted proudly, like a stranger returned home.

"Why, that's Bloody Butcher, a hardy corn that grew up in the Missouri Valley in the 1890s," said Carl "White Eagle" Barnes, who has been collecting corn seeds since the 1940s. A native Oklahoman of Cherokee ancestry, he is dedicated to saving endangered corn varieties like this one. "Mighty important corn in the history of our country. Butcher helped pave the way for use of hybrid corn in the corn belt."

I filled with pride on learning that Henry A. Wallace, founder of Pioneer Seed Company and later Vice President under Franklin D. Roosevelt, crossed Butcher with a hardy line called Leaming to produce one of the first commercial hybrid corns. The result was a misshapen reddish corn called Copper Cross. It won the gold medal at the Iowa Corn Yield Test in 1924, showing farmers that there might be something to Wallace's hybrids after all. Hybrids have an advantage over older varieties because they are deliberately crossbred for

high yield, uniformity, and characteristics such as drought tolerance and pest resistance, whereas traditional strains result from the random crossing of attributes, as the wind blows pollen from one plant to another.

No longer must scientists rely solely on crossing and recrossing varieties, studying generations of plants for years to find the highest yielding or the sturdiest, most disease-resistant corn. Using techniques of molecular biology, they can extract segments of DNA from a variety of organisms, identify those genes with favorable characteristics, and splice them into the genetic material of corn plants.

To see how corn is studied from the inside out, I visited Pioneer Hi-Bred International's plant-breeding laboratory in Johnston, Iowa. Located on the same land where young Wallace planted his hybrid corn seven decades ago, Pioneer is the world's largest seed company, controlling almost 40 percent of the U. S. seed-corn market and selling more than a billion dollars' worth of products annually.

"Venture capitalists and farmers are really excited about genetically engineered corn," says John Howard, head of Pioneer's biotechnology section. He shows me corn that only ten years ago would have been science fiction.

Several corn plants contain a gene from a wheat plant that is toxic to the infamous European corn borer, *Ostrinia nubilalis*, a moth whose larvae cause an estimated 800 million dollars' worth of damage to U. S. corn crops each year. If this experiment with the wheat gene succeeds, the corn will, in effect, manufacture its own pesticide. At Pioneer and elsewhere, scientists are also working on other disease- and pest-resistant varieties.

"The truth is that Native Americans made most of the major genetic changes in corn ages ago," says Dwight Tomes, then technology director of Pioneer's corn transformation department. "What we are doing is fine-tuning the plant. Corn is still corn."

THE INDUSTRIAL landscape of northern New Jersey is a far cry from the endless cornfields of America's heartland, but it is here that "eco-entrepreneurs" who say they are "into" cornstarch come up with some of the newest applications for America's native grain.

"We sit around thinking of all the neat things that can be made with cornstarch: shotgun shells, fishing lures, toys, golf tees—hundreds of goodies!" says Steve Mojo, a market-development director at Novon Products, a division of Warner-Lambert created exclusively for the production of biodegradable polymers—materials made from corn or potato starch that decompose harmlessly when exposed to soil and water.

"We test to make sure our polymers are truly biodegradable," Mojo tells me, as he displays cornstarch diapers, ear swabs, and cereal-box liners. He places a cornstarch fork in a glass of water, where it promptly disintegrates. That's good for the environment, of course, but perhaps not for business. Fortunately Mojo's company has since perfected a line of cornstarch utensils that won't melt in your mouth.

Other cornstarch products have their origin in experiments like those conducted at National Starch and Chemical Company. A few years back researchers there were trying to develop a new corn snack and ran some cornstarch through a machine called an extruder. The blobs of starch looked an awful lot like polystyrene packing peanuts. With a little modifying, the researchers created Eco-Foam, a biodegradable loose-fill packing that is 95 percent cornstarch. Last year a company called American Excelsior sold four million dollars' worth of Eco-Foam to businesses such as Eastman Kodak and Amway.

"A few years ago so-called biodegradable products got a black eye when they didn't degrade completely," Mojo says. "We need to get rid of our waste more intelligently, and corn is one of the answers."

When I point out that things do not readily degrade in landfills, Peter Salis, a vice president at National Starch and Chemical, says the solution is municipal compost facilities similar to those in the Netherlands, where as much as 25 percent of biodegradable household wastes are composted and sold as humus to farmers. It's not a completely utopian idea—even New York City has begun building compost facilities for its degradable waste. National Starch also suggests that products like Eco-Foam aren't meant to reach your garbage can. Throw the starch peanuts on your lawn, in your vegetable garden, or on your compost pile, and they will disappear into the earth with the first rain or pass from a sprinkler hose.

In search of new parasite-resistant breeds, a geneticist at the International Maize and Wheat Improvement Center in Mexico inspects a segment of corn DNA (above). This is an early step in mapping a breed's genetic code. Ultraviolet light reveals aflatoxin, a mold byproduct known to cause cancer in animals, fluorescing on dent corn and in test tubes (below). A 1988 U. S. outbreak tainted tens of millions of bushels.

Maya tradition says the human race sprang from maize, and the grain is used in rites merging Maya and Catholic symbols. Mystical or mundane, corn is sold at the Sololá market (above), where farmers await customers like Leona Bocel Coj (right, foreground), who with her sister-in-law Marta makes corn tortillas.

I SUPPOSE THOSE STARCH PEANUTS are edible, but they can't compare with the wonderful taste of fresh sweet corn. At the Annual Sweetcorn Festival in Urbana, Illinois, 18,000 hungry people watch the husking and steaming of 20,000 ears of corn.

While the smell of steamed corn and butter fills the air, the crowds cheer local celebrities in the corn-eating contest. Yet, among these thousands of sweet-corn connoisseurs, I can't find one who's ever raised an ear. Even in the corn belt—which covers most of middle America from Ohio to Nebraska, from Minnesota to Missouri—the family corn farm is a disappearing way of life.

Head south, I'm told, and if you're lucky you might meet a Mennonite or Amish farmer who still farms the old way. Instead I meet Elva Gingerich, a Mennonite whose family farms 6,000 acres the new way near Arthur, Illinois. They use enormous, air-conditioned corn combines purchased at $120,000 each, and Gingerich chuckles softly when I ask him about finding an old-fashioned husking bee. "No one does that any more," he says. "Corn is no longer a way of life; it's big business."

But out on Route 133, west of Arthur, I find Daniel Kaufman, an 87-year-old Amish tending sweet corn in a garden next to a barn. His family still farms the old way. But, "even our Amish people have had to change with the times," he says. "It's not like when I was young and we did everything by hand and with horses."

Many of the Amish in the corn belt still shun artificial fertilizers and tractors. Kaufman's son-in-law and grandson can harvest eight to ten acres of corn a day. For their non-Amish neighbors it takes about an hour to do the same work, using modern machinery.

Early one morning I drive along an empty highway smack in the middle of the corn belt and head for a café called Dutch Diner on Main Street in Tampico, Illinois. As the sun rises over desiccated cornfields, waves of early morning heat ripple on the horizon—another dry year.

The café fills with farmers, big men with strong hands and faces tanned up to the browline. Coffee is served up, and the farmers of Tampico waste no time telling me about how dry it is. "Gettin' so hot out there that corn is starting to pop in the field," Harry Thompson says, pulling up a chair.

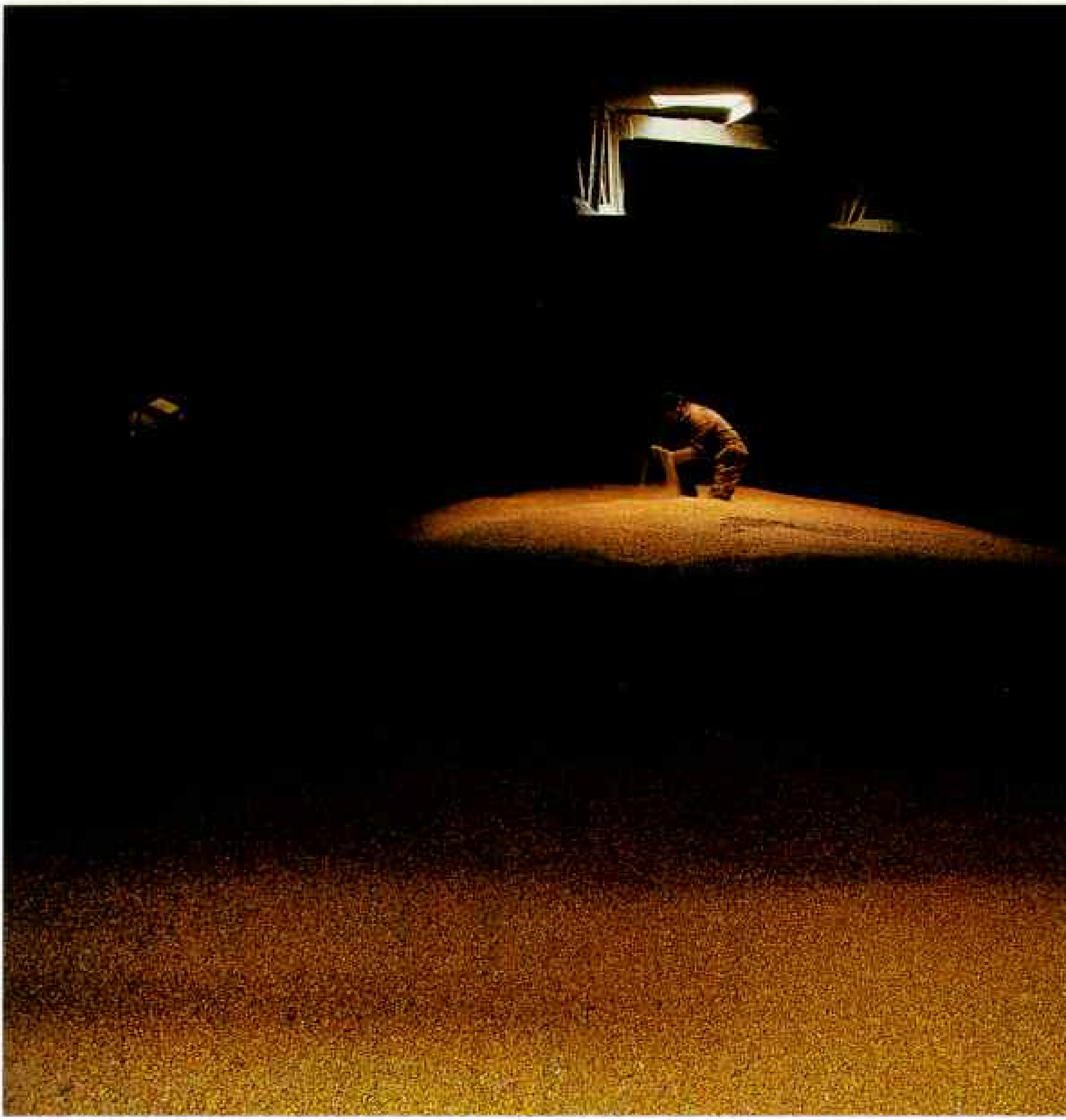
Their heat is aimed at bureaucrats and politicians who set farm policy in Washington. Thompson, now retired, complains, "Back in 1947, when I just started farming, we got $2.38 a bushel; this year we might get $2.40."

"Yeah, I'm still paying for the drought in 1988," says Steve Mickley, a 36-year-old who farms 700 acres. That drought dried up nearly 40 percent of the U. S. corn harvest, wiping out seven billion dollars' worth of crops.

Steve and I walk out of the café, down the still, empty street, past the house where President Ronald Reagan was born. Parked on the far side of a grain elevator is a red pickup with

Mosaics on the Corn Palace at Mitchell, South Dakota, are a hundred-year-old tradition. Every September some 20,000 ears of varying colors are stapled and

nailed to create images like this Native American dancer, designed by artist Oscar Howe in 1962. Tourists flock to Mitchell's homegrown spectacle. So do pigeons.



an aging bumper sticker: "Save the American Farm, Export Reagan." Next to it, "Don't Be a Scud, Be a Patriot, Use Ethanol."

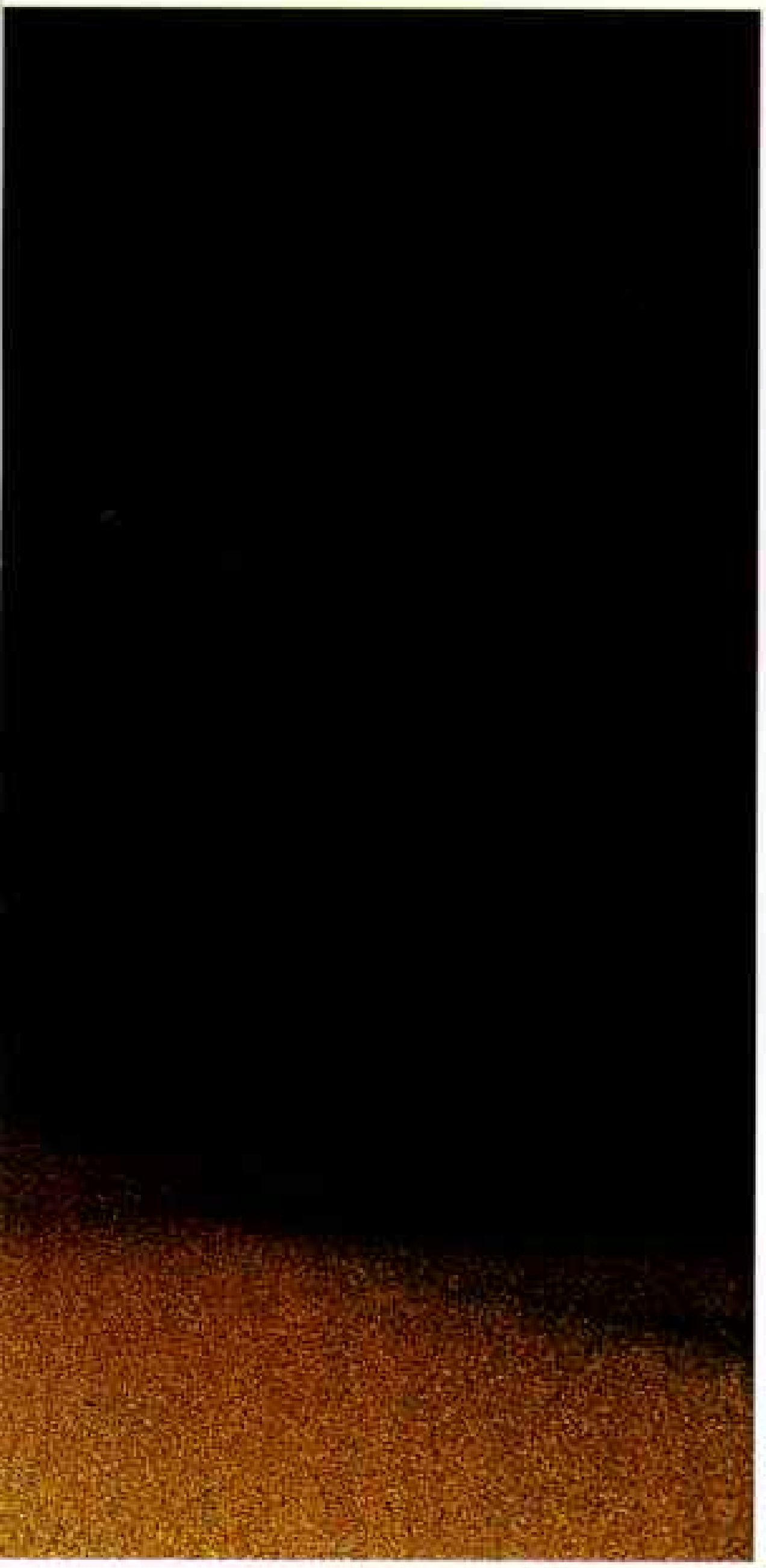
Every day Steve monitors corn prices and foreign affairs on his computer. He hits a key, and the corn prices for the next ten months appear. He hits the key again to come up with this week's agronomy tips.

"Think I'll sell in December," he says, "but that'll depend on what we hear about how much the Russians are buying."

To discover the origin of the prices that flash across Steve's computer screen and thousands of others like it, I went to Chicago and headed straight for the corner of LaSalle and Jackson. There stands the 45-story Chicago Board of Trade building, crowned with a 31-foot, art deco statue of Ceres, the Roman goddess of agriculture, a sheaf of wheat in her left hand, a sack of grain in her right.

Inside, a thousand traders stood shoulder to shoulder in octagonal pits—for trading soybeans, oats, wheat, corn—or milled about the floor of the agricultural exchange, a place half the size of a football field.

Promptly at 9:30 a.m. the gong signaling the opening of trade rang out, and grown men and women shouted, jumped up and down,



An inspector checks moisture in nearly a half million bushels awaiting export in Champaign, Illinois. Its beginnings shrouded in myth, corn still takes new forms through the collaboration of time, nature, and human genius.

grimaced, threw paper, and waved their hands, frantically buying and selling grain contracts. I wondered how they kept from fighting one another. Runners scurried to pick up slips of paper, which noted who made each trade and for how much. Commodity prices established by the trades flashed across three big boards above the floor.

I made my way to a spot near the corn pit. "This is a *slow* day," said Joel Jacobson, a husky, bearded fellow who has worked as an independent trader for 23 years. "I prefer the corn pit; it's less physical than the soybean pit. Corn traders are more gentlemanly. Soybeans came onto the market years after corn and have been dominated by younger, more aggressive traders."

I climbed up to the market pulpit overlooking the corn pit, where Joel was just another face in a crowd of 200. Although the scene looked like nothing but chaos, the trading system has worked for more than a hundred years. Each trader acts as his own auctioneer, using hand signals and shouts to indicate his price and whether he's buying or selling. Market reporters in the pulpit record the price changes.

