

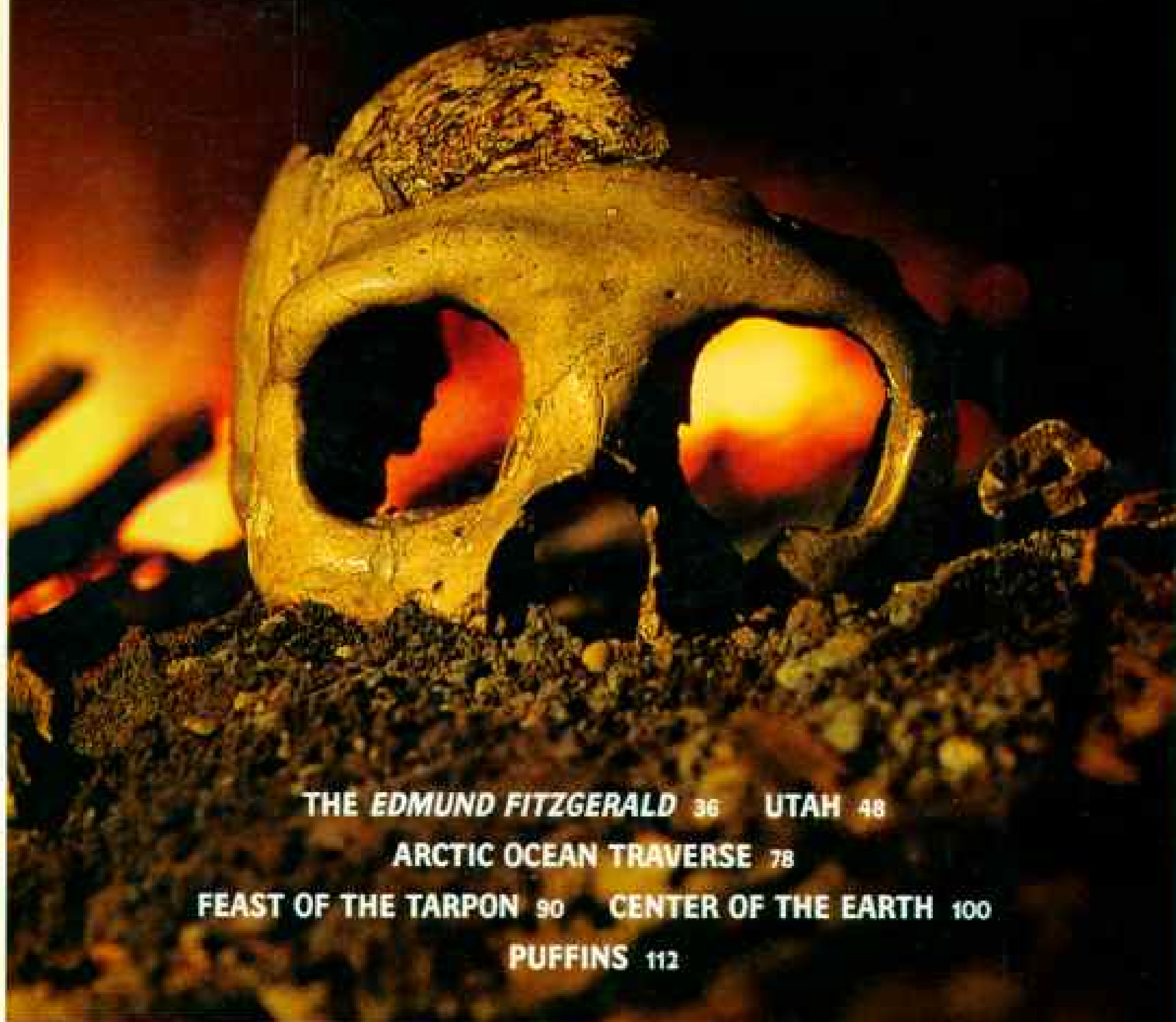
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NATIONAL GEOGRAPHIC

Neanderthals



THE EDMUND FITZGERALD 36 UTAH 48

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PUFFINS 112

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THE DAWN OF HUMANS

Neander

She was stocky, built for the cold. She was enormously strong. And her brain was larger than our own. Scientists have named her Krapina 3, for the cave in the Balkans where her skull was unearthed. This Neandertal woman—whose kind once dominated Europe—perished with a baffling secret. Were the Neandertals, who disappeared some 30,000 years ago, among our direct ancestors? Or were they a separate species—one driven to extinction by the arrival of modern humans? Experts are exploring the shadowy lives of these ancient people.