To reduce the risk of having to sell his corn when prices are low, a farmer can sell a futures contract months before the harvest. Such contracts are often purchased by independent traders who hope to make a profit from price fluctuations. These speculators very rarely accept or make a delivery of corn.

AS I FLEW OVER ILLINOIS, where the neat rectangular fields would soon be greening with a new year's corn crop, my thoughts drifted back across my journey. Although corn touches our lives in so many ways, it no longer has the meaning it once had for the Native American and the frontier pioneer.

Almost 60 years ago Henry Wallace, then secretary of agriculture, returned to his alma mater, Iowa State College, to give a speech lamenting Americans' ignorance of his favorite subject.

"It is to be regretted that . . . millions whose prosperity rests on the corn plant should have so little appreciation or knowledge of it," he said. "Even those who work most with corn display little of the genuine reverence for it which characterized the majority of the corn growing Indians up until this century."

Then again, who's to say some anthropologist won't think we appreciated corn—maybe even worshiped it—when he unearths an Eco-Foam nugget from a landfill a thousand years hence? □

BANGLADESH

When the Water Comes

Passing paddies submerged by monsoon floods, villagers of Nishantapur slog over land that is both enriched and imperiled by the raging waters their nation struggles to tame.

By CHARLES E. COBB, JR.

Photographs by JAMES P. BLAIR
BOTH NATIONAL GEOGRAPHIC STAFF

WANTON RIVER Swollen by June-through-September monsoon rainfall, the huge Jamuna (Brahmaputra), at top right, annually spills over its banks. The spreading waters carve into cropland and lap at huts crowded onto higher ground. As it recedes, the river leaves silt and algae, which nourish crops.

BANGLADESH is a country that floats. It sits atop one of the world's largest river deltas, a vast floodplain where the Ganges, Jamuna (Brahmaputra), Padma, and Meghna Rivers and their myriad tributaries interlace across terrain only a few feet above sea level. Water completely defines Bangladesh. Every year floods sweep across much of the land. Catastrophic tropical cyclones bring storm surges as well as murderous winds. Yet the power of the water to destroy is almost equally matched by its power to create.

I began to understand this on a *char*, a sort of pancake of land, in the middle of the Jamuna River. Chars change shape continually as the rivers move silt—two billion tons a year—into the Bay of Bengal. During flood season most chars rise only a foot or so above the water. Almost always they disappear within a decade.

Yet many people have no choice but to live on these temporary islands: Bangladesh is among the most densely populated countries in the world, with 2,000 people per square mile (a density comparable to putting half the population of the United States into the state of Wisconsin). And at the current growth rate, the population will double in 30 years. Many people told me that despite the risk, they prefer chars to the squalid, crowded city slums.

Manushmara char was only 2,000 feet long and 70 feet wide, yet 475 families lived there. "At least on a char you can own something," one resident, a man named Nazabuddin, told me matter-of-factly.

On another char, near the confluence of five rivers, a man named Abdul Aziz took me to the water's edge. Great cracks ran from the bank back toward a small settlement. Chunks of land crumbled into the water. The children made a game of timing the disintegration, and they plunged laughing into the river along with the falling soil. "In one week a hundred meters has gone," Aziz said with a sigh.

Before a char is engulfed, its residents must look for another. "I don't know how long I'll stay here," Nazabuddin told me on Manushmara. "It all depends on the river."

Land is the real hunger in Bangladesh. Eighty percent of Bangladesh's population is rural. Sixty percent is landless. Just 10 percent of rural households possess more than 50 percent of the arable land. And Bangladesh is one of the world's poorest nations. Per capita income is $200. Only 30 percent of men and 19 percent of women are literate. Sixty percent of children are malnourished. Infant mortality is 120 per 1,000 live births.

This is a country in which any problem inevitably assumes overwhelming proportions. And of all the natural disasters that hit—floods, drought, earthquakes, and tornadoes—cyclones may be the worst of all.

Bangladesh sits at the head of the Bay of Bengal, directly in the path of some of the world's most powerful tropical storms (maps, pages 124-5). During the past 32 years, 16 devastating cyclones (winds in excess of 75 miles an hour) have slammed into Bangladesh. Over the bay, usually during the spring and fall, swirling tropical depressions form, which can sometimes become cyclones right on the doorstep of Bangladesh.

In 1991 a cyclone and accompanying storm surge killed an estimated 139,000 people. It left perhaps ten million homeless. That was a "super" cyclone, as A. M. Choudhury of the Space Research and Remote Sensing Organization calls it, "equivalent to several thousand atom bombs of megaton strength."

THE ISLANDS in the Bay of Bengal bear the brunt of such cyclones. Like chars, these islands are densely populated, but they are more stable. Here energetic shrimp fishermen and rice farmers produce for commercial as well as local consumption.

The temperature had reached 95 degrees when I took a boat to Maiskhal, one of the larger islands, where 9,000 residents had been killed in 1991. After greeting me, Nurul Huda Khan lopped the top off a green coconut and offered me its cool refreshing water. I eagerly took it. Oh yes, he said, he remembered the night of the cyclone. "The sky became so red that one would imagine there was a big fire in the sky."

Shajatdul Karim, 27, recalled that he was tutoring students at home when "a breeze started." But he "didn't give it a thought." Then suddenly part of his roof blew off, and as the wind grew ferocious, he and his family fled to a nearby concrete house.

Today Karim's island doesn't look as if it had been devastated by a cyclone. The rubble has been cleared. Small gardens worked by women are planted with peppers, tomatoes, radishes, and cauliflower. Almost all the men on Maiskhal fish. As I watched, many were hard at work repairing their boats and *jaals*, or fishing nets. But the island still has not recovered. "The growth of coconut is not good now. Too small," one man complained. "And this is the mango season. Look around. There are hardly any mangoes." Tests showed dramatic increases in soil salinity everywhere, though agricultural officials note that the salt content in well-drained soil is dropping quickly.

I heard many conflicting views on whether the nation's complex ten-level cyclone warning system is effective and various opinions on how better to manage the aftermath of the fury. But on one point everyone agrees. The difference between life and death in a severe cyclone is shelter. In low-lying coastal areas storm surges, not wind, are the real danger, and the many flimsy huts of mud and grass are no protection from killer water. "When it hits," said Abu Sayed, "there is no time at all. You are barely out of the house before the water comes and takes you."

Maiskhal has three massive cyclone shelters, two-story concrete structures built on pylons able to shelter from 2,000 to 3,000 people. How big a difference can they make? In 1970 a cyclone killed everyone on nearby Sonadia Island. Then a shelter was built, luckily before the cyclone of 1991, which all 650 residents survived.

"It is a fact that because of that shelter many people were saved," 25-year-old Taher Faruqui told me when I visited Sonadia. "The wind came up strong that night, and its sound was like an airplane." He immediately raced to the shelter on the other side of the island. Others waited, however, not believing that the cyclone would be that bad. Some managed to escape the rising water by climbing trees.

About 300 shelters have been built in the coastal region; officials think around 3,000 are needed. Why haven't they been built? Lack of money is one reason. Shelters cost from $60,000 to $120,000. As Marcel Fortier of the International Federation of Red Cross and Red Crescent Societies put it, Bangladesh is a country where "every problem is enormous, but not the resources." So, little priority has been given to building cyclone shelters.

At the urging of the United Nations, a construction program was begun after the 1970 cyclone. However, the effort slowed as the memory dimmed of how terrible that cyclone had been. "We did not know how many shelters there were," Dr. Choudhury told me. "Then this cyclone came, and we found only a few." After the 1991 disaster, construction began on 200 shelters, and 340 more are proposed. Private relief agencies and foreign governments pay for building most of the cyclone shelters. But their resources are limited too. It seems likely that another cyclone will arrive before enough shelters go up.

Flood control, more than shelter building, is what dominates official concern and public expenditure. Floods affect the cities, the rich as well as the poor, industry as well as peasant plots. And the floods come each year.

"The river wanders this way and breaks that way—that is the river's play." So goes an old Bengali folk song. Although the nation of Bangladesh is just 21 years old, Bengali

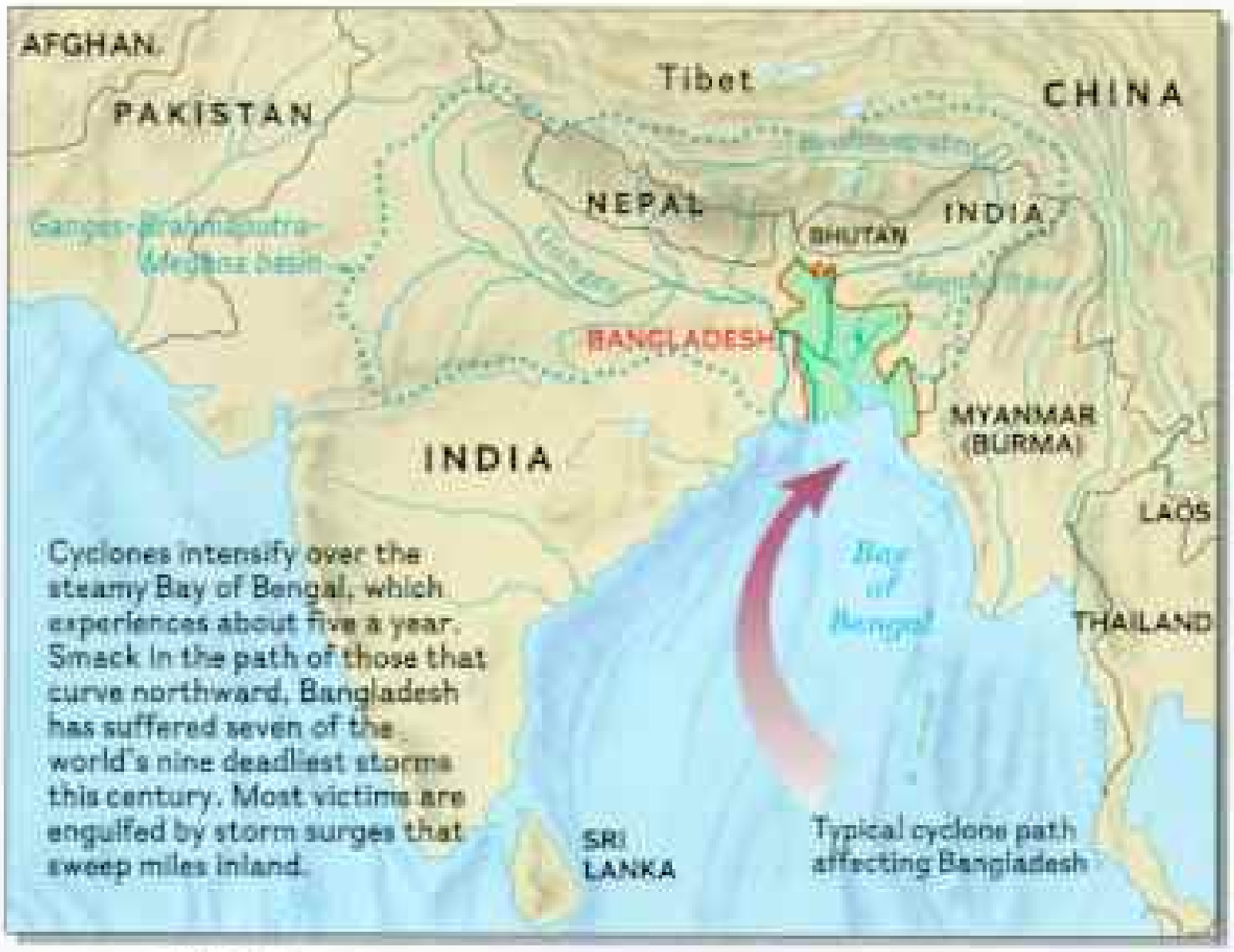
DAILY STRUGGLE Wearing a cane *mathal* to shield against rain, this survivor of the 1991 cyclone that killed 139,000 people waits in line for relief supplies on South Hatia Island. Prone to both cyclones and floods, Bangladesh yearly relies on some two billion dollars in foreign aid.

Profile of a liquid land

If the Himalaya are the "roof of the world," then Bangladesh—prostrate at their base—is the drain. Making up only 8 percent of the 600,000-square-mile Ganges-Brahmaputra-Meghna basin (blue outline, right), Bangladesh funnels nearly all the outflow to the Bay of Bengal. Fed by Himalayan snowmelt and copious rains, Bangladesh's great rivers race southward, slicing off chunks of precious land and flooding one-fifth of the nation annually.

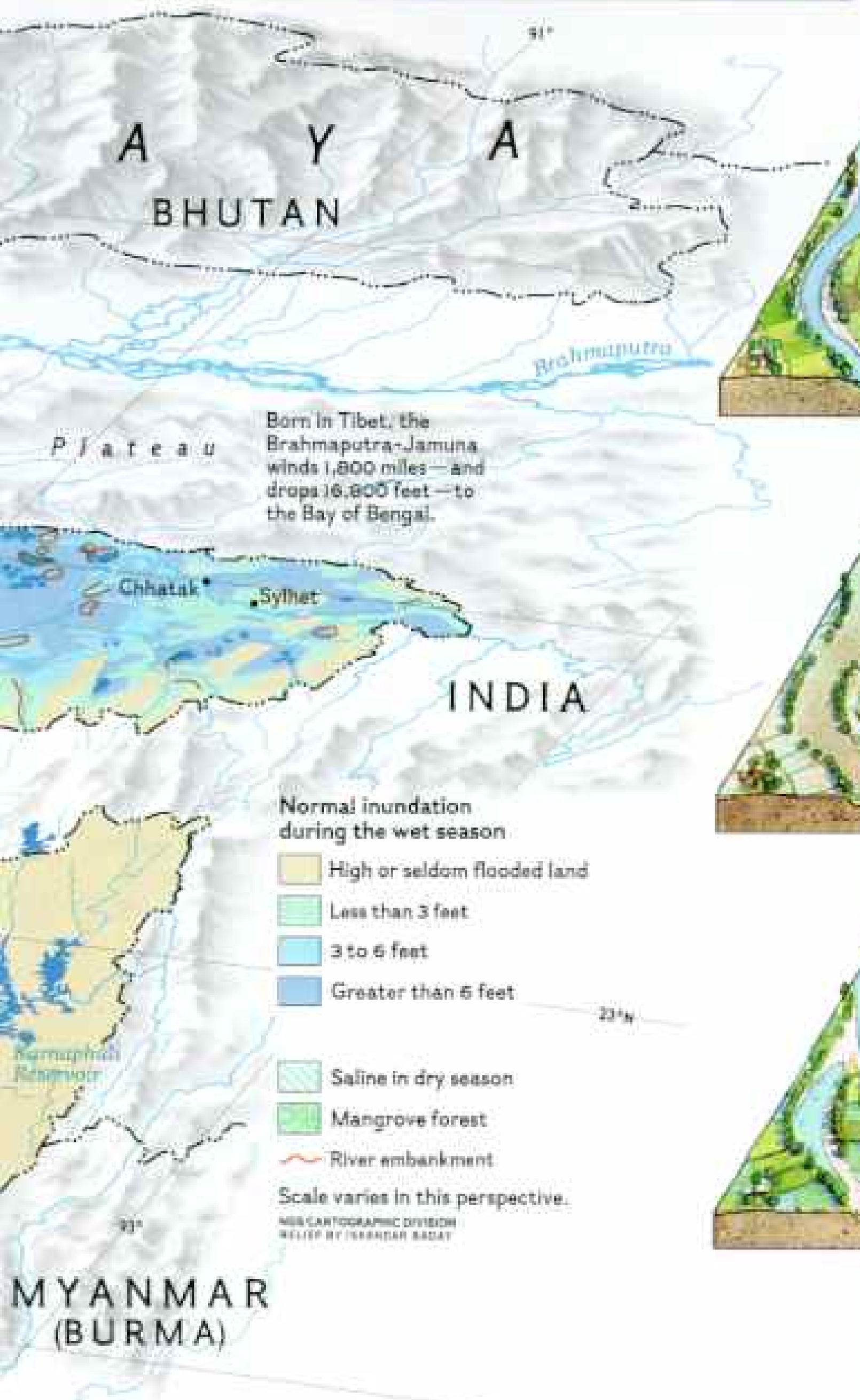
The country's burden is also its lifeblood. Bangladeshis rely on the flooding to renew fish stocks, groundwater, and soil. Carrying two billion tons of fertile silt a year, the rivers help balance erosion by forming new land through silt accretion.

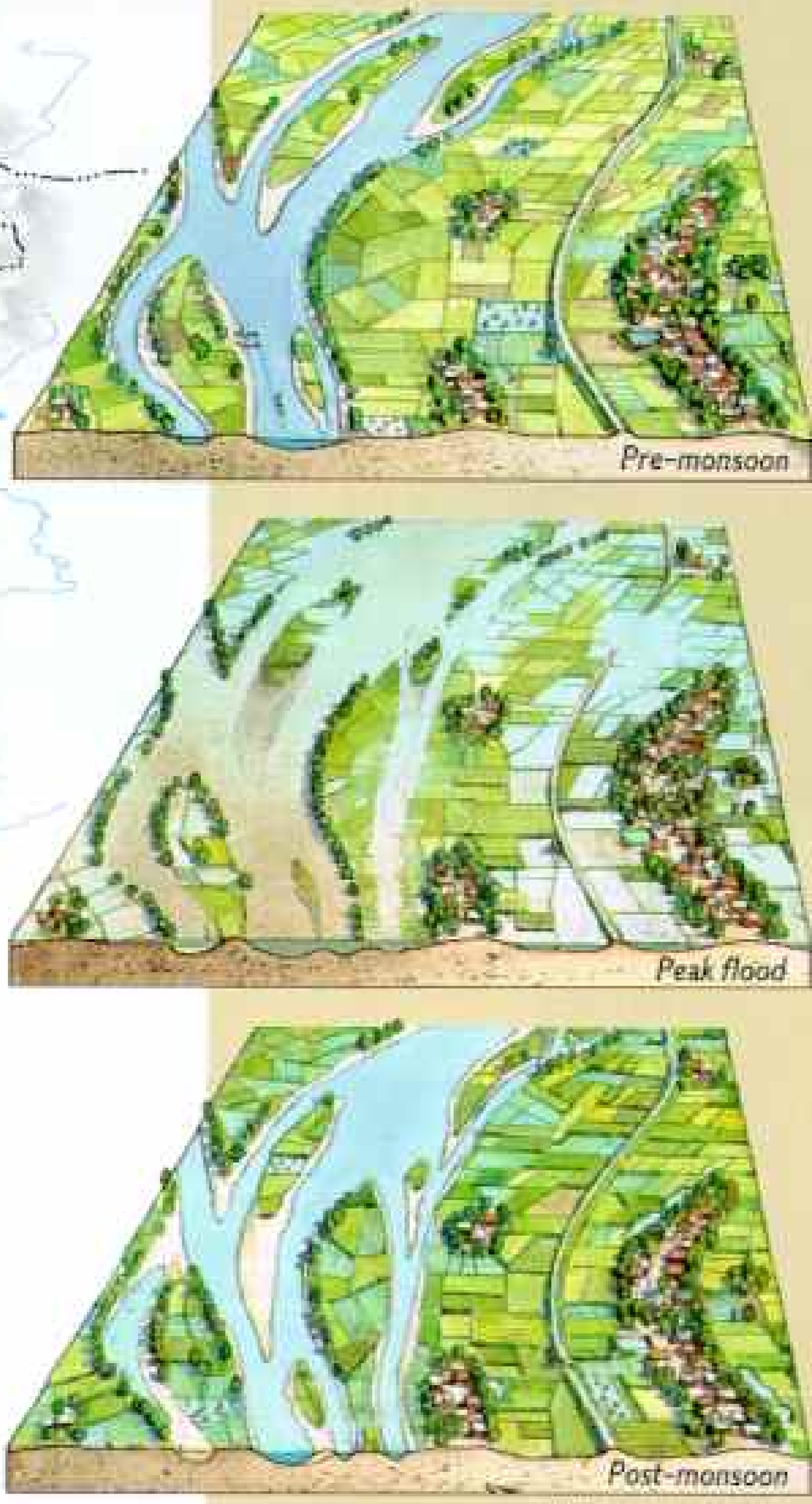
Efforts to control flooding and flow with embankments can upset this balance—and are often futile. Willful rivers have breached much of the 2,500 miles of embankments already built. Bangladeshis remain at the mercy of the waters that daily redraw their map.



An endless harvest

"Green and gold mingle here, and caress the sheaf of new harvest round the gracious year," writes Bengali poet Imran Noor. Flooding and irrigation enable year-round cropping of rice and winter vegetables in much of Bangladesh. Rivers replenish, but they also resew the patchwork of paddies, villages, and roads—and farmers must adapt. A flood might carve new channels, erode land upriver, accrete soil downstream, and leave fish-filled oxbow lakes.





PAINTING BY RICHARD SCHLECHT

civilization spans more than 2,000 years. Bengalis learned long ago that the main currents affecting the flow of their lives are those of the rivers.

Many sections of land are like saucers, with riverbanks forming their rims. Silt raises the riverbeds, not only creating chars but also causing the rivers to spill over their banks, sometimes carving out a new course. The resulting floodplains make Bangladesh one of the most fertile nations in the world. Everywhere among the meandering rivers are bountiful fields. Bangladeshis call their land *sonar Bangla*, or golden Bengal, for the gold of ripening paddies.

In many places peasant farmers grow three rice crops a year, thanks to a combination of hard work, river-brought fertility, and high-yield rice introduced by international aid agencies. "In rice we are definitely self-sufficient," says Ken Moots of the International Fertilizer Development Center, which has been assisting Bangladesh with food production for more than a decade. "Farmers are growing more than they can sell."

When the rivers swell with monsoon rains and snowmelt from the mountains of India and Nepal, much of the land goes underwater. Villagers wait for the water to subside, then plant again. The most important thing I learned in Bangladesh was how rain and river recycle life.

"To understand Bangladesh, you must understand our rivers," my friend Mishu Kabir told me. He is a newspaper editor, shrimp exporter, building-materials supplier, and tea grower. The rivers form a vast transportation network for the entire country. Huge rafts float bamboo and jute. Other watercraft carry rice, wheat, wood for fuel, coal for waterside brickmaking kilns. And, of course, people travel in boats of all kinds. The waterways offer better connections than Bangladesh's limited road system. And so I was traveling with Mishu up the Meghna River to Chhatak just below India.

About two hours out from the port town of Bhairab Bazar, our boat ran aground. "Do

TERRA INFIRMA Sustenance for the land-starved, a silt island, or *char*, formed of Jamuna River sediments lies muddied by flooding (left). Perhaps as many as five million people live on such fickle isles, which may linger 30 years or vanish in months. Riverbanks are scarcely more stable. At Sadullapur (top) the Meghna River ate away 200 feet of earth in ten days. Left with little but an umbrella, Mono Mia, 55, lost the sliver of land that sustained his family. "I can't think exactly of what I am going to do."

you realize we've been traveling over rice fields?" he laughed.

Roads and rice fields were underwater. Here and there clusters of small huts huddled on tiny patches of higher ground. Every so often a tree or a telephone pole jutted out of the water.

The monsoon rains had come, and even the river—one of the mightiest in Bangladesh—was underwater. It had vanished. The Meghna depression had become a freshwater sea as far as you could see. Ill-kept channel markers were of little help.

Eventually a local fisherman, Rajendra Chandra Das, climbed aboard and guided us to safe anchorage. When I commented on how much water there was, he answered casually, "There is not much water this year."

All day I had been traveling across flooded rice fields, and in my mind that added up to catastrophe, disaster. But to Rajendra the flood meant good things: the chance to use his boat to visit neighboring villages, rather than walking all day; an abundance of fish; and sediment left behind that makes the land bountiful and gives him the chance to grow his own rice. "Such water," he said, "what the Lord has given us."

Sometimes, though, monsoon rains combine with massive flows from the rivers that begin in the mountain watershed. Then the floods indeed become calamitous, especially if the rivers fill up simultaneously. "These are the floods we worry about," said Tauhidul Anwar Khan of the Ministry of Irrigation, Water Development, and Flood Control.

"If the water comes all of a sudden, everything is gone," a villager told me. "Everything" means the meager possessions that villagers have managed to acquire: clothing, utensils, perhaps a treasured photograph or letter. Often whole homes are swept away.

In 1988 water engulfed the country as the Ganges, Jamuna, and Padma Rivers reached their flood peaks within days of each other. Two-thirds of Bangladesh was submerged for six weeks. Badly hit was the city of Chandpur on the banks of the Meghna, downstream of its confluence with the swollen Padma.

"People were shouting and screaming that the river was breaking fast . . . just like people shout when a house is on fire," recalled 28-year-old Ahad Ali, who was living in Chandpur at the time.

Danger had been evident for days: faster, angrier water and increasing erosion. Ali and his mother left to look over a possible new homesite on higher ground more than a mile away. His little sister stayed behind. "She released the cows," he told me, "and she thought that if the cows were saved, she would be saved. So she tried to ride out on one of the cows, neighbors say."

Ali never saw her again. "There was no chance to even look and see where she would be. The river kept flowing on." Since then, he told me, his mother has moved across the country, trying to put the sad memory behind her. "She has never been back."

FOR ALL THE DRAMA of high waters, it is erosion that takes a daily toll of land. Rushing rivers continually chip away at shorelines and undermine earthen embankments, literally breaking up communities.

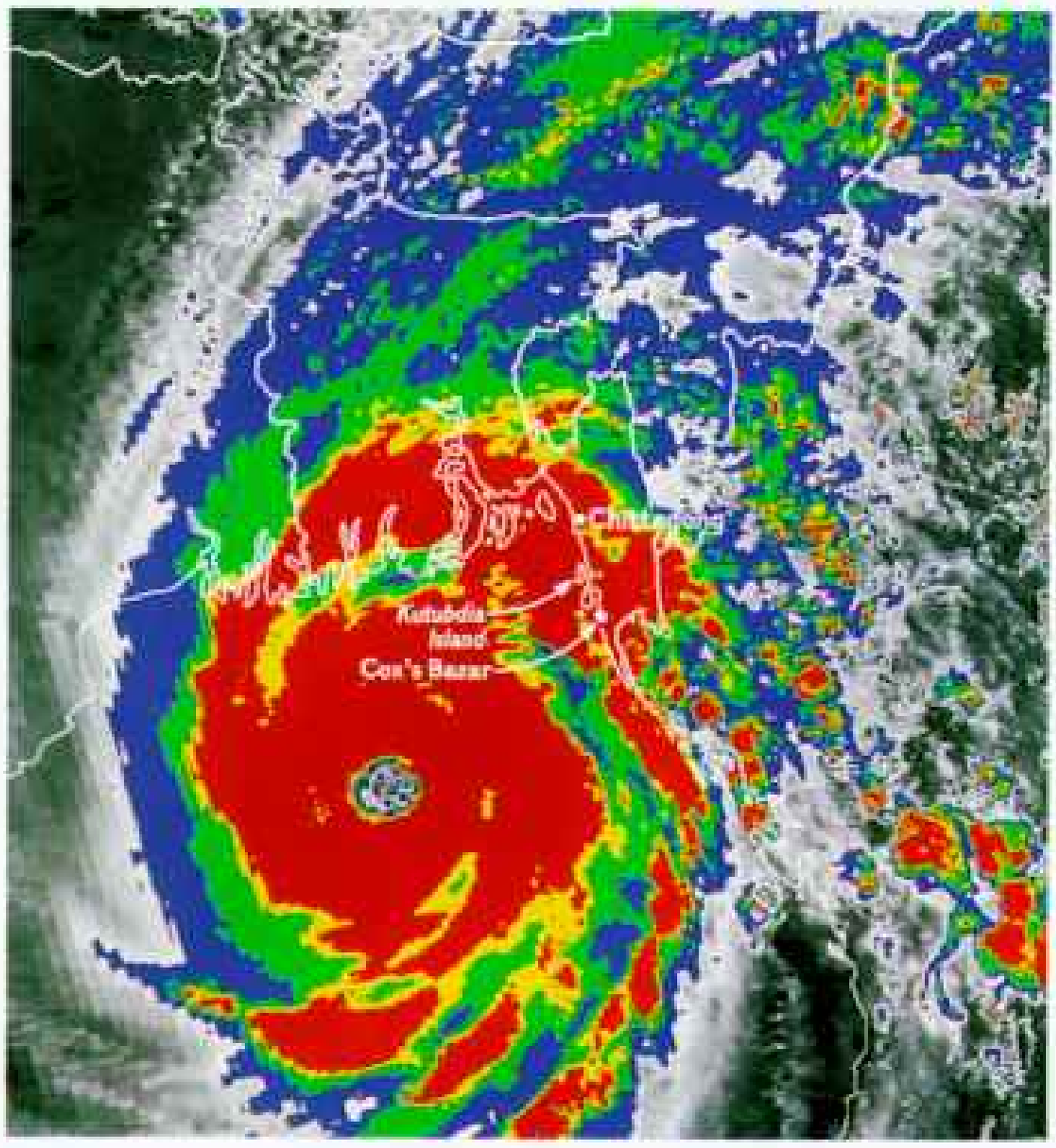
When the flooding Meghna River changed course in 1988, it cut a new channel 40 yards deep at one end of Chandpur. Mosques, shops, businesses, even part of the railroad station were washed away.

Stone riprap now lines the broken edge facing the wide expanse of the river. "They are putting in those boulders in such a way that the rest of the town may be saved," said a man bathing in the river where his house once stood, taking a toothbrush out of his mouth.

Is Chandpur doomed? "We are in great danger; conditions get worse every year," said Nural Alam, an engineer with the Bangladesh Water Development Board. "You can leave a village easily, but not a place like Chandpur. Protect it." But protection is no simple matter. Hardened embankments force water downstream, accelerating erosion in unprotected places. Often time runs out: Land erodes before it can be protected.

Near Chandpur I visited the 20-year-old Meghna-Dhonagoda Irrigation Project. More than 50 million dollars has been spent constructing high embankments to control both flooding and erosion over some 80 square miles of farmland. But still the river bludgeons the land, eroding one section by more than a mile since 1979. "The current is so fast, there's never any time, no time at all, and we are engulfed," said Ronzil Kumer Mondol, the engineer who accompanied me.

A bulwark of reinforced concrete guards a stretch where erosion is particularly bad.



Cyclone 1991: A wave of death

The satellite image of April 29, 1991, served notice: Bangladesh faced its strongest storm this century. Radios blared warnings. Volunteers urged villagers to flee to the few concrete shelters available. On April 29-30 a monster hit the crowded coast between Chittagong and Cox's Bazar. Its 145-mile-an-hour winds and 20-foot storm surge left ten million homeless; 139,000 people and nearly half a million animals died. Bloated corpses lined islands like Kutubdia, fouling water and spreading disease. "I was terrified, so I sang lullabies," said Moni Baula, a ten-year-old orphaned by the storm.

NOAA/EARTH SATELLITE CORPORATION (TOP); PABLO BARTHOLOMEW, GAMMA LIAISON

Other new embankments lie two miles from the river to contain floods that spread far and wide. Ronzil hopes that these government efforts will prevent further destruction. Will it work? "We are doing this on an experimental basis," Ronzil said.

Hundreds of makeshift huts crowd a main embankment along the river. Water covers land once occupied by homes and fields. The presence of refugees complicates efforts to maintain the continually eroding barrier. "How shall we repair the embankment if people are living there?" asks Ronzil. But one resident asked in turn, "Would you have me live in the water? There is no land."

Calamity is a part of daily life in Bangladesh, but so is survival against tremendous odds. "I am always amazed at the capacity of the people to survive with so little," said Marcel Fortier of the Red Cross and Red Crescent Societies.

Fatalism is also a kind of bulwark. "So it has been ordained, so it must happen" was a frequent reply when I asked villagers whether they thought flooding and erosion would ever be brought under control. "Life and death, they take it as the wish of the almighty God," said Farida Hasan, a member of parliament.

But some are determined to do more than just survive. In the town of Kazipur I met Mohammed Boduizzaman, who coordinates the Association for the Renovation of Community Health and Education Services (ARCHES). More than 300,000 people live in this district amid fields of rice, wheat, and jute. The Jamuna River, eight miles wide here, has split the district into mainland and char land.

"Kazipur has been washing away since 1980," Boduizzaman said, claiming that the erosion rate was 550 yards a year. "We have lost everything." One study reports that 64 percent of households have been displaced at least once—the average number of displacements is seven.

Recently ARCHES has helped some of the landless begin a banana tree cooperative on land it owns. Fifty-year-old Abu Rahman showed me around. "There are 140 of us, male and female," he explained. "Every week for one year we put two taka [about five cents] in the bank. When we got 7,000 taka, we decided to use it. We thought about raising cows and goats, but we selected banana trees because they grow fast and you get good profit." He told me proudly that the fruit should earn the cooperative about $2,100 this year.

Although we are miles from the river, floods increase the number of homeless poor, thus adding to the already intense pressure for space. Any solution to this complex mix of social and environmental problems "will take lots of money," Boduizzaman said, a trace of bitterness in his voice. "And that is why the government does nothing."

ACTUALLY, THE GOVERNMENT, with the World Bank and other international agencies, has big plans—a controversial Flood Action Plan (FAP). They want to master the rivers. As the irrigation ministry's Tauhidul Anwar Khan puts it: "It is time to attack the rivers. We can't let them do what they like."

At this writing the plan consists of 26 study proposals and pilot projects. The estimated cost of these alone is 150 million dollars over five years. But the general goal is to "train" the rivers with a massive complex of embankments, dams, and diversions.

Everyone agrees that flooding is beneficial. Even following the 1988 flood, crop yields were larger than before. But change the rivers? That is risky and could cause more harm than good by upsetting both environmental and social balances. For example, construction of embankments could block the normally free access of fish onto the floodplains where they breed. Fewer fish means a decline in protein supply. And, says Shapan Adnan of Research and Advisory Services, previous flood-control structures have "led to disaster in the long run, although the immediate effect may be good."

"That is why we have begun these studies," says Ross Wallace, who is a World Bank coordinator of the plan. "The most efficient way to assist Bangladeshis is to find out what works best. The trick is to go in without a preformed technical plan."

Fine sentiments, critics admit, but they remain skeptical. "There is too much of

SOAKED BUT SMILING Toting a tower of poultry baskets to market, a van ricksha driver pedals the streets of Dhaka, awash in backed up monsoon waters. Even waist-high flooding does not stop work in this teeming capital of nearly six million, which lies less than 25 feet above sea level.

JOYFUL SPLASH For a luscious break from August temperatures that average 84°F, a young herder does refreshing backflips off water buffalo taking their daily bath in the Turag River just west of Dhaka. Though waters near the capital are polluted by oil, dyes, chemicals, and sewage, most of the

nation's roughly 250 rivers are wide enough or fast enough during the monsoon to flush out impurities.

Water buffalo, worth about $300 each, are used mainly for plowing and milking. Children also must toil. Most start working before age ten to augment meager family incomes.