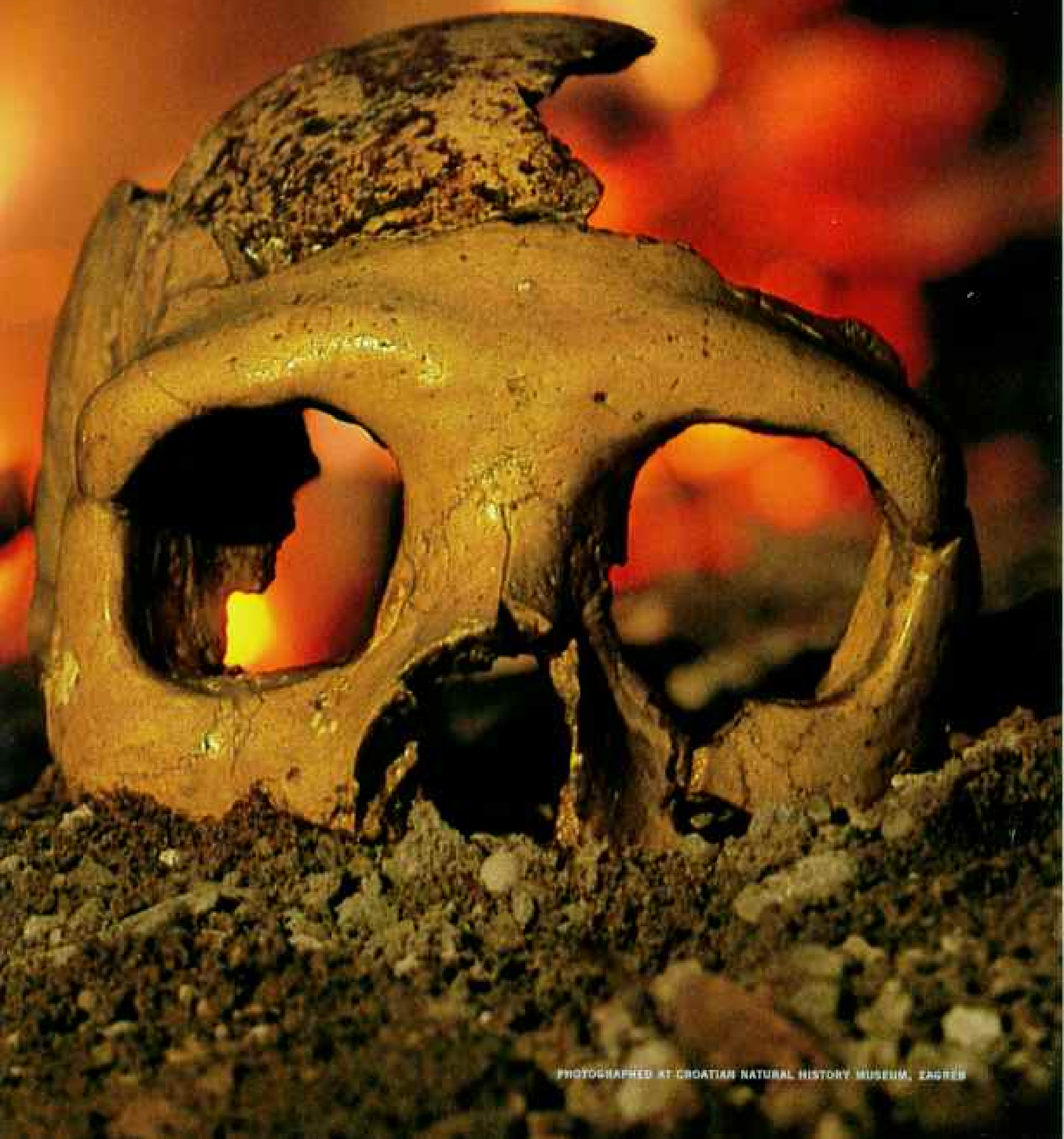
By RICK GORE
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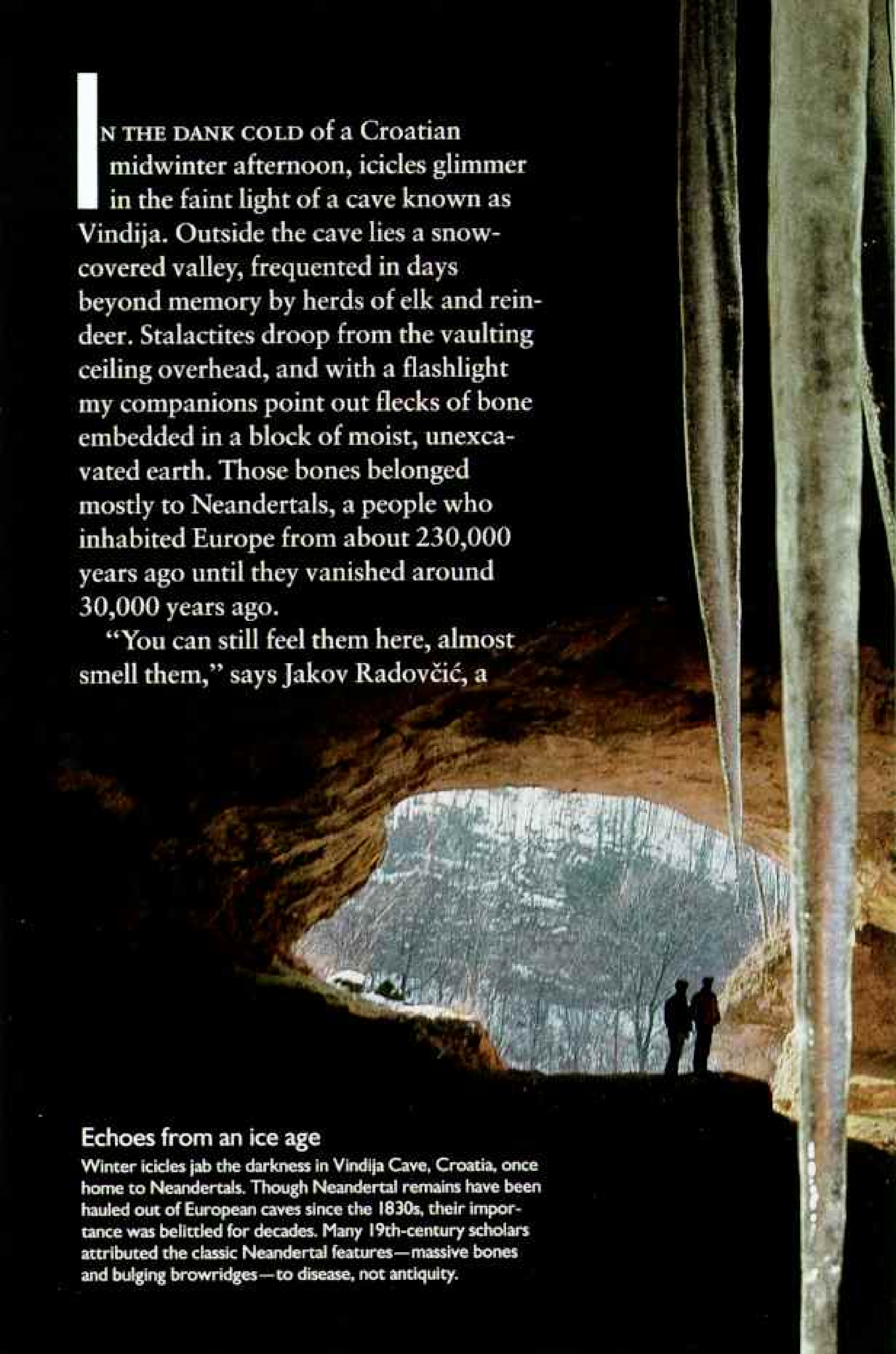