STAYING AFLOAT North of Dhaka on the Lakhya River, a wooden country boat, or *nouka* —overcrowded and barely above water—symbolizes Bangladesh as aptly as does its national flower, the water lily. Often the only choice for travel, boats ply some 5,200 miles of waterways. Though overflowing with 112 million people crammed 2,000 to the square mile, Bangladesh abounds in what it needs most: *prottasha*. Hope.

a structural approach," says Saleemul Huq, who directs the Bangladesh Center for Advanced Studies. "FAP is driven by engineers."

Nonetheless, the fact that there is argument about such matters eases Huq's concern. "To the extent that the environment is a major issue now, that is a victory," he says. "Stop FAP, no. Modify it, yes."

THERE IS AN ABUNDANCE of healthy argument in Bangladesh these days. One common theme, especially among younger Bangladeshis, is that the country is too dependent on foreign aid. A sense of pride is asserting itself.

"Development here is not solely a matter of foreign assistance," says newspaper editor Mishu Kabir. Shahidul Alam, a professional photographer, adds, "We would have been using the development money far more effectively had we been deciding how it was spent." Mishu, Shahidul, and others believe Bangladesh has barely begun to tap its own internal resources. After all, the decade-long military dictatorship was overthrown only two years ago, and a new civilian government elected. This is the first year Bangladesh has been self-sufficient in rice, and now it is aggressively expanding corn and wheat production. A thriving garment industry has developed. And Bangladesh is taking meaningful steps in family planning—rare among Muslim countries.

On one of my last days there I visited Sonargaon. It was the capital of Bengal when the Mogul conquerors ruled four centuries ago. Not much remains of its past grandeur. But the 18th-century Menikhali Canal does. It may have been part of the embankments by which the Moguls once crisscrossed much of the region. This remnant of canal reminded me that if solutions to the many complex problems do not yet seem clear, human resources and ingenuity have been tackling problems in Bangladesh for a very long time. □

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Brief Summary of
Prescribing Information as of January 1995

SELDANE-D®

(terfenadine and pseudoephedrine hydrochloride)

Extended-Release Tablets

WARNING BOX

QT INTERVAL PROLONGATION/VENTRICULAR ARRHYTHMIA

RARE CASES OF SERIOUS CARDIOVASCULAR ADVERSE EVENTS, INCLUDING DEATH, CARDIAC ARREST, TORSADES DE POINTES, AND OTHER VENTRICULAR ARRHYTHMIAS, HAVE BEEN OBSERVED IN THE FOLLOWING CLINICAL SETTINGS, FREQUENTLY IN ASSOCIATION WITH INCREASED TERFENADINE LEVELS WHICH LEAD TO ELECTROCARDIOGRAPHIC QT PROLONGATION:

1. CONCOMITANT ADMINISTRATION OF KETOCONAZOLE (NIZORAL) OR ITRACONAZOLE (SPORANOX)
2. OVERDOSE, INCLUDING SINGLE TERFENADINE DOSES AS LOW AS 360 MG
3. CONCOMITANT ADMINISTRATION OF CLARITHROMYCIN, ERYTHROMYCIN, OR TROLEANDOMYCIN
4. SIGNIFICANT HEPATIC DYSFUNCTION

TERFENADINE IS CONTRAINDICATED IN PATIENTS TAKING KETOCONAZOLE, ITRACONAZOLE, ERYTHROMYCIN, CLARITHROMYCIN, OR TROLEANDOMYCIN, AND IN PATIENTS WITH SIGNIFICANT HEPATIC DYSFUNCTION.

DO NOT EXCEED RECOMMENDED DOSE.

IN SOME CASES, SEVERE ARRHYTHMIAS HAVE BEEN PRECEDED BY EPISODES OF SYNCOPE. SYNCOPE IN PATIENTS RECEIVING TERFENADINE SHOULD LEAD TO DISCONTINUATION OF TREATMENT AND FULL EVALUATION OF POTENTIAL ARRHYTHMIAS.

(See CONTRAINDICATIONS, WARNINGS, CLINICAL PHARMACOLOGY, AND PRECAUTIONS, DRUG INTERACTIONS.)

DESCRIPTION

SELDANE-D (terfenadine and pseudoephedrine hydrochloride) Extended-Release Tablets are available for oral administration.

Each tablet contains 60 mg terfenadine and 120 mg of pseudoephedrine hydrochloride in an outer press coat for immediate release and 120 mg pseudoephedrine hydrochloride in an extended release core. Tablets also contain as inactive ingredients: colloidal silicon dioxide, ethylcellulose, glycerin, hydroxypropyl cellulose, hydroxypropyl methylcellulose 2208, hydroxypropyl methylcellulose 2910, lactose, magnesium stearate, microcrystalline cellulose, polysorbate 80, povidone, sodium carboxymethyl propylene glycol ether, sodium lauryl sulfate, sodium starch glycolate, talc, titanium dioxide, and zinc stearate.

INDICATIONS AND USAGE

SELDANE-D is indicated for the relief of symptoms associated with seasonal allergic rhinitis such as sneezing, rhinorrhea, pruritus, lacrimation, and nasal congestion. It should be administered when both the antihistaminic properties of SELDANE (terfenadine) and the nasal decongestant activity of pseudoephedrine hydrochloride are desired (see CLINICAL PHARMACOLOGY).

SELDANE-D has not been studied for effectiveness in relieving the symptoms of the common cold.

CONTRAINDICATIONS

CONCOMITANT ADMINISTRATION OF SELDANE-D WITH KETOCONAZOLE (NIZORAL), ITRACONAZOLE (SPORANOX) IS CONTRAINDICATED. SELDANE-D IS ALSO CONTRAINDICATED IN PATIENTS WITH DISEASE STATES OR OTHER CONCOMITANT MEDICATIONS KNOWN TO IMPAIR ITS METABOLISM, INCLUDING SIGNIFICANT HEPATIC DYSFUNCTION, AND (UNLESS PATIENT USE OF CLARITHROMYCIN, ERYTHROMYCIN, OR TROLEANDOMYCIN, OT PROLONGATION HAS BEEN DEMONSTRATED IN SOME PATIENTS TAKING TERFENADINE IN THESE SETTINGS) AND RARE CASES OF SERIOUS CARDIOVASCULAR EVENTS, INCLUDING DEATH, CARDIAC ARREST, AND TORSADES DE POINTES, HAVE BEEN REPORTED IN THESE PATIENT POPULATIONS. (See WARNINGS and PRECAUTIONS, Drug Interactions.)

SELDANE-D is contraindicated in nursing mothers, patients with severe hypertension or severe coronary artery disease, patients receiving monoamine oxidase (MAO) inhibitor therapy, and in patients with a known hypersensitivity to any of its ingredients (see DESCRIPTION section).

WARNINGS

Terfenadine undergoes extensive metabolism in the liver by a specific cytochrome P-450 isoenzyme. This metabolic pathway may be impaired in patients with hepatic dysfunction (alcoholic cirrhosis, hepatitis of any etiology) and taking drugs such as ketoconazole, itraconazole, a clarithromycin, erythromycin, a troleandomycin, a other potent inhibitors of this isoenzyme. Interference with this metabolism can lead to elevated terfenadine plasma levels associated with QT prolongation and increased risk of ventricular tachyarrhythmias (such as torsades de pointes, ventricular tachycardia, and ventricular fibrillation) at the recommended dose. SELDANE-D is contraindicated for use by patients with these conditions (see WARNINGS BOX, CONTRAINDICATIONS, and PRECAUTIONS, Drug Interactions).

Other patients who may be at risk for these adverse cardiovascular events include patients who may experience rises in concentration of QT prolongation while receiving certain drugs or having conditions which lead to QT prolongation. These include patients taking certain antiarrhythmics (eg, quinidine, procainamide), patients with cardiac disease, patients with electrolyte abnormalities such as hypokalemia or hypomagnesemia, or taking diuretics with potential for inducing electrolyte abnormalities, and patients with congenital QT syndrome. SELDANE-D is not recommended for use by patients with these conditions.

The relationship of underlying cardiac disease to the development of ventricular tachyarrhythmias while on SELDANE-D therapy is unclear; nonetheless, SELDANE-D should also be used with caution in these patients.

Sympathomimetic amines should be used judiciously and sparingly in patients with hypertension, diabetes mellitus, ischemic heart disease, increased intraocular pressure, hyperthyroidism, or prostatic hypertrophy (see CONTRAINDICATIONS). Sympathomimetic amines may produce CNS stimulation with convulsions or cardiovascular collapse with accompanying hypotension.

Use in Elderly

The elderly are more likely to have adverse reactions to sympathomimetic amines.

PRECAUTIONS

General

SELDANE-D should be used with caution in patients with diabetes, hypertension, cardiovascular disease, and hyperreactivity to sympathomimetic amines.

Information for Patients

Patients taking SELDANE-D should receive the following information and instructions. Patients should be advised to take SELDANE-D only as directed and NOT TO EXCEED THE PRESCRIBED DOSE. Patients should be questioned about use of any other prescription or over-the-counter medications, and should be cautioned regarding the potential for life-threatening arrhythmias with concomitant use of erythromycin, troleandomycin, clarithromycin, ketoconazole, or itraconazole. Patients should be advised to consult the physician before concurrent use of other medications with terfenadine. Patients should be questioned about pregnancy or lactation before starting SELDANE-D therapy, since the drug is contraindicated in nursing women and should be used in pregnancy only if the potential benefit justifies the potential risk to the fetus. Patients should be directed to swallow the tablet whole. Patients should also be instructed to store this medication in a tightly closed container in a cool, dry place, away from heat, moisture, or direct sunlight and away from children.

Drug Interactions (see CONTRAINDICATIONS)

Monoamine oxidase (MAO) inhibitors and beta-adrenergic agonists increase the effects of sympathomimetic amines. Sympathomimetic amines may reduce the antihypertensive effects of methyldopa, mecamylamine, and reserpine. MAO inhibitors may prolong and intensify the effects of sympathomimetics.

Care should be taken in the administration of SELDANE-D concomitantly with other sympathomimetic amines because combined effects on the cardiovascular system may be harmful to the patient.

Ketoconazole

Spontaneous adverse reaction reports in patients taking concomitant ketoconazole with recommended doses of terfenadine demonstrate QT interval prolongation and can produce cardiac events (eg, dizziness, cardiac arrest, and ventricular arrhythmia including torsades de pointes). Pharmacokinetic data indicate that ketoconazole markedly inhibits the metabolism of terfenadine, resulting in elevated plasma terfenadine levels. Presence of unchanged terfenadine is associated with statistically significant prolongation of the QT and QTc interval. **Concomitant administration of ketoconazole and SELDANE-D is contraindicated** (see CONTRAINDICATIONS, WARNINGS, and ADVERSE REACTIONS).

Itraconazole

Torsades de pointes and elevated paired terfenadine levels have been reported during concomitant use of terfenadine and itraconazole in clinical trials, at postmarketing and from foreign post-marketing sources. One death has also been reported from foreign post-marketing sources. **Concomitant administration of itraconazole and SELDANE-D is contraindicated** (see CONTRAINDICATIONS, WARNINGS, and ADVERSE REACTIONS).

Due to the chemical similarity of other azole-type antifungal agents (including fluconazole, miconazole, and intraconazole) to ketoconazole and itraconazole, concomitant use of these products with SELDANE-D is not recommended pending full examination of potential interactions.

Macrolides

Clinical drug interactions studies indicate that erythromycin and clarithromycin can exert an effect on terfenadine metabolism by a mechanism which may be similar to that of ketoconazole. Such a dose-related effect (although erythromycin moderately decreases the clearance of the terfenadine alkyl metabolite, its influence on terfenadine plasma levels is still under investigation). A few spontaneous accounts of QT interval prolongation with ventricular arrhythmias including torsades de pointes have been reported in patients receiving erythromycin and troleandomycin.

Concomitant administration of SELDANE-D with clarithromycin, erythromycin, or troleandomycin is contraindicated (see CONTRAINDICATIONS, WARNINGS, and ADVERSE REACTIONS). Pending full characterization of potential interactions, concomitant administration of SELDANE-D with other macrolide antibiotics, including azithromycin, is not recommended. Studies to evaluate the potential interaction of terfenadine with azithromycin are in progress.

Carcinogenesis, Mutagenesis, Impairment of Fertility

No studies have been conducted to evaluate the carcinogenic potential of SELDANE-D.

Oral doses of terfenadine corresponding to 40 times the recommended human daily dose or more for 18 months or as little as 24 months, revealed no evidence of tumorigenicity. Microbial and mammalian test assays with terfenadine have revealed no mutagenic activity.

Reproduction and fertility studies with terfenadine in rats showed no effects on male or female fertility at oral doses of up to 21 times the human daily dose. At 40 times the human daily dose there was a small but significant reduction in implants and at 125 times the human daily dose reduced implants and increased post-implantation losses were observed, which were judged to be secondary to maternal toxicity. Animal reproduction studies have not been carried out with pseudoephedrine.

Pregnancy Category C

The combination of terfenadine and pseudoephedrine hydrochloride (in a ratio of 1:2 by weight) has been shown to produce reduced fetal weight in rats and rabbits at 40 times the human dose and delayed ossification with delay also in a few fetuses when given to rats at a dose of 60 times the human daily dose. There are no adequate and well-controlled studies in pregnant women. SELDANE-D should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus.

Nursing Mothers (see CONTRAINDICATIONS)

Terfenadine has caused decreased pup weight gain and survival in rats given doses 60 times and 125 times the human daily dose throughout pregnancy and lactation.

Pediatric Use

Safety and effectiveness of SELDANE-D in children below the age of 12 years have not been established.

ADVERSE REACTIONS

Cardiovascular Adverse Events

With terfenadine, rare reports of severe cardiovascular adverse effects have been received which include ventricular tachyarrhythmias (torsades de pointes, ventricular tachycardia, ventricular fibrillation, and cardiac arrest), hypotension, palpitations, syncope, and dizziness. Rare reports of deaths resulting from ventricular tachyarrhythmias have been received (see CONTRAINDICATIONS, WARNINGS, and PRECAUTIONS, Drug Interactions). Hypotension, palpitations, syncope, and dizziness could reflect undetected ventricular arrhythmias. IN SOME PATIENTS (WITH CARDIAC ARREST OR TORSADES DE POINTES) HAVE BEEN PRECEDED BY EPISODES OF SYNCOPE. (See WARNINGS BOX.) Rare reports of serious cardiovascular adverse events have been received, some involving QT prolongation and torsades de pointes, in apparently normal individuals without identifiable risk factors. There is not conclusive evidence of a causal relationship of these events with terfenadine. Although in rare cases there was measurable plasma terfenadine, the implications of this finding with respect to the sensitivity of terfenadine metabolism in the normal population cannot be assessed without further study. In controlled clinical trials in otherwise normal patients with months' usual recreation or QTc interval were observed at doses of 60 mg b.i.d. or multiples of 300 mg b.i.d. a mean increase in QTc of 19% (range −4% to + 33%). Linear increase of 46 msec was observed.

General Adverse Events

In double-blind, parallel, controlled studies in over 300 patients, in which SELDANE-D was compared to controlled vehicle (pseudoephedrine), adverse reactions reported for greater than 1% of the patients receiving SELDANE-D were not clinically different from those reported for patients receiving pseudoephedrine (see Table below).

Frequently (>1%) Reported Adverse Events for SELDANE-D in Double-blind, Parallel, Controlled Clinical Trials*

Adverse Event	Percent of Patients Reporting		
	SELDANE-D (N=374)	Pseudoephedrine (N=287)	Placebo (N=152)
Central Nervous System			
Insomnia	2.9	2.8	3.3
Headache	7.8	7.7	4.3
Drowsiness/Sedation	7.2	4.9	11.8
Nervousness	4.7	3.4	1.3
Dizziness	3.2	3.8	0.0
Fatigue	2.1	1.4	2.1
Restlessness	1.1	1.0	0.0
Irritability	1.1	0.0	1.3
Concentration	1.1	0.3	0.0
Increased Energy	1.1	0.3	0.0
Hyperkinesia	1.1	1.0	0.0
Autonomic			
Dry Mouth/Nose/Throat	21.1	21.3	11.8
Gastrointestinal			
Nausea	4.3	6.6	5.3
Skin			
Rash	1.1	0.3	0.7
Cardiovascular			
Palpitations	2.9	3.8	0.7
Allergic Symptoms			
Sore Throat	1.9	1.7	1.3
Cough	1.6	0.3	1.3
Other			
Infection, Upper Respiratory	1.3	2.8	0.7
Eyes Abnormal	1.1	1.0	1.3

*SELDANE-D (pseudoephedrine 120 mg b.i.d.)

Pseudoephedrine may cause sympathomimetic reactions such as tachycardia, palpitations, headache, dizziness, or nausea. Sympathomimetic drugs have also been associated with certain untoward reactions including skin anxiety, tenseness, restlessness, tremor, weakness, pallor, respiration difficulty, dysuria, insomnia, hallucinations, convulsions, CNS depression, arrhythmias, and cardiovascular collapse with hypotension.

In controlled clinical trials with terfenadine using the recommended daily dose of 60 mg b.i.d., the incidence of adverse events in patients receiving terfenadine was similar to that reported in patients receiving placebo. These effects included:

Central Nervous System: Drowsiness, headache, fatigue, dizziness, nervousness, weakness, appetite increase.

Gastrointestinal System: Abdominal distress, nausea, vomiting, change in bowel habits.

Eye, Ear, Nose and Throat: Dry mouth/nose/throat, cough, sore throat, dyspnea.

Skin: Eruptive (including rash and urticaria) or itching.

Also reported spontaneously during the marketing of terfenadine were alopecia, hair loss or thinning, anaphylaxis, angioedema, bronchospasm, confusion, depression, galactorrhea, insomnia, menstrual disorders (including dysmenorrhea), musculoskeletal symptoms, nightmares, paresthesia, photosensitivity, rapid form of psoriasis, seizures, sinus tachycardia, sweating, thrombocytopenia, tremor, urinary frequency, and vasculitis.

Rare or clinical trials, severe incidences of mild or, in one case, moderate transaminase elevations were seen in patients receiving terfenadine. Mild elevations were also seen in placebo treated patients. Marketing experience include isolated reports of jaundice, cholestatic hepatitis, and hepatitis, in most cases jaundice information is incomplete.

OVERDOSAGE

Management should be supportive and symptomatic. Induction of vomiting or gastric lavage with a cuffed endotracheal tube to prevent aspiration should be considered. Activated charcoal may be effective in limiting absorption of terfenadine. Hemodialysis is not effective. Monitoring cardiac function is recommended. Treatment of overdosage with terfenadine should include close medical supervision and support for at least 4 hours, and should continue until the patient's ECG is monitored for 24 hours. Overdosage with pseudoephedrine may cause signs and symptoms of sympathetic stimulation, including nervousness, dizziness, sweating, palpitations, headache, nausea, vomiting, tachycardia, elevation of blood pressure, difficulty in urination, and more severe cardiac arrhythmias. Treatment should be symptomatic and supportive. Gastric lavage is recommended. Hemodialysis is not effective. Monitoring cardiac function is recommended. Treatment of overdosage with pseudoephedrine may include the use of activated charcoal, sedation, and control of hypertension if necessary. Refer to the PDR for more information on overdosage management.

DOSAGE AND ADMINISTRATION

Adults and children 12 years and older: one tablet every morning and night.

USE OF DOSES IN EXCESS OF ONE TABLET B.I.D. IS NOT RECOMMENDED BECAUSE OF THE INCREASED POTENTIAL FOR QT INTERVAL PROLONGATION AND ADVERSE CARDIAC EVENTS. (See WARNINGS BOX.) USE OF SELDANE-D IN PATIENTS WITH DISEASE AND HEPATIC DYSFUNCTION AND IN PATIENTS TAKING KETOCONAZOLE, ITRACONAZOLE, CLARITHROMYCIN, ERYTHROMYCIN, OR TROLEANDOMYCIN IS CONTRAINDICATED. (See CONTRAINDICATIONS, WARNINGS, and PRECAUTIONS, Drug Interactions.)

HOW SUPPLIED

SELDANE-D Tablets, containing 60 mg of terfenadine and 120 mg of pseudoephedrine hydrochloride in an outer press coat for immediate release and 120 mg of pseudoephedrine hydrochloride in an extended release core are supplied as follows:

NDC 0068-0737-67 Bottles of 100 tablets

Tablets are white to off-white, biconvex capsule-shaped, debossed "SELDANE-D". Store at controlled room temperature 59-86°F (15-30°C).

Protect from moisture.

Prescribing information as of January 1995

Marion Merrell Dow Pharmaceuticals Inc.

Subsidiary of Marion Merrell Dow Inc.

Kansas City, MO 64114

U.S. Patents 3,878,217; 4,254,555; 4,808,587; 4,254,129

0x8/0195a

Mrs. Donivan's Kids Skate Through Science Class.

In Marilee Donivan's class, kids learn for themselves how Newton's Laws of Motion really work. They start with classroom activities using toy cars, marbles, ramps and balance scales.

Then, with the help of skates, ropes, hockey pucks and sticks, the kids put Newton's Laws to the test on the ice. They experiment with skating, spinning, sliding or walking–feeling friction and the effects of gravity.

For her contribution to the world of science, State Farm is proud to present Marilee with the Good Neighbor Award. And $5,000 to her school, McCall-Donnelly Elementary, McCall, Idaho.

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THE PRESIDENT'S REPORT ON THE

Education Foundation

Geographic Alliances All in Place

Great pieces of a jigsaw puzzle, geographic alliances in Arizona, Washington, and Montana have this year joined 47 other states and Puerto Rico to complete the picture.

Since I announced the first six states to join the Society's Geographic Alliance Network in 1986, the cause of geography education has mushroomed. Each alliance recruits local educators and others—parents, elected officials, business people—to promote geography in the classroom. The alliances encourage updating of curricula and participate in teachers workshops and summer institutes. Besides receiving state funds, alliances raise money from local organizations and companies. The Society's Education Foundation matches those totals up to $50,000 a year.

In seven years the alliances have grown beyond our dreams, with membership nearing 100,000.

Most important, the alliance movement gets teachers fired up about geography. How's it working? Listen to Russ Bush, a Buckhannon, West Virginia, teacher who attended last year's Workshop on Water in Mammoth Lakes, California: "I am energized; it has made a difference in my teaching, and my colleagues find my enthusiasm contagious."

Geography teacher Dorothy Schuyler of La Grange, Georgia, declares, "We are charging ahead to deal with the 'geo-ignorant' wherever we find them!"

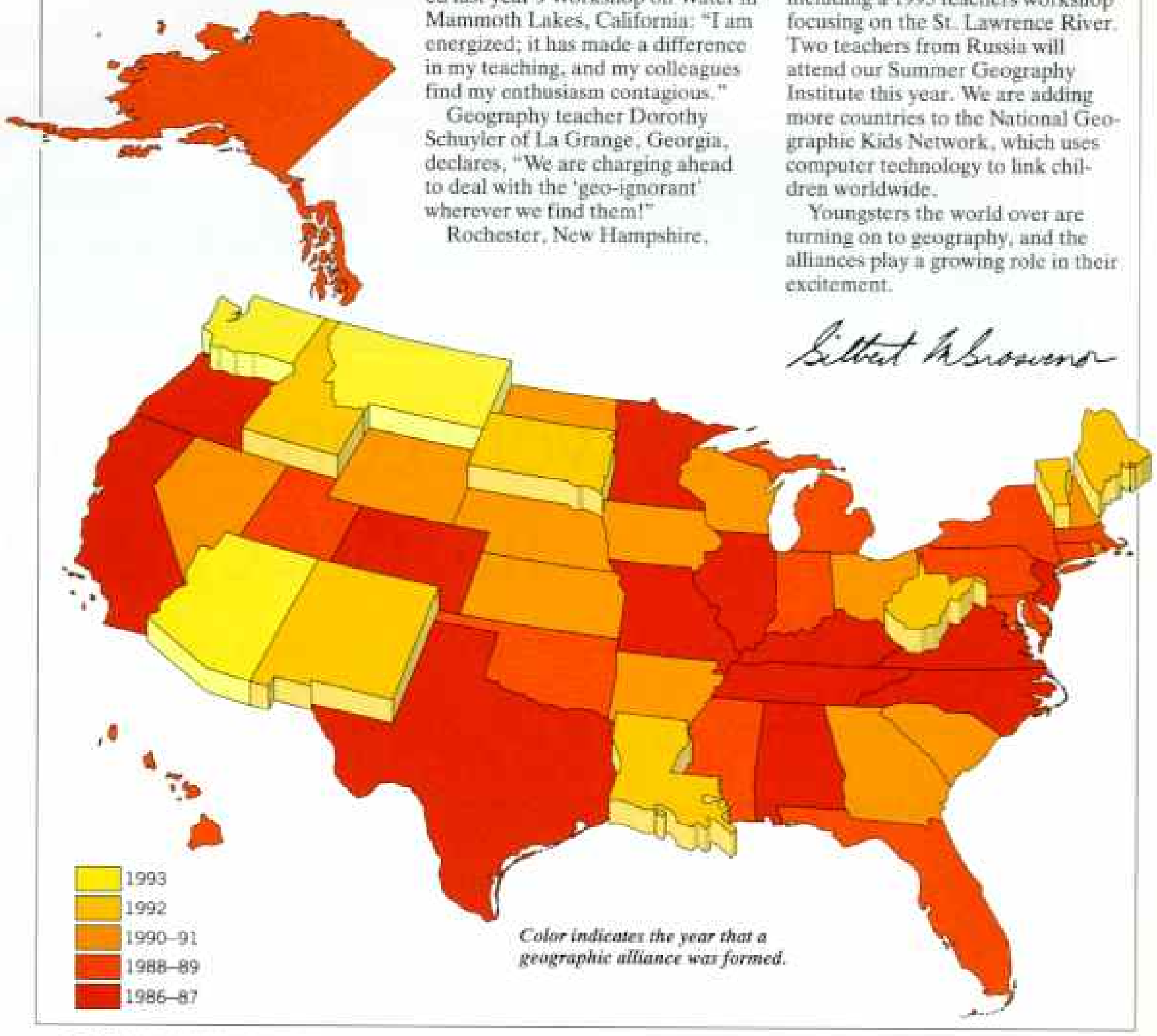
Rochester, New Hampshire, teacher Barbara Newton summed it up after last year's National Geographic Instructional Leadership Institute: "At a time when it has become popular to criticize public education, the alliance pursues a positive path in promoting geography education. As an educator and parent, I applaud that."

I applaud the tens of thousands of alliance members spreading the word of geography education.

Still, we cannot become complacent. Our commitment to geography education continues to grow. The Society is laying the groundwork for an education program in Canada, including a 1993 teachers workshop focusing on the St. Lawrence River. Two teachers from Russia will attend our Summer Geography Institute this year. We are adding more countries to the National Geographic Kids Network, which uses computer technology to link children worldwide.

Youngsters the world over are turning on to geography, and the alliances play a growing role in their excitement.

Gilbert M. Grosvenor



Color indicates the year that a geographic alliance was formed.

For Chrysler, the only thing floating at last year's North American International Auto Show was a rumor. Word was that the New Yorker, then just a "concept" car, would soon become a reality. A rumor that Chrysler is happy to confirm. Introducing the very

As far as we're concerned, are once again

antithesis of Detroit–the totally new Chrysler New Yorker. We started with our award-winning "cab forward" design, which maximizes interior room while giving the car a wide track for precise handling. Then we added four-wheel independent suspension, and an engine with more horsepower than a BMW 535i. The result? A six-passenger car

that stays reassuringly stable in tight turns. While its occupants are pampered by a sumptuous interior. But in the pursuit of precise handling and luxury, we didn't overlook safety. Dual air bags and anti-lock four-wheel disc brakes are standard.

"boat," "barge" and "yacht" nautical terms.

Nor did we forget about style. *Motor Trend* called it "...the most distinctive American sedan by a country mile." Waiting for an affordable luxury car that isn't a boat? Your ship just came in. For more information, call 1-800-4A-CHRYSLER.

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Geographica

Okinawa: A Terrific Place to Grow Old

If it's long life you're after, consider Okinawa. Relative to total population, five times as many people on that island chain live to the age of 100 as in the rest of Japan—and Japanese live longer than any other nationality on the planet. In fact, by the year 2000 some 20 percent of all Japanese will be 65 or older, compared with about 13 percent in the United States. A 16-year study of Okinawa's 1.2 million residents turned up 390 who had reached the age of 100. No wonder Okinawans annually celebrate Older People's Day.

Though some may be blessed with genes that protect against diseases linked with aging, most older Okinawans owe their longevity to factors over which they have some control: diet, life-style, and attitude.

Okinawans eat a low-salt, low-fat diet, featuring local fish and huge amounts of tofu and seaweed. And they haven't lost their zest for life: 108-year-old Genkan Tonaki (right), an Okinawan who is Japan's oldest man, only recently stopped proposing to his nurses, such as Yumiko Nohara, at right.

He is at a loss to explain his longevity: "It's the kind of thing I cannot tell you, because life is given by heaven." Tonaki worked in sugarcane fields until retiring at 85. He admits he gave up drinking six bottles of beer a day and now drinks hot water instead.

SCOTT LYNN RILEY

Makoto Suzuki, a cardiologist studying the Okinawa centenarians, and Faith Boucher, of the University of California at Davis Medical School, found that many older Okinawans are active and creative. "They're still composing music, making clothes, and singing songs instead of just sitting around," Boucher says.

JEFF SLAVEN

Two Billion Copies: A Figure Fanatic's Feast

Somewhere out there, someone reading these words holds the two-billionth copy of NATIONAL GEOGRAPHIC to be printed and bound in Corinth, Mississippi, since magazine production moved there in 1977.

Three offset presses and two gravure presses of the Corinth Division of Ringier America, Inc., print about ten million copies of the magazine each month, using nine million pounds of paper and 685,000 pounds of ink. Two bindery lines, each 375 feet long, bind a total of 40,000 copies an hour.

How much is two billion NATIONAL GEOGRAPHICS? A typical copy is a quarter of an inch thick and weighs 12.5 ounces. The two billion magazines printed in Corinth have a total weight of 780,000 tons. Laid end to end, they would stretch all the way to the moon and a third of the way back toward earth. Edge to edge, they would cover an area one and a half times the size of Manhattan.

NATIONAL GEOGRAPHIC was printed and bound in Washington, D. C., from 1888 until 1959, then in Chicago until the move to Corinth, a community of 12,000. About 270 of the Ringier America plant's 790 employees work full-time in producing the magazine.

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Geographica

Sea Tests for Traditional Hawaiian Sailing Canoe

An open-ocean catamaran—of ancient design and all-natural materials—splashes into the sea off Oahu this summer. If 57-foot-long *Hawaiiloa* proves seaworthy, she will be shipped to the Marquesas and launched in 1995 for a 2,500-mile sail back to Hawaii. The project, aimed at highlighting indigenous Hawaiian culture, is spearheaded by 40-year-old navigator Nainoa Thompson. At 23 he crewed on the maiden voyage of *Hokule'a* to Tahiti, a journey guided by the stars, which confirmed ancient Polynesian seafaring traditions (GEOGRAPHIC, October 1976).

Hokule'a's hulls were fiberglass, her sails machine-made. *Hawaiiloa*'s builders, sponsored by the Bishop Museum, are using olona, a very strong fibrous plant, for cordage and rigging, says Thompson. Craftsmen are weaving dried pandanus leaves, or lauhala, into sails. But the huge koa trees that once were shaped into canoe hulls have virtually disappeared. *Hawaiiloa*'s twin hulls are crafted from Sitka spruce from Alaska (top).

"The Hawaiians must have built thousands of these canoes in the past 2,000 years," Thompson laments. "Today we can't build even one." One impact of the project: a koa reforestation program.

MONTE COSTA, COURTESY BISHOP MUSEUM

Tanzania's Lions Pose a Threat to Chimps

For the first time, scientists have found definitive evidence that lions prey on chimpanzees.

Chimp hair, bones, and a tooth turned up in lion feces in Tanzania's Mahale Mountains National Park shortly after two adult female chimps and two adolescent males disappeared. The missing primates were part of a hundred-member study group, one of three in the park that have been observed since 1965, reports Takahiro Tsukahara of the University of Tokyo. On rare occasions when researchers heard a lion roar, they saw chimps react—climbing trees, whimpering, and issuing alarm calls. But the scientists never saw the two species together.

PETER RAUGUST

Ordinarily lions, which live on grassy plains or in open woodland, do not cross paths with forest-dwelling chimpanzees. But in the Mahale area, mixed forest and savanna woodland attract both species. Because the study area has been free of poaching and field burning since 1974, animal populations have dramatically increased, heightening the likelihood of predation.

Hominid Remains Emerge in South Africa

Some of the best known fossil remains of "ape-men" were discovered in South African caves in the early decades of this century (GEOGRAPHIC, November 1985). But the last site there was found in 1948, and paleoanthropologists shifted their focus to East Africa—until now.

Last year Lee Berger, an American graduate student at the University of the Witwatersrand, uncovered two teeth (above) in Gladysvale Cave, north of Johannesburg. The teeth date from 1.7 to 2.5 million years ago, an era when at least two species of australopithecines and the earliest species of *Homo* roamed Africa. These specimens probably belonged to *Australopithecus africanus*.

The cave also yielded the remains of 31 species of antelope and the first nearly complete skeleton of a wolflike animal found in sub-Saharan Africa. In its stomach was a seed from a date palm known today only in the tropics. From this faunal and climatic evidence "we can re-create the environment," says Berger. "We can put the hominids from Gladysvale in their context—a tropical savanna with a forest and a large body of water nearby."

TOSHISADA NISHIDA

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GOODYEAR

Geographica

A High-tech Autopsy for Egyptian Mummies

The four "patients" admitted to the George Washington University Medical Center in Washington, D. C., were no emergency cases. Their condition had stabilized over the past 2,000 or more years: They were mummies from the Smithsonian Institution collections headed for X rays and computed tomography (CT) scans. Such noninvasive techniques could reveal sex, age at death, and perhaps cause of death.

CHIP CLARK, SMITHSONIAN INSTITUTION

Three of the mummies had been mostly unwrapped earlier, but the fourth, found in Luxor a hundred years ago, was in almost pristine condition inside its painted sarcophagus, says David Hunt, a Smithsonian physical anthropologist. In a protective shroud of plastic film, the mummy case entered the CT scanner (below left), which peered inside to reveal a male who died in his early 40s. There were no signs of trauma or serious illness in his bones or in those of the others. A child had died at about 3 years of age, a male in his mid-30s, and a female—long thought to be male—in her late 20s. "They died of something so fast acting it doesn't show up on an X ray or CT scan," says Hunt, who expects tests of tissue samples to yield more information.

A Digger Bee's Busy Life in the Fast Lane

The fuzzy, fast-flying digger bees of Arizona's Sonoran Desert spend most of their days underground. Their life in the light is short, but what a life it is!

Each spring the males dig their way out of brood cells. They feed on the nectar of flowering paloverde and ironwood trees, then search for

JOHN ALCOCK

a mate. Somehow they are able to detect the presence of a female "through several inches of hard-packed desert soil," says Stephen Buchmann, a University of Arizona evolutionary ecologist who has studied *Centris pallida* with Arizona State University's John Alcock.