IN THE DANK COLD of a Croatian midwinter afternoon, icicles glimmer in the faint light of a cave known as Vindija. Outside the cave lies a snow-covered valley, frequented in days beyond memory by herds of elk and reindeer. Stalactites droop from the vaulting ceiling overhead, and with a flashlight my companions point out flecks of bone embedded in a block of moist, unexcavated earth. Those bones belonged mostly to Neandertals, a people who inhabited Europe from about 230,000 years ago until they vanished around 30,000 years ago.

“You can still feel them here, almost smell them,” says Jakov Radovčić, a

Echoes from an ice age

Winter icicles jab the darkness in Vindija Cave, Croatia, once home to Neandertals. Though Neandertal remains have been hauled out of European caves since the 1830s, their importance was belittled for decades. Many 19th-century scholars attributed the classic Neandertal features—massive bones and bulging browridges—to disease, not antiquity.





paleontologist at the Croatian Natural History Museum. "This was one of their shelters."

Analysis of Neandertal bones discovered here in the 1970s has yielded provocative clues to the lives of these hunter-gatherers, who occupied this cave some 50 millennia ago. Fine cut marks and unusual fractures—similar to those made on the bones of butchered animals—suggest that Neandertals practiced cannibalism, either from hunger or as some kind of death ritual. But finds at other Croatian caves suggest another, more compassionate side to the Neandertals. A skull fragment found at a nearby Neandertal rock-shelter shows evidence of a serious head wound that had healed. Someone had taken care of the victim for a long time.

Staring into the gloom, I imagine the cave's ancient inhabitants, wrapped in bear skins, huddled near a fire. The haunches of a reindeer roast in the fire.

A mother nurses her infant. Children playfully throw pieces of bone into the flames. An old woman tends the wounds of a hunter with an herbal ointment. The strong smells of smoke, unwashed bodies, and rotting carcasses thicken the air.

Flames highlight the Neandertals' faces, accentuating their broad noses and the thick browridges over their eyes. They lack the strong chins and high foreheads of modern humans. Instead their skulls slope back low over their brains. Beneath their eyes, their faces jut forward, making their cheekbones angle to the side rather than facing front, as ours do.

For many months I have been trailing these early humans, slipping through dark caves

KENNETH GARRETT frequently covers ancient peoples and civilizations for the *GEOGRAPHIC*. He photographed "The Timeless Vision of Teotihuacan" in last month's issue.

Locked in time

Flowstone shrouds the skeleton of a middle Pleistocene hominid discovered by cavers near Altamura, Italy, in 1993. With fewer than 30 Neandertal skeletons known to science, such finds are anthropological gold. Altamura also contains thousands of animal bones, probably washed down ancient sinkholes.

such as this one to reach their haunts, holding their stone tools and bone fragments in my hands. Gradually, I have discarded the old stereotype of Neandertals as insensitive brutes. So have most scientists.

In the past, scholars did indeed view Neandertals as hulking subhumans of low intelligence who lacked the anatomical or intellectual ability to speak. Neandertals left scant evidence that they could create art. They appeared uninventive; their toolmaking skills seemed primitive.

Recent excavations and analysis have demonstrated that Neandertal tools in fact required a high level of craftsmanship and mental skills as adept as modern humans'. Neandertals deftly worked pieces of flint into knives, scrapers, points, and blades. They organized group hunts and took care of the weak and the sick, which suggests a social organization

more complex than previously believed. Most scholars now accept the idea that Neandertals spoke at least a rudimentary language.

"Neandertals were highly resourceful, highly intelligent creatures," says Fred Smith, a Neandertal specialist at Northern Illinois University. "They were not big, dumb brutes by any stretch of the imagination. They were us—only different."

And that, for modern man, is the challenge of Neandertals—to understand them as creatures coping with a world that was unlike ours. They lived and died by the rules of carnivores, surviving as animals must in a harsh, cold land. Yet they were large-brained humans, with all the mental complexity that that endowment implies. How did they think? How did they feel? Despite all our enticing new clues, the Neandertals remain a people of mystery.



Articles in this series focus on early members of our own genus and the hominids that preceded them. Much of this research was supported by your Society.



A troublesome treasure

Dislodged by quarrymen's picks near Düsseldorf, Germany, in 1856, the first recognized Neandertal fossils (right) took their name from the picturesque Neanderthal, or Neander Valley, where they were found. (The silent "h" in *thal* has been dropped in modern German.) The valley—featured in 19th-century travel guides—has been largely destroyed for its limestone, but the controversy surrounding its famed fossils endures. One early scientist dismissed them as the remains of "some poor idiot or hermit." Another, citing the Neandertal's heavy, bowed legs, declared the skeleton's owner to be a Mongolian cavalryman who had suffered from rickets. Eventually the Neandertal bones would play a key role in supporting the most radical new scientific idea of the time—Charles Darwin's theory of evolution. Though Neandertals have been intensely studied for nearly 150 years, much about them still sparks debate. One example: cannibalism. Cut marks on a skull from Krapina Cave in Croatia (below) suggest to some that Neandertals had a taste for human flesh. Others believe the marks are ceremonial.