Warding off other suitors, the largest male furiously digs down until he finds the female, climbs on her back, and rides her out. Now he must fight off 10 to 50 other eager males. While mating (above), he strokes her sides with his legs and rasps a soothing song, "good vibrations" that make her unreceptive to others. She collects pollen and nectar, digs a nest, and lays eggs.

"Both partners die within weeks, the males first," says Buchmann. "That's life in the fast lane for many male animals: Live fast, die young."

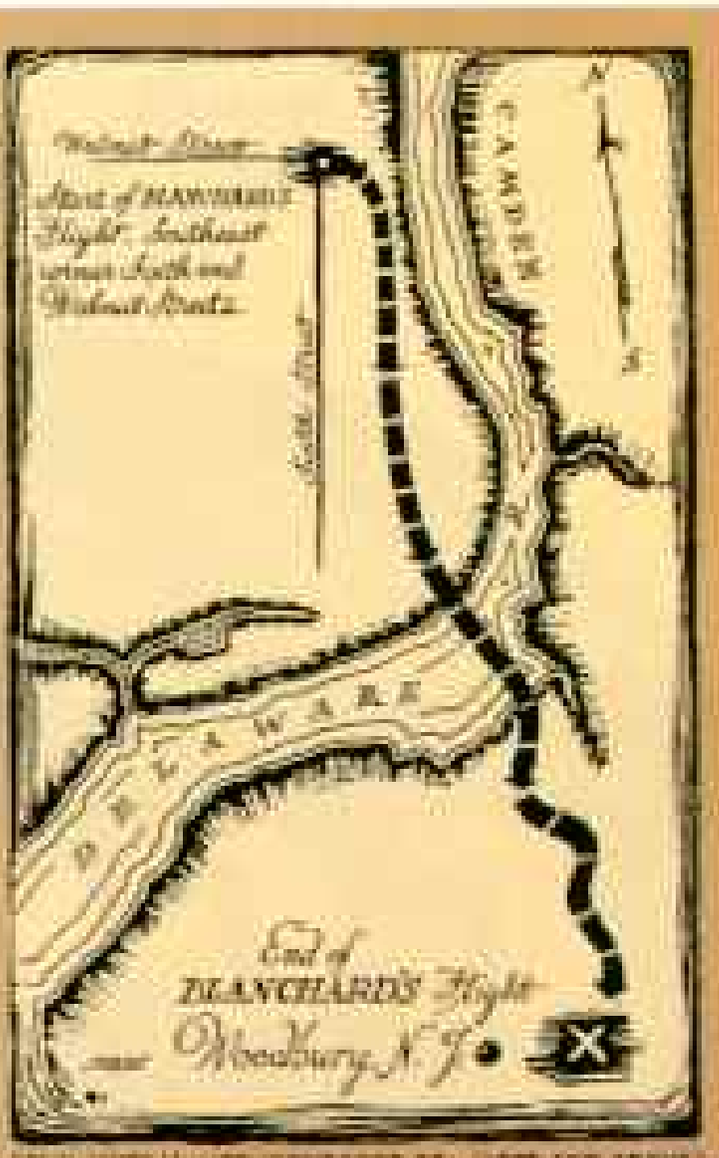
Snowy, Windy Jubilee of a Pioneer Balloon Trip

"What sweet ecstasies take possession of the soul of a mortal who, leaving the terrestrial abode, soars into the ethereal regions!" So wrote pioneering French balloonist Jean-Pierre-François Blanchard of the New World's first air voyage on January 9, 1793. Balloonists who met in Philadelphia this past January to mark the 200th anniversary of Blanchard's flight enjoyed no such ecstasies; high winds and snow forced them to cancel a commemorative flight.

Manned ballooning was only nine years old when Blanchard, who had made 44 flights in Europe, arrived in Philadelphia. President George Washington gave him a letter of passage in case he met difficulty after landing; thousands watched as Blanchard and a companion, a little black dog, ascended in a hydrogen balloon from the Walnut Street prison yard. They soared to 5,812 feet and floated 15 miles in 46 minutes before putting down gently near Woodbury, in what is now Deptford, New Jersey.

Unlike some successors, Blanchard faced no weather problems. The temperature was 55°F—"most delightful and quite extraordinary for this season of the year," he wrote.

—Boris Weinstraub



PENN MUTUAL LIFE INSURANCE CO. (LEFT AND ABOVE)

National Geographic, June 1993

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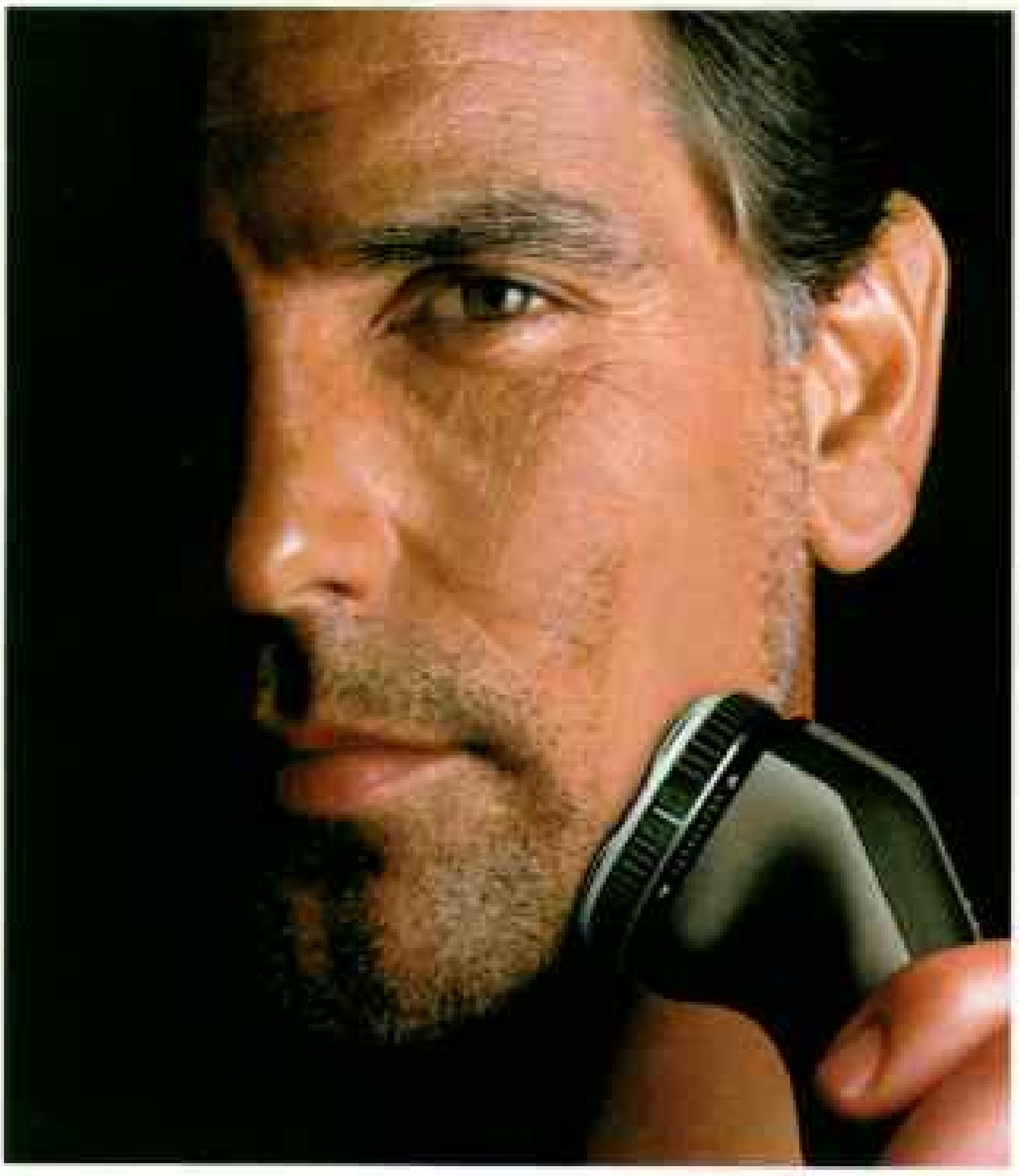

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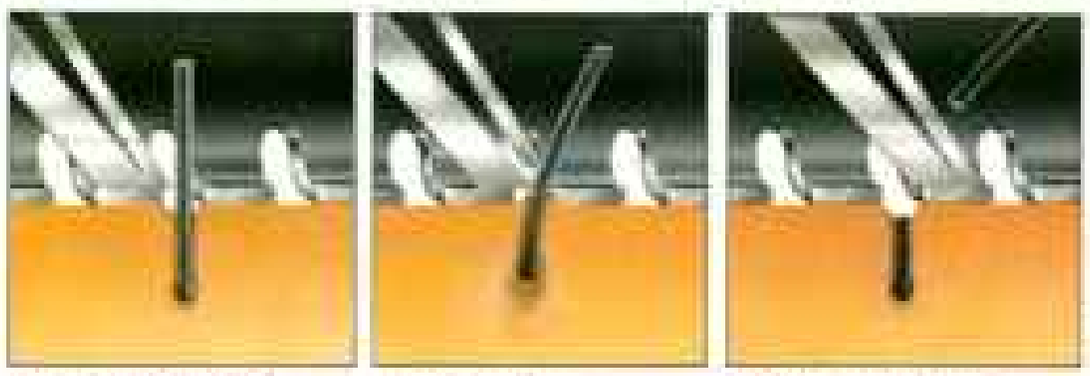

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—Robert Urich

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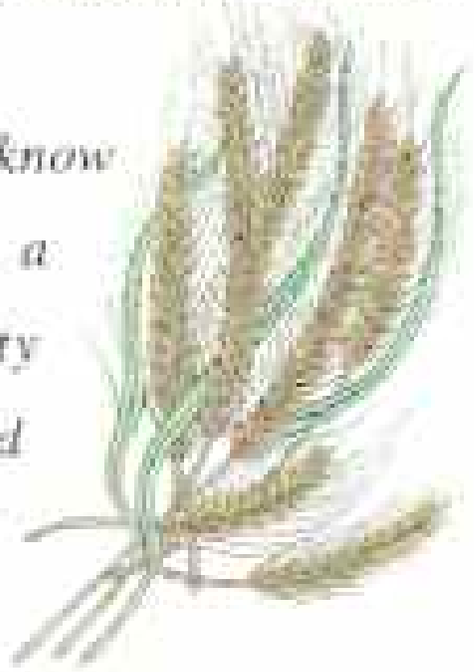

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Forum

The Mekong

My family used to live in Laos. After the Vietnam War broke out, we crossed the Mekong River to get to Thailand. From there my family chose to come to the United States. I wish I could remember more, but I was very young then. It never occurred to me how much danger was involved in crossing the river until I read Thomas O'Neill's article (February 1993). It makes me more appreciative of how much my parents sacrificed and how precious my history is to me.

XAO HER
Macon, Georgia

I was saddened to read about the dam-building proposals on one of the last great free-flowing rivers of the world. The loss of rejuvenating soil downstream in the Mekong's rice fields will eventually damage rice production, the backbone of Southeast Asia's economy. The fishing industry, dependent on migratory species, will also suffer. Thousands of people will lose excellent farmland and have to be relocated. As a substitute for dams, sluiceways off fast-flowing rivers like the Mekong can be used to power hydroelectric facilities. These would be less damaging to the economy and environment.

DAVID DVORAK, JR.
Cleveland Heights, Ohio

Almost 21 years to the day after I left Phung Hiep, Vietnam, I was back, circling for a landing in the pages of the GEOGRAPHIC. I spent ten wartime months as adviser to the district office in Can Tho, but what I remember most are the sweet bananas at the marketplace, the fresh canal-water lemonade, the deft bamboo basket weavers, and the children. If I never get back, I can reread my 150 letters to my wife-to-be, study my few snapshots, and now open up the GEOGRAPHIC. I thank Thomas O'Neill and photographer Michael Yamashita for stopping off in Phung Hiep on their unsentimental trip down the Mekong.

RICHARD E. SCHADE
Cincinnati, Ohio

In 1969 I served with the United States Coast Guard's Squadron One on an 82-foot patrol boat. Our mission was to patrol the endless estuaries and canals of the Mekong Delta and to board and search Vietnamese watercraft. I still remember the many nights cruising with our Vietnamese liaison and the U. S. Navy Swift-class boats. Our crews never knew when the river would turn angry. Someday I hope to return to the delta to learn the peaceful lessons the Mekong River and its people have to offer.

WILLIAM M. FINDLAY
Baldwin, Wisconsin

Venus Revealed

The descriptions of the spectacular images of the planet Venus make reference to elevations without giving the base point from which they are measured. With no sea level as a starting point, are elevations measured from some level at the base of a mountain or from the lowest point on the planet? And how does the distance from the highest to the lowest point on Venus compare with Earth's extreme of 12.3 miles from the top of Mount Everest to the bottom of the Mariana Trench?

DON SANCTON
Kirkland, Quebec

Topography on Venus is measured from the planet's mean radius of 3,760.5 miles. The highest point rises 7.5 miles above this mean; the lowest is 2.5 miles below it. The distance between them is thus less than that between Mount Everest and the Mariana Trench.

As a teacher of planetary geology I applaud the coverage of Venus. However, the artwork reflects some vertical exaggeration of the terrain, and you provide no scale. I have a hard time explaining this exaggeration to students, who come away with the impression that Venus is a planet with steep mountains and valleys.

JOSEPH C. CAIN
Florida State University
Tallahassee, Florida

Vertical exaggeration, a standard practice for scientists analyzing planetary surfaces, is a way to emphasize topographical detail. In the two views in our article, vertical features were multiplied by a factor of 22.5.

My three-year-old son has enjoyed seeing Venus in the sky, and your article was a wonderful way to have the planet come alive for him. Edward pored over the photographs and could hardly get his questions out fast enough: "What does a volcano do? What is lava? Are there volcanoes on Earth? Where are the spacemen?" He also informed me, with absolute certainty, that "very hot people live on Venus."

ALIDA CYNRIC
Madison, Wisconsin

Newborn Panda in the Wild

Thank you for this beautiful story and the moving photographs of Jiao Jiao and her newest cub, Xi

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Wang. I hope there will be a follow-up story in a future issue.

JENNIFER HENTSCHEL
Rasmussen, Australia

We continue to monitor Jiao Jiao, Xi Wang, and the other pandas of China's Qin Ling mountains and hope to issue further reports.

Twilight of Apartheid

With so much talk about negotiations and power-sharing in South Africa, somehow the people have been forgotten. Charles E. Cobb's article brought them back into focus.

GAY MCDOUGALL
Washington, D. C.

Would it not have given balance to show along with the poverty and shacks the impressive Nelson Mandela mansion and other beautiful, expensive houses? When I show slides of my trip to Soweto, I present both sides.

BARBARA J. BELL
Portland, Oregon

As a white South African who never supported apartheid or the Nationalist government, I was appalled at the one-sided tone of both the article and photographs. Contrary to what Archbishop Tutu may say, the cause of violence among blacks is ethnic, as well as cultural and political. The article gives the impression that Inkatha, the South African government, and the whites are the "baddies" and the African National Congress is as pure as the driven snow.

DOROTHY HYAM
Pretoria, South Africa

I found your article on South Africa to be well informed and superbly illustrated. What my country needs now is foreign investment in industry on a massive scale.

D. CLEWS
Cape Town, South Africa

In the Heart of Appalachia

At first I thought, finally, an article that will represent the true Appalachia. Instead it perpetuates all the old myths and stereotypes of the poor, ignorant hillbilly. I am proud of all the important gains made in this area just during my lifetime. I was born and raised in Appalachia and have chosen to make my home in Big Stone Gap, Virginia. I am 37 years old. I work at the local community college, and my husband works as a coal miner. For the record, Big Stone Gap has never set aside a street for teenagers to cruise on the weekends as stated in your picture caption. Streets in Big Stone Gap are open to all drivers.

KATHRYN K. COLLIER
Big Stone Gap, Virginia

Finally! Many thanks for an accurate and enjoyable article on the frequently maligned region of Appalachia. I hope your readers were pleasantly surprised to have some of the myths about this area debunked. You have painted one of the most realistic pictures of Appalachia I have read. I am a native of southwest Virginia and, like many who grew up here, wanted to leave as fast as I could. After a year in Washington, D. C., and three years in law school, I returned to the misty valleys of Tazewell County. It is true that life is hard here and not always as pretty as the mountains. But we are resilient folk, and those of us who love Appalachia wouldn't move for all the power of Washington, the money of New York, or the glamour of L.A.

H. SHANNON COOKE
Cedar Bluff, Virginia

Only one paragraph in the article makes mention of an obvious way for Appalachia to achieve economic prosperity: tourism.

STEPHEN V. GILMORE
Charlotte, North Carolina

Appalachia's people are its greatest and most enduring resource, but they can be exploited by tourism as well as by mines and factories. Appalachia's neighborliness, which your author documents, cannot be encapsulated in hillbilly theme parks or weekend festivals. The challenge of building upon it without undermining it ranks with the challenge of redeeming our natural and cultural resources from the effects of past exploitation. Such challenges are what make Appalachia such an exciting place to live today.

JOHN ALEXANDER WILLIAMS
Director, Center for Appalachian Studies
Boone, North Carolina

Geographica

Monterey Bay National Marine Sanctuary (March 1993) may protect an array of marine life, but the animal pictured is a harbor seal, not a sea otter.

C. FRED ZEILLEMEKER
Cold Bay, Alaska

The map of the Monterey Bay National Marine Sanctuary shows some serious slippage. Last time I looked, Santa Clara would have been approximately above the letter "C" in California, and Santa Cruz was still looking out on Monterey Bay. That is, unless you know something more about the next big earthquake?

KATHLEEN R. MIRANDA
San Jose, California

Isn't it amazing? We can put out an entire atlas with no apparent errors, and then we make two in a short Geographica story. As one staff wag said: "We otter know better."

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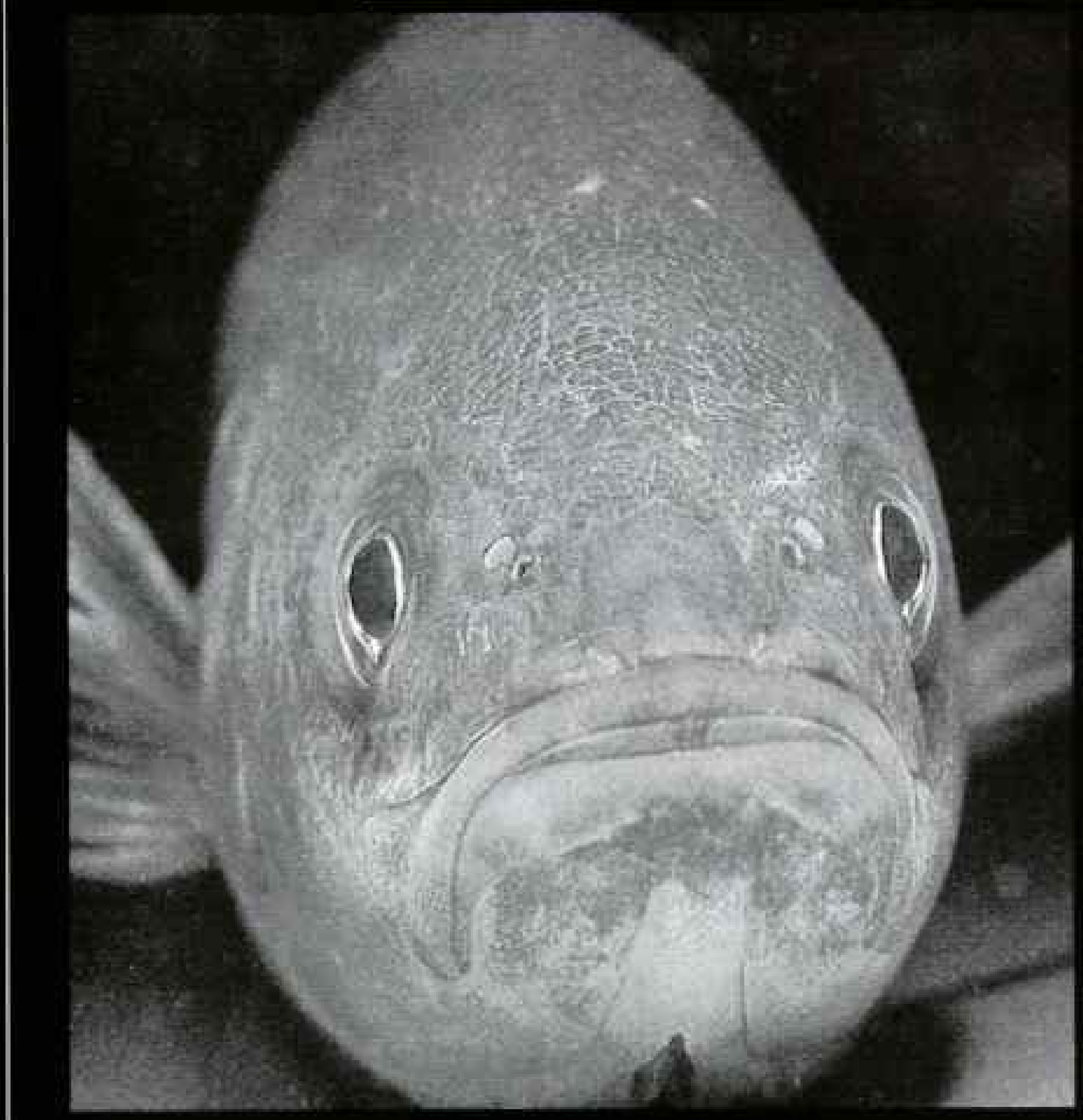

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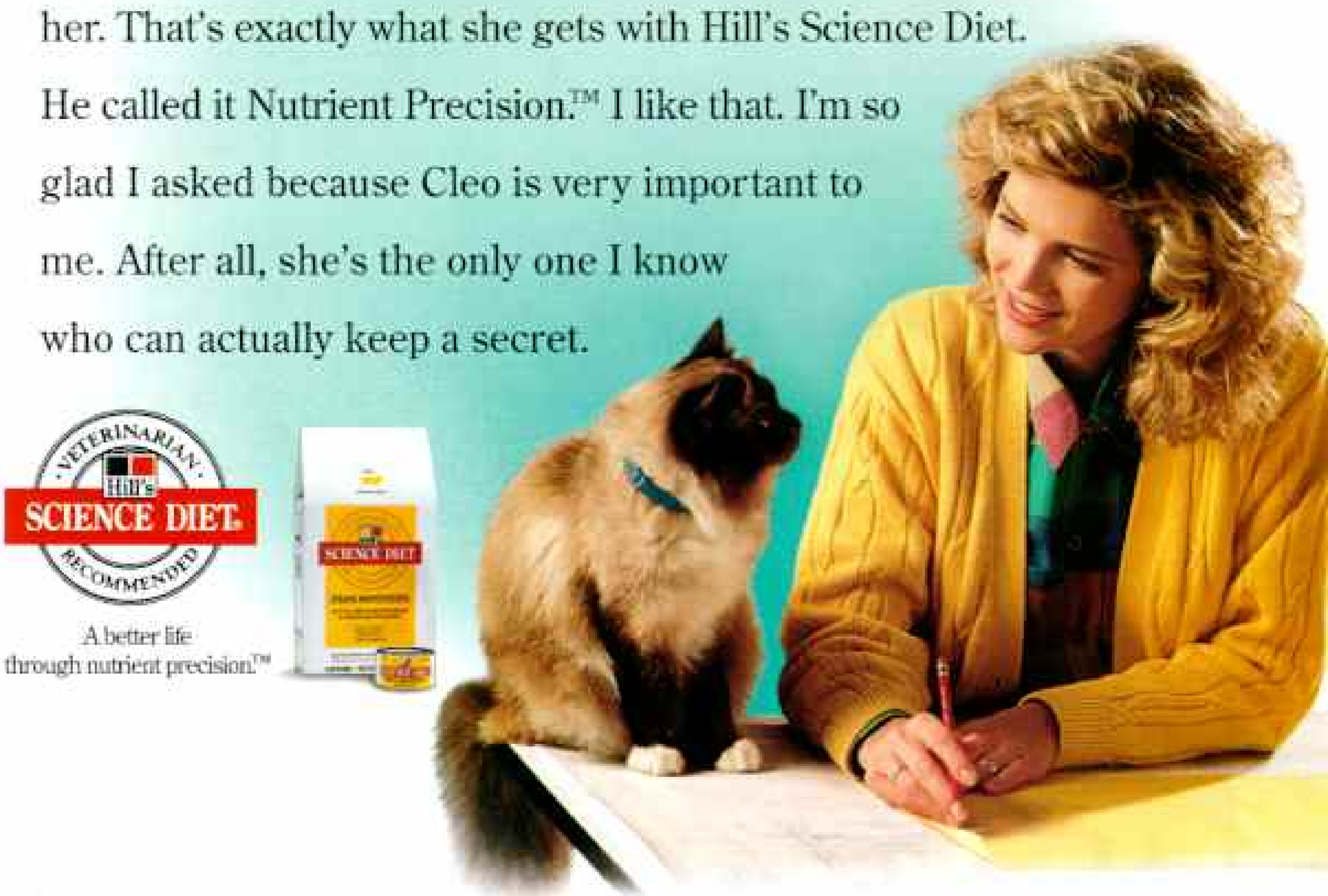
conversation. In fact, more satisfying conversation than I have with most people. Naturally, I want to do everything I can to keep Cleo her healthy best. So, I asked my veterinarian what food he recommends. Without skipping a beat, he said, "Hill's® Science Diet®." He said just as I have to eat a proper balance of foods to keep healthy, Cleo has to have a balance that's right for her. That's exactly what she gets with Hill's Science Diet. He called it Nutrient Precision.™ I like that. I'm so glad I asked because Cleo is very important to me. After all, she's the only one I know who can actually keep a secret.



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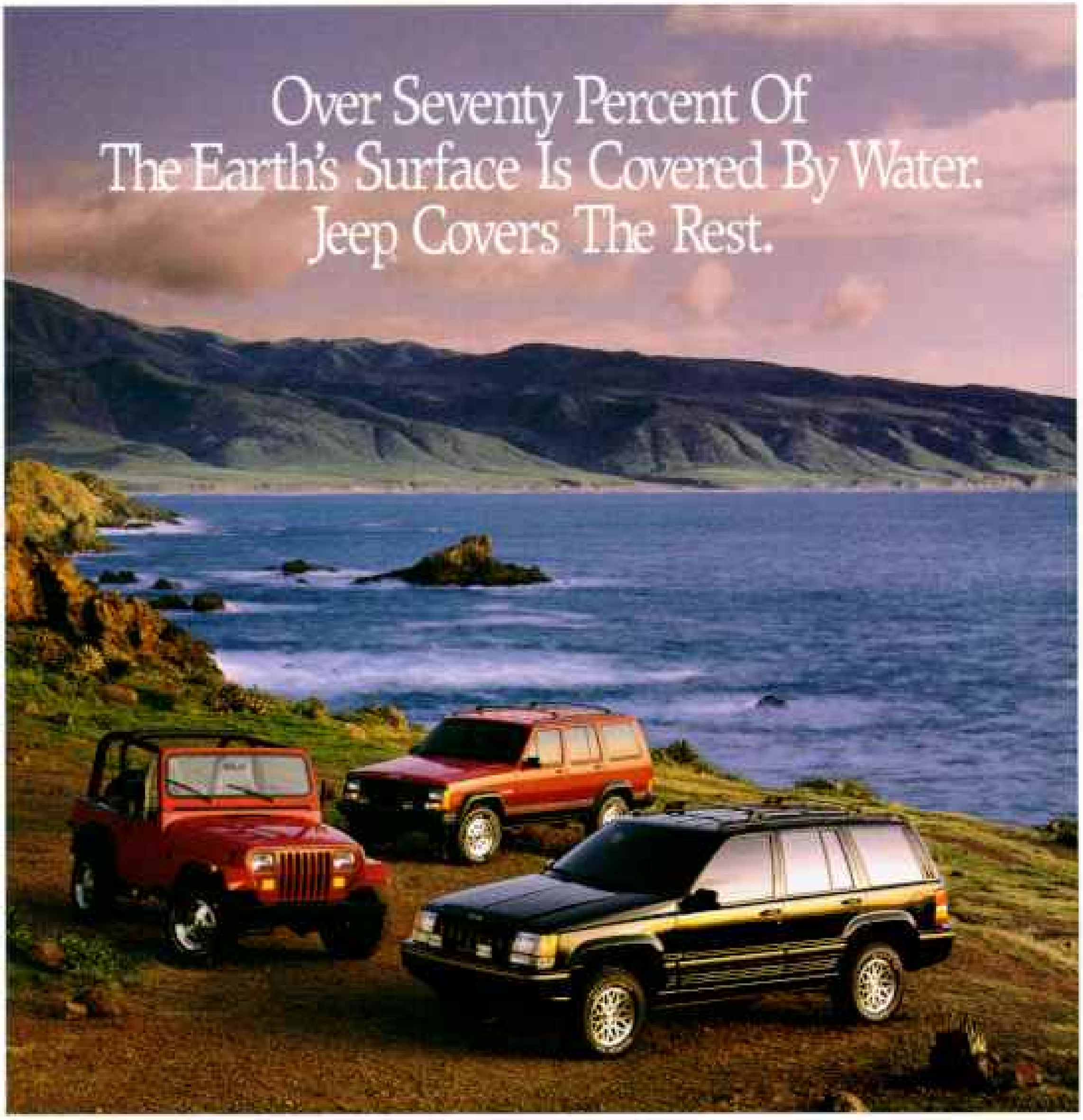

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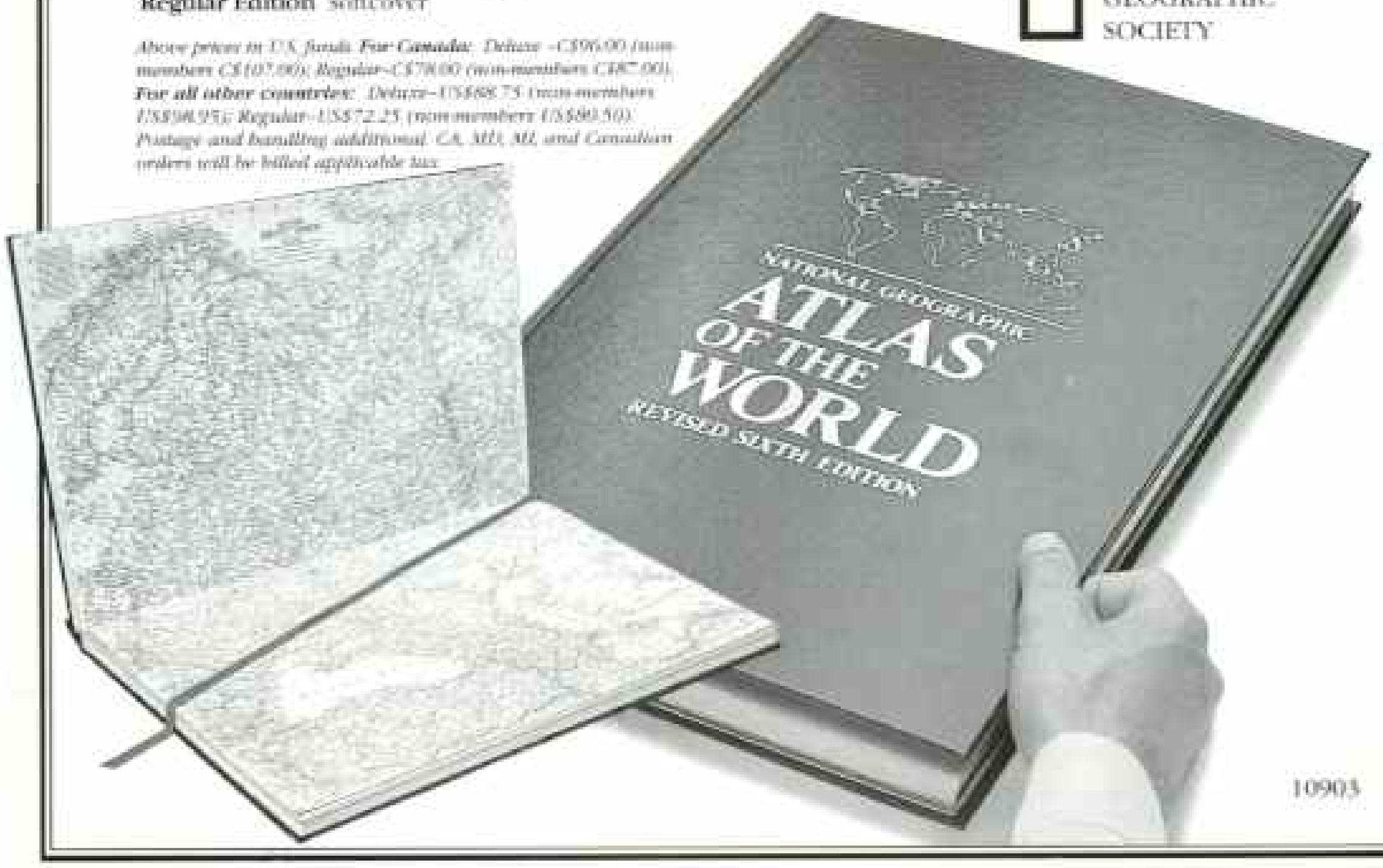

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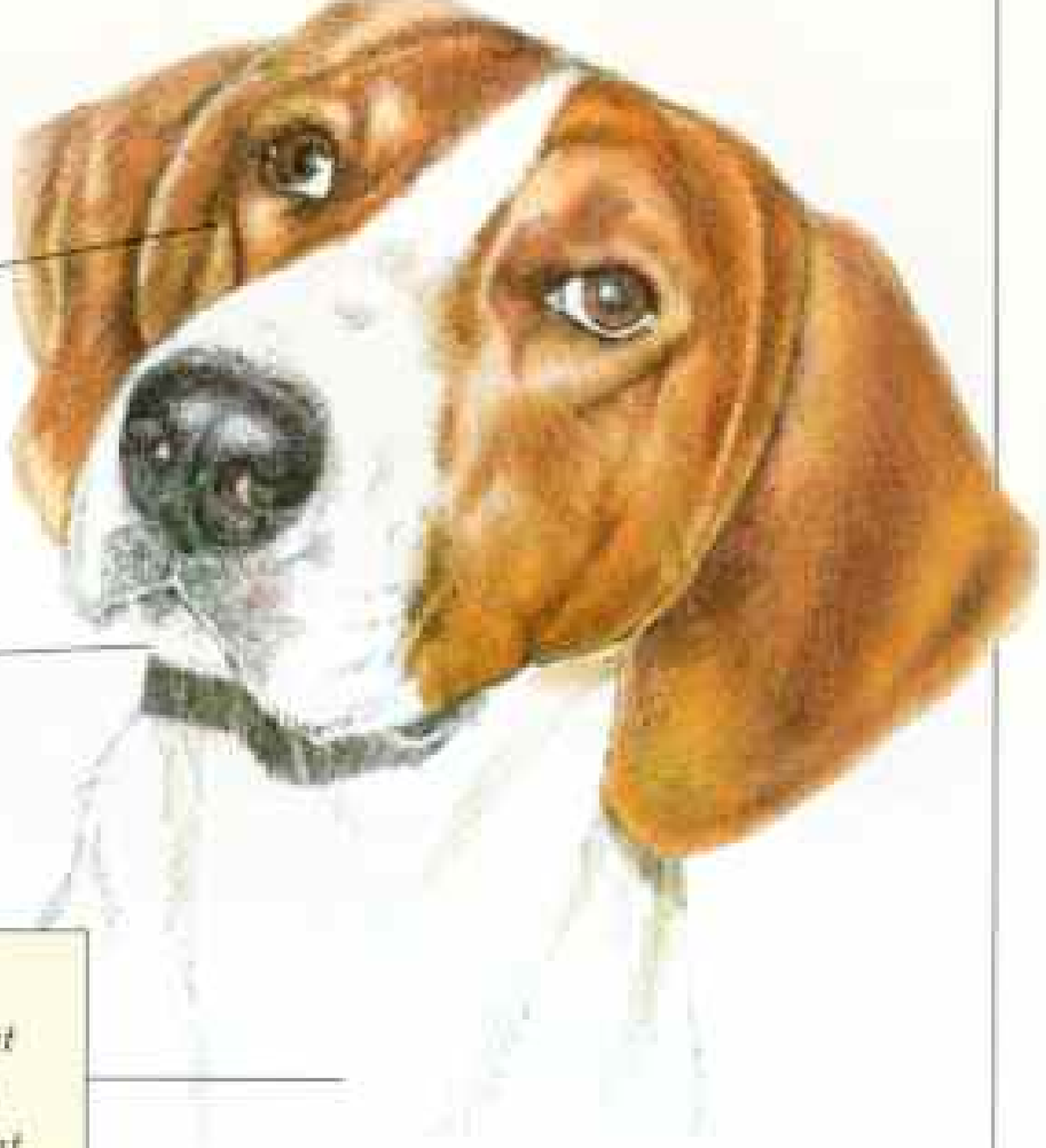
A thorough examination of why the more meat in IAMS matters.