MYSTERY PROVOKES CONTROVERSY, which the Neandertals have sparked since the discovery of the remains of a Neandertal in the Neander Valley of Germany in 1856. (There is even disagreement over their name. *Tal* means "valley" in today's German, but the word was spelled *thal* in the 19th century. Some scientists still prefer the original spelling, Neanderthal.)

Found by quarry workers near Düsseldorf, the original Neandertal man was proclaimed by some to be the missing link between apes and humans. Others argued that this odd specimen with the apelike browridges was simply a misshapen freak from the Middle Ages. But soon more bones with the same strange features were unearthed in Belgium, France, and

other parts of Europe. Then, at the turn of the century, the bones of as many as 80 Neandertals were discovered in a cave in the Croatian village of Krapina. By then it was clear: These people were not modern humans.

The origins of the Neandertals are uncertain, but scientists suspect that they share a common ancestor with modern humans: a tall, slender species known as *Homo erectus*, which migrated into Europe probably from Africa through western Asia between 700,000 and a million years ago.

Nor does anyone understand why Neandertals disappeared. Around 40,000 years ago modern humans began spreading through Europe. By about 10,000 years after their arrival, all record of Neandertal life ends. Perhaps the modern humans conquered and destroyed the



PHOTOGRAPHED AT FREIJSCHES LANDESMUSEUM, BOHN CAROVEL, CROATIAN NATURAL HISTORY MUSEUM

Neandertals. Perhaps the newcomers introduced deadly new diseases, much as Europeans carried smallpox to the New World. The Neandertals might have interbred with the modern humans. Or maybe the Neandertals slowly died off, unable to compete with the more adaptable moderns.

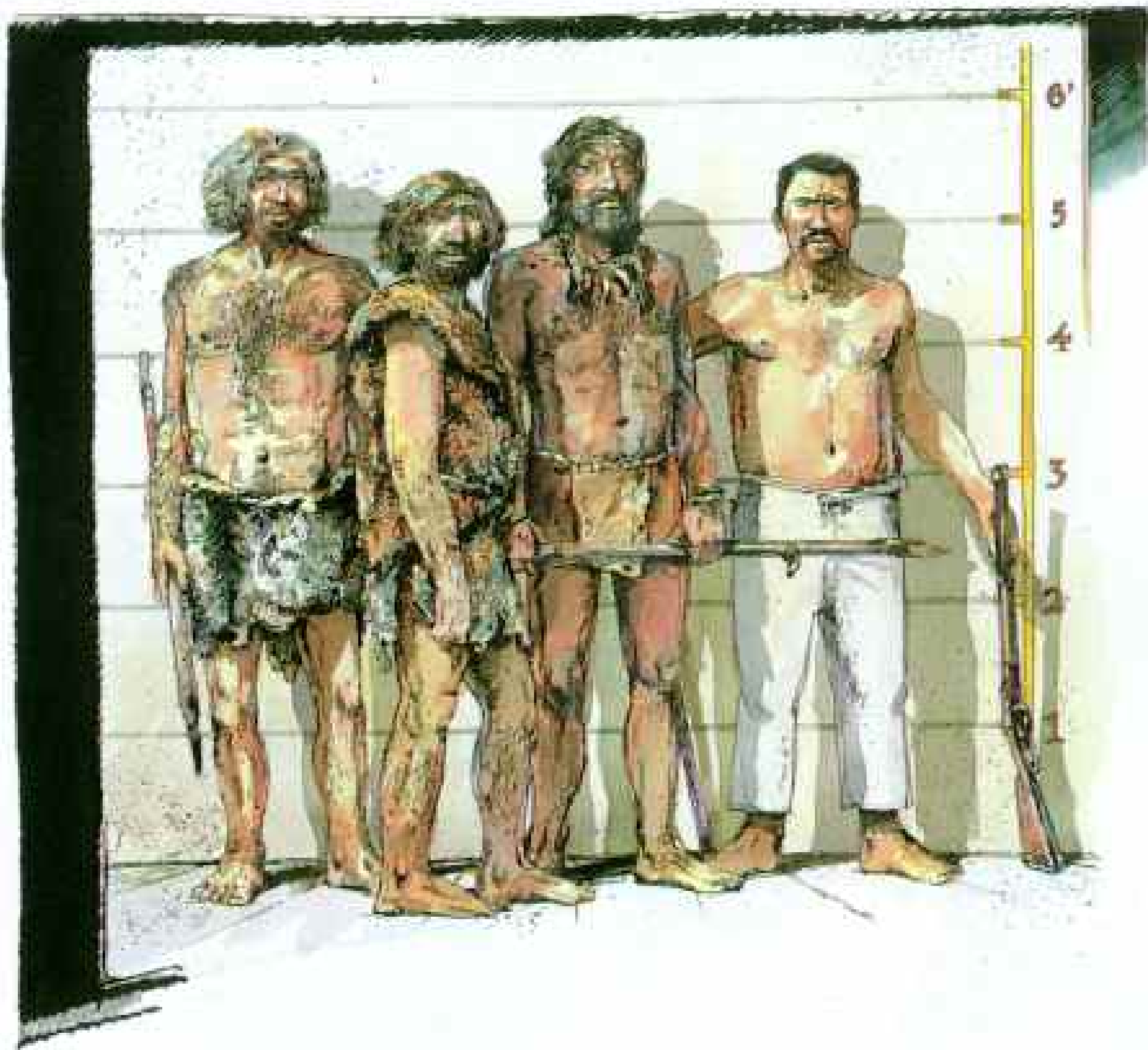
We do know that Neandertals roamed as far north as Britain and as far south as Spain, probably in bands of fewer than 30. From central Europe they extended east into central Asia and migrated into the Middle East. Never numerous, their total population at any one time probably numbered only in the tens of thousands.

The land that shaped the Neandertals was a harsh, often frigid wilderness. Occasionally, warm periods would moderate the climate,

creating subtropical conditions as far north as England for 10,000 years or more. During those mild times hippopotamuses flourished in the Thames. But the glaciers always returned, and the Neandertals adapted to survive.

Like Arctic dwellers today, Neandertals had short limbs and stocky bodies. "In cold climates you want to have a thick body core to retain heat and a relatively small amount of surface area from which to lose it," says Erik Trinkaus, a Neandertal specialist at the University of New Mexico.

Their powerful musculature enabled them to bring down big game, such as bison or elk. Their noses were broad, possibly to provide more inner surface area to add moisture to the frigid, dry air they had to breathe. On average they had even larger brains than people do



Climate makes the man

Short, thick bodies retain heat better than tall, slim physiques. Thus, from left to right, pre-Neandertals may have inherited tall builds from the first humans to leave balmy Africa. The "classic" Neandertals of later ice ages were shorter. Early modern humans—again, probably from Africa—were tall and possibly darker skinned. Today's Inuit show cold-adaptations such as barrel chests.

today, but in this case it seems that bigger didn't necessarily mean smarter. Because we are smaller in physique, our brains are relatively larger. Some experts speculate that Neandertals needed more brain cells to coordinate their extra body mass.

These Neandertal traits probably began emerging between 230,000 and 300,000 years ago. Evidence of their antiquity has recently been discovered in the muddy floor of a cave in the Sierra de Atapuerca of northern Spain.

ALIGHT SHINES at the bottom of a pit more than 40 feet below me as I grasp a rope with both hands and, hoping my harness holds, swing out into the dark at the site known as La Sima de los Huesos. Two of the Spanish paleontologists who are excavating here begin to lower me down the shaft with a pulley. My shaking leg finds the first rung of a chain-link ladder that lies flat against the wall of the shaft.

Inexperienced in caving, my body involuntarily swings out of control away from the wall of cold, wet limestone. Finally, I twist and stabilize. Sweating and cursing to myself, I slowly flail my way down, rung by rung.

Reaching the bottom of the shaft, about 160 feet underground, I am greeted by the team's leader, Juan-Luis Arsuaga of the Complutensian University of Madrid.

"This is the last heroic excavation in Europe," he boasts. I look up the shaft and think he's right. For one thing, it took heroic persistence to haul tons of excavated dirt in backpacks up that shaft.

"Be careful not to step on any ground," says Arsuaga as we walk across scaffolding into the chamber. "It's filled with human remains. We have found pieces of at least 30 individuals here. There are probably many more."

Arsuaga believes these people lived here about 300,000 years. (Continued on page 16)

Years before present



The icy world of Neanderthals

Living on the chilly fringes of the Eurasian ice sheets, Neanderthals flourished for 200,000 years, eventually spreading from Gibraltar to Uzbekistan. Herds of elk and horses grazed European grasslands, and forests lay pooled in protected valleys. But not all of the Neanderthal reign was glacial. During interglacial times (see time line) Neanderthals undoubtedly pushed north as ice sheets shrank, leaving their stone tools in their wake. When the deep freeze returned in the late Pleistocene, they retreated as far south as Israel. Meanwhile, in Africa and possibly in the Middle East, anatomically modern humans were evolving. The origins and relatedness of the two groups are still murky, but the ultimate result of their meeting is not. Some 40,000 years ago, propelled by a cultural explosion in toolmaking, language, and art, the moderns strode into Europe. In just 10,000 years the Neanderthals and their culture were gone—vanquished or absorbed.