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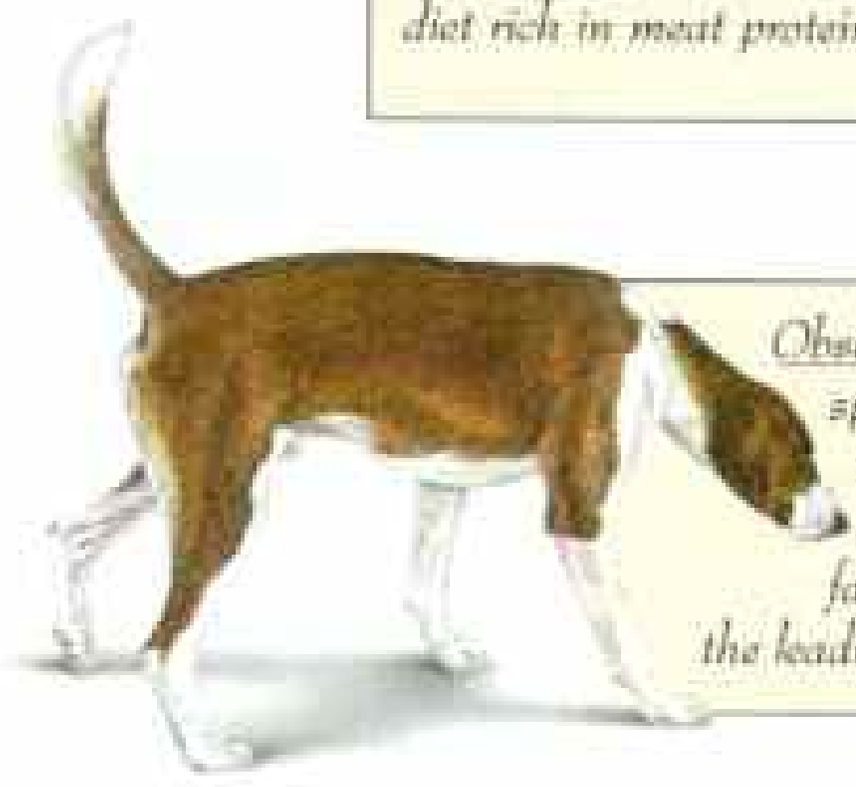

Observe your dog's level of activity. Because, generally speaking, when a dog looks and acts healthy, he is. Energy and proper muscle development come from a balanced diet high in protein. And the simple fact is, there's more meat protein in Iams than even the leading supermarket or specialty dry dog food.

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Iams is available only through leading pet supply stores, food stores and other pet professionals. For the store nearest you call 1-800-255-4738.

On Television

CARY WOLINSKY

Down the Volga: Journey to Russia's Heartland

A dream cruise has been put in dry dock. The prospect of a voyage on the Volga brightened long winter days for workers and their families during the communist era. Many sailed to Volgograd (above), known for its memorials to Soviet heroism in World War II. Now most of the Volga pleasure fleet lies idle, grounded in part by ticket prices that have soared to half a year's earnings.

To discover how ordinary citizens manage their lives in this time of turmoil, National Geographic filmmakers Peter and Cornelia Schnall traveled into the Russian heartland. Their film "Volga, the Soul of Russia," a two-part EXPLORER presentation, follows the river to uncover stories of personal experience amid public upheaval.

Ports of call include Kazan, capital of the Republic of Tatarstan, where a police captain battles corruption.

In the auto-manufacturing city of Togliatti a single mother paints cars on the assembly line but does not earn enough to both feed her family and buy a warm coat for herself.

A journalist in Astrakhan, "capital of caviar," investigates the least known of many environmental disasters in the Volga basin—underground nuclear explosions set off to create vast reservoirs for natural gas. Above ground, one of Russia's largest natural-gas processing plants, six years old and already outmoded, emits fumes so toxic that doctors say the health of children in villages 50 miles away is affected.

Russians affectionately call the 2,200-mile river, longest in Europe, Matushka, or "mother." As long as Russia rules the Volga, folks say, the country cannot be conquered. It is, however, caught in a sweep of radical change. Cornelia Schnall, raised in East Germany, was struck by a scene in Nizhniy Novgorod (right): "A vendor displayed *religious* art and engaged in *private* enterprise—and no one arrested her!"

CORNELIA SCHNALL

"Volga, the Soul of Russia" airs June 13 and 20 on EXPLORER, TBS SuperStation, 9 p.m. ET.

For our 125th birthday, we'd like to propose a toast.
Or at least a pizza, some french fries, and maybe a few nachos.

Earth Almanac

DOUG ALLAN, ANIMALS ANIMALS

Do El Niño's Ripples Extend to Antarctica?

Every few years the world's largest climate system runs amok. In a phenomenon known as El Niño, a huge pool of warm water in the western Pacific expands eastward, turning global weather patterns upside down from North and South America to Australia. Now scientists are learning that El Niño's long reach may extend to wildlife at the bottom of the world.

Weddell seals in Antarctica may be feeling El Niño's effect, according to Ward Testa of the University of Alaska Fairbanks. For the past 12 years an average of 420 seal pups were born annually at his study site in McMurdo Sound near Ross Island. But in 1992 only 330 pups were counted. El Niño had shown up in 1991 and continued into 1992.

Testa has observed that the seal birthrate has declined every four to six years—coinciding with strong El Niños. He speculates that their effects disturb currents and ice conditions in Antarctic seas, resulting in fewer fish. Stressed, the seals produce fewer pups. Similar patterns have been seen in seals studied by British observers on the Antarctic Peninsula.

Brazilian City's Blueprint: Environmental Harmony

A shining exception to many problem-ridden cities, Curitiba in southern Brazil is a model of environmental planning. Innovative programs control garbage, aid squatters fleeing rural poverty, run efficient mass transit, and create new parks for the city's 1.6 million people.

About 70 percent of the population recycle their trash. Incentives are offered in poorer neighborhoods, where a boy has exchanged garbage for bags of surplus vegetables (right).

Many buses work like subways. Passengers pay in advance and enter through wide doors. "The system transports 1.3 million people a day," says its champion, former Mayor Jaime Lerner. "That's four times as many as Rio de Janeiro's subway carries, and our system costs a hundred times less."

The parks program has created 550 square feet of open space for every citizen, three and a half times the amount in New York City. Lerner says his city can show others the way: "Every city can be a Curitiba."

ANTHONY SUAU

National Geographic, June 1993

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Earth Almanac

Starfish Leaves Predators With Slime on Their Faces

Any crab or fish that tries to eat one particular kind of starfish is in for a rude awakening. When disturbed, the slime star *(Pteraster tessalatus)* instantly secretes prodigious amounts of thick, rubbery, poisonous mucus to ward off enemies.

"I really love these things. Look at them the wrong way, and they'll slime you. They're such obnoxious animals," jokes marine ecologist Larry McEdward of the University of Florida. Funded in part by a Society research grant, McEdward has discovered that slime stars, found off the Pacific coast of North America, do not produce larvae, as other starfish do. Instead the embryos, which hatch from eggs, develop directly into juvenile slime stars—a newly discovered and highly evolved form of development.

L. P. BRAITHWAITE

Troubled Skies for North America's Largest Hawk

Sweeping over western grasslands on wings more than four feet long, the ferruginous hawk—named for its rust-colored feathers—is a hefty predator that weighs about four pounds. It fears little except human intrusion. In the lower 48 states only 3,000 breeding pairs remain, about the same as the number of bald eagles in the area.

Although the hawks are not classified as endangered or threatened, they are decreasing and are monitored by the U. S. Fish and Wildlife Service and conservation groups.

"Their prey includes prairie dogs, which are often poisoned as pests, and the hawks can pick up the poison, too," says biologist Eric Meyer of HawkWatch International. Loss of native grasslands has also meant fewer jackrabbits for the birds to eat. And if disturbed while on the nest—a spectacular structure that can reach 12 feet high and six feet across—the hawks will abandon their eggs, and the female will not lay a second clutch.

Hitchhikers Fight to Fly the Love Bug

Giant harlequin beetles of the Americas' tropical rain forest often change addresses by flying from one rotten fig tree to another when it's time to start a new generation.

Dozens of tiny hitchhikers—male and female pseudoscorpions also seeking a new home—swarm aboard each three-inch-long beetle before it departs from its old tree. Larger males shove many smaller pseudoscorpions off, then set up territories on the beetle's belly and fight to defend them. As the beetle takes wing, the pseudoscorpions hang on by spinning safety harnesses of silk and clutching with their claws.

When the beetle shuttle lands, large male pseudoscorpions kick off remaining rivals and mate with females. But once life in the new tree begins, smaller, quicker males appear to be better at finding mates than the big bullies, say researchers David and Jeanne Zeh of the Smithsonian Tropical Research Institute in Panama, who are conducting DNA tests on the pseudoscorpions.

—John L. Eliot

JEANNE A. ZEH, SMITHSONIAN TROPICAL RESEARCH INSTITUTE

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WILDLIFE AS CANON SEES IT

Blue-throated Macaw

Genus: *Ara*

Species: *glaucogularis*

Adult size: Length, 85 cm

Adult weight: 750 – 850 g

Habitat: Flooded savannahs in Bolivia

Surviving number: 28 known in the wild

Photographed by E. Nycander & C. Munn

A blue-throated macaw and its chick peering from the nest cavity are the first of this species to be photographed in the wild. Only in 1992 did scientists first locate and observe this enigmatic bird in its natural habitat. The largest animal endemic to Bolivia, the blue-throated macaw was feared to be near extinction, possibly a result of the pet trade. To save endangered species, it is essential to protect their habitats and understand the vital role of each species within the earth's ecosystems. Color images, with their unique ability to reach people, can help promote a greater awareness and understanding of the blue-throated macaw and our entire wildlife heritage.

NATURE

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

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On Assignment

MARK R. HOLMES, NGS STAFF

From high in the Ötztal Alps, author DAVID ROBERTS, right, and photographer KENNETH GARRETT survey the rugged terrain where the Iceman spent his final hours. The body was found near Niederjoch Glacier, behind them.

"It was like looking down on a three-dimensional map on which to plot the Iceman's route," says Roberts, himself a seasoned climber. "I could understand why he took one pass instead of another. I was seeing how he was seeing the landscape."

A former professor of literature and mountaineering at Hampshire College in Massachusetts, Roberts has written seven books. *Once They Moved Like the Wind,* due out in July, portrays the Apache warrior Geronimo, subject of Roberts's October 1992 GEOGRAPHIC article.

More comfortable in the jungles of Mesoamerica, where he has photographed Maya and Olmec cultures, Garrett quickly acclimated to icy elevations. Lingering to photograph shepherds, he was almost caught by a late summer storm. "That's probably what happened to the Iceman," he says. In Innsbruck, the Virginia-based Garrett was given 30 seconds to capture the frozen body on film. "The scientists pointed at the temperature gauge; and I kept shooting. It was not that different from shooting a sporting event at the second something happens."

JOHN GURCHE felt that he was living with the Iceman after spending 600 hours reconstructing his face. Using skills ranging from painting and sculpting to interpreting forensic data, the Denver artist finished by punching in human hairs for the beard.

For this last act, Gurche took out a newspaper ad: "I'll buy your beard!" A dozen people responded. "Finally a person came in with a dark beard of the right length," Gurche says. "My assistant snipped it off. Cost me $70. Weeks later I was still getting calls from people wanting to sell their beards."

Gurche also painted dinosaurs for the January 1993 issue.

KENNETH GARRETT

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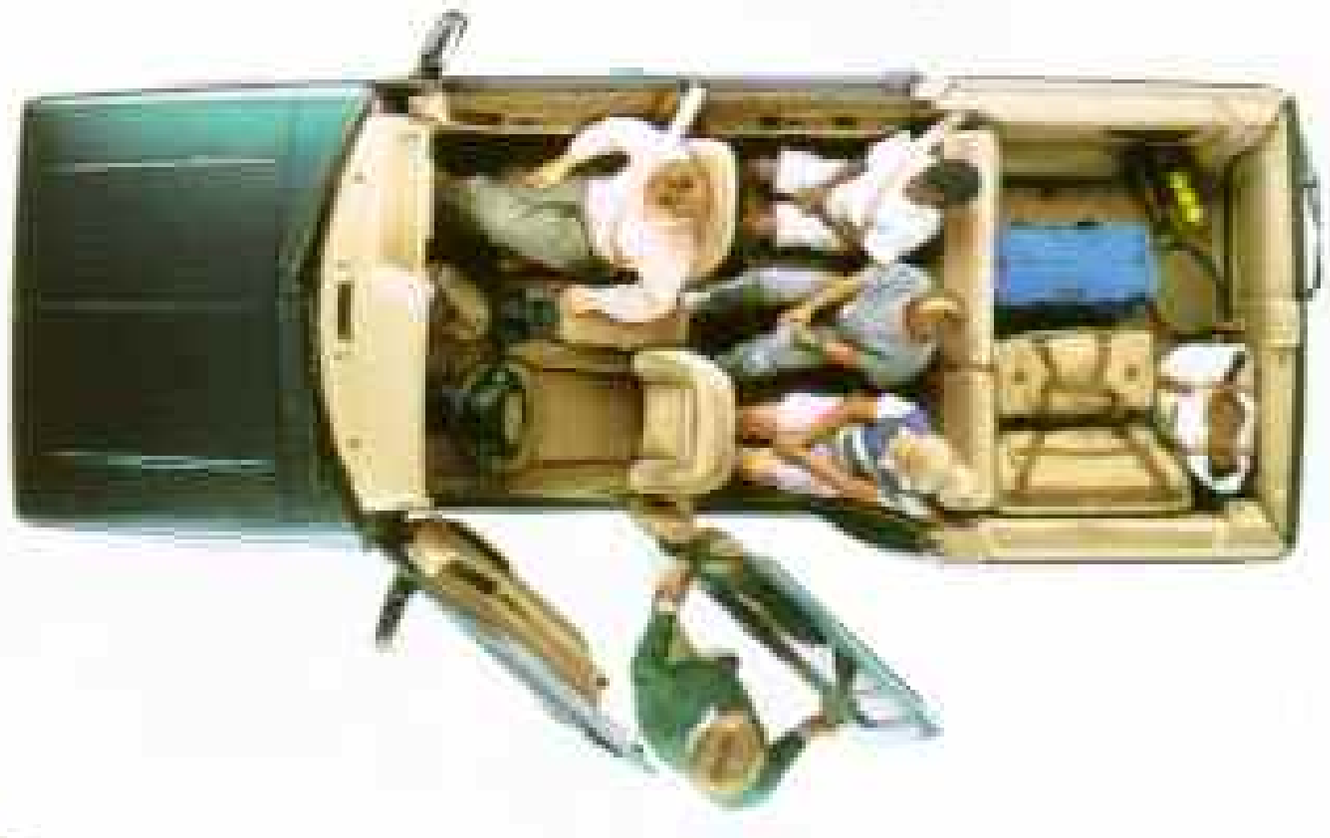
FIND YOURSELF

A thoughtful feature can make a big difference. With the spare stored under the vehicle, the cargo area is more generous and is easy-to-load.

More overall room than anything in this class. All passengers have easy access. Plus, the benefits of anti-lock brakes and a 4.0L EFI V-6.



Ford

Have you driven a Ford...lately?

Buckle up–together we can save lives.

IN AN EXPLORER.