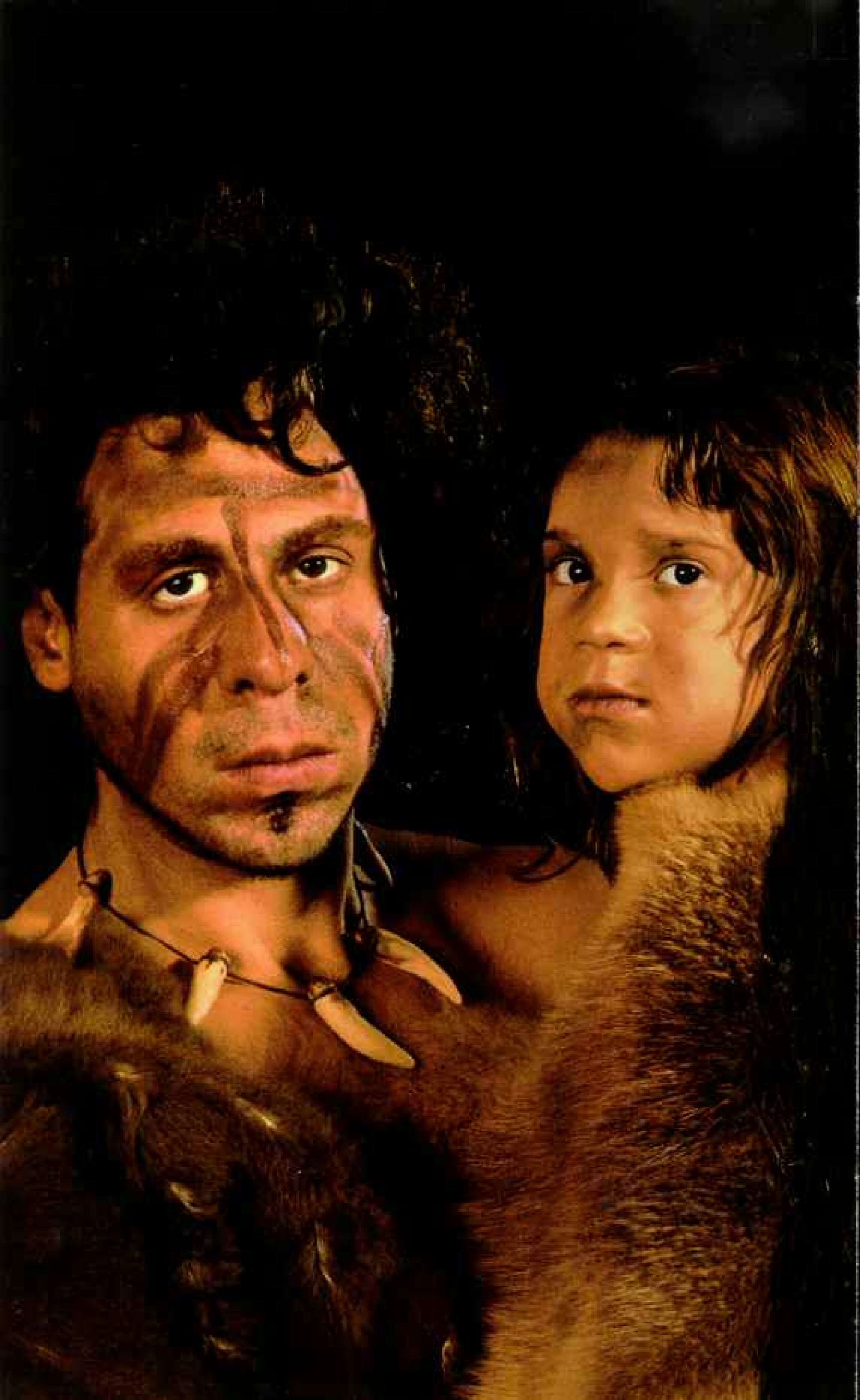
Signatures in stone

Different stone tools have long been associated with specific human ancestors. *Homo erectus*, the first hominid to leave Africa, crafted heavy Acheulean hand axes. The Neanderthals'

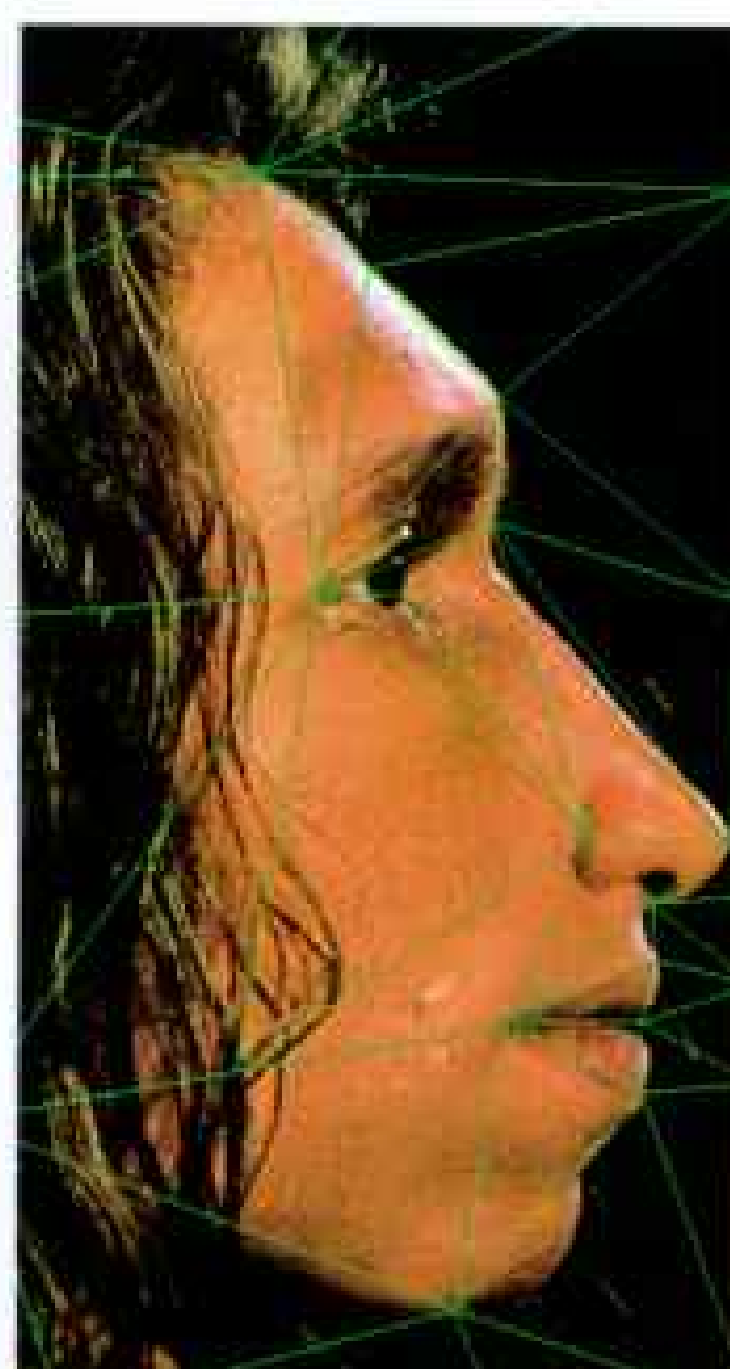
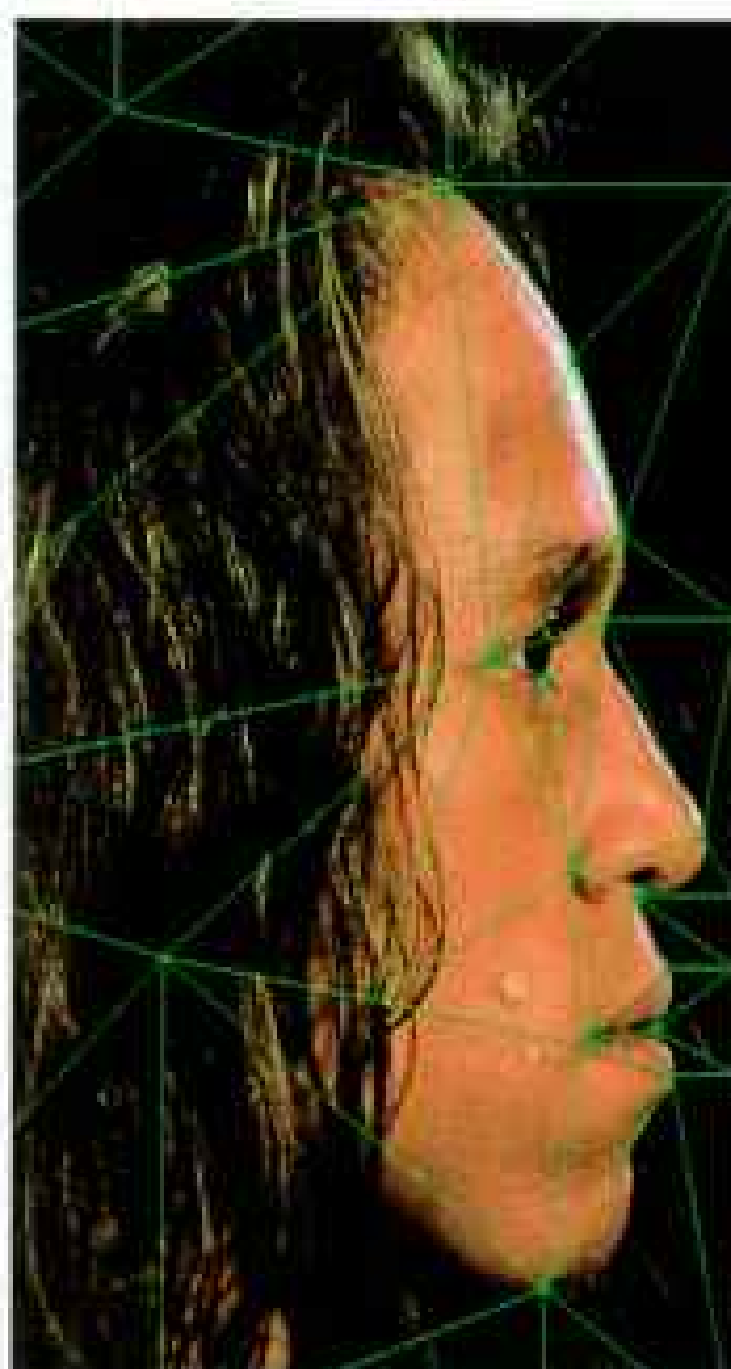
Mousterian technology—flaked tools such as scrapers and points—remained largely unchanged for more than 100,000 years. Near the end of their existence Neanderthals

created more complex implements, possibly with hafted points, called Châtelperronian technology. Aurignacian blade tools are generally associated with early modern people.





Virtual Neandertals



DATA FOR RECONSTRUCTIONS FROM NATURAL HISTORY MUSEUM, LONDON; UNIVERSITY OF ZURICH, AND CYBERMARK

Grafting images of living humans onto Neandertal skulls, computer experts at the University of Illinois at Chicago have resurrected faces that last gazed out on an ice age.

"It was pretty amazing to see the profile appear," says Paul Neumann (below right), a researcher at the school's Biomedical Visualization Laboratory, who performed the computerized makeovers (left).

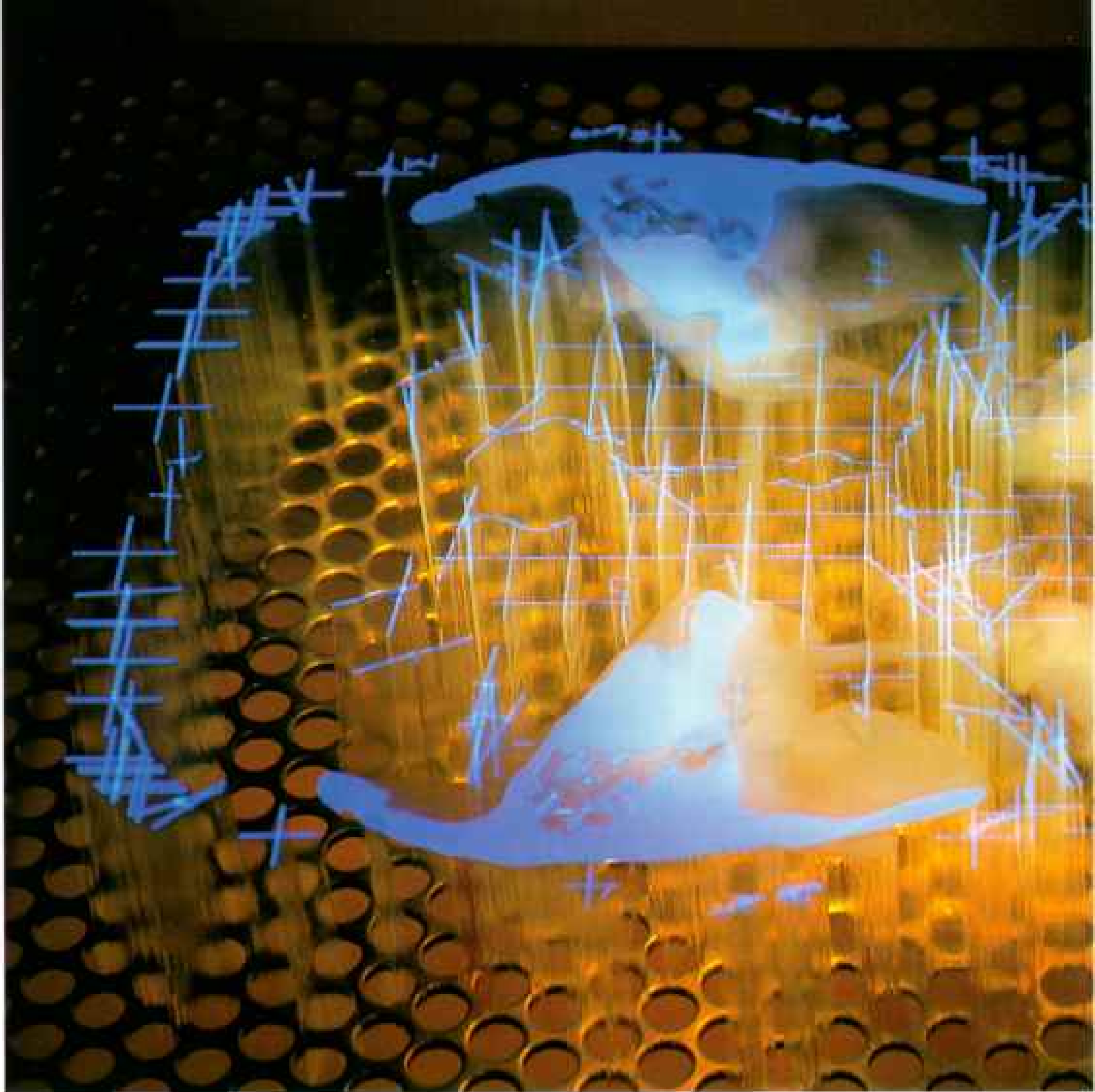
Anthropologists surmise that the Neandertals' large noses helped warm chilly air as it traveled through the head to the lungs. Other differences from modern humans include a receding forehead and chin, a heavy jawbone, bigger front teeth, and bony brows. Accommodating the child model's head to the larger Neandertal skull made her look older than her five years.

The wizardry was accomplished with software designed to artificially age missing children and reconstruct the faces on unidentified

skeletal remains. After digitizing images of the ancient skulls and the models' faces, researchers assigned cranial landmarks (above) where tissue depths could be calculated from anatomical data collected from modern humans. The computer then "morphed" the face to fit the skull. So massive are

Neandertal crania that the models' eyeballs stretched noticeably—they had to be redrawn on the screen manually. Some experts believe Neandertal noses were even bigger than the computer's reconstructions. Hairiness—impossible to deduce from the fossil record—was not enhanced.





(Continued from page 10) ago, although the exact date of the deposit is uncertain. He calls them pre-Neandertals, because their faces differ from classic Neandertals but show the onset of features we now associate with the group. They may be the Neandertals' immediate ancestors.

We join several of Arsuaga's young colleagues and students, who sit or lie on the scaffolding, picking out tiny pieces of bone from the dirt below them. A few lightbulbs illuminate the walls of the musty chamber. Someone had painted "Chris 1955" on one wall. On my descent I saw the names of other adventurers, dating back to the 16th century. One had carved "1585" next to his graffiti on the limestone—not far from claw marks engraved many millennia earlier by a bear.

"It was a local tradition for young men to come down here as an act of bravery," explains a team member. "They collected fossil teeth of bears to present to their girlfriends. Over time the cave became famous among speleologists. Then in the 1970s a paleontologist from Madrid recognized 'bear teeth' from the cave as human."

That discovery sparked the interest of other paleontologists, and in 1984 the laborious excavation finally began. A few years ago the team's hard work began to pay off. They found three nearly complete skulls, which showed that the middle of these people's faces projected out like a Neandertal's. The backs of the skulls also had a slight bulge, evocative of the one seen in classic Neandertals.

Why the remains of so many people lie

Piecing together the past

Computers have replaced glue and plaster as the tools of choice for rebuilding and copying fragmentary Neandertal fossils. Using CT-scan technology and 3-D software, researchers in Zurich, Switzerland, were able to replicate a child's skull that was missing a third of its bone structure. First, computer mirror imaging fills in the bone gaps. Then, in a process called stereolithography, a computer-guided laser (blue, at left) hardens layers of plastic resin in the shape of the skull's cross sections. Bit by bit, a precise copy of the skull takes shape. The replica (shown in finished and unfinished versions below, with casts of the original fossil fragments) was used in the digital imaging on the preceding pages. "The big problem with fossil hominids is that they are difficult to get your hands on," says French paleontologist Jean-Jacques Hublin (bottom), making a CT scan in Paris. "With this technology everybody can have a real and a virtual reality skull copy. In your computer you can go caving in its sinuses."



SKULL FROM MUSÉE DE L'HOMME, PARIS



A hole to nowhere

Tumbling into a gruesome grave, the body of a young pre-Neandertal is cast into the darkness some 300,000 years ago in northern Spain. The shaft, deep inside a cave in the Sierra de Atapuerca, may once have been located near a cavern mouth and hominid living area, long since obliterated by a landslide. Researchers have excavated hundreds of animal bones and the remains of more than 30 humans from test pits in a chamber beneath the vertical well (below). The human fossils are unique: Reaching back to the very origin of Neandertals, they hint at a transitional stage from a more ancient ancestor, *Homo erectus*. "It was like finding the Holy Grail," says paleontologist Juan-Luis Arsuaga (below right, in red). "I spent my youth digging here. During the rest of my life, I'll explore maybe a third of the cave." The richness of the site has scientists baffled. Some believe bodies were disposed of in the shaft simply for housecleaning. Others suspect ritual or cite the possibility of a natural disaster.



Conditions at the Spanish cave site, called La Sima de los Huesos, are grueling. Oxygen is in short supply. And rock and dirt removed from test pits must be carried up a 40-foot shaft in backpacks.

Orange areas indicate test pits.

clustered here is unknown. Perhaps the cave collapsed or a catastrophic flood swept the bodies here. Maybe the cave was a favorite feasting site for predators. But Arsuaga and his team have offered a more intriguing possibility.

"They weren't brought here by carnivores," says José Miguel Carretero, a paleoanthropologist. "None of the bones have tooth marks, and there are no remains of other species carnivores prey on.

"We think that there once was another, easier entrance close to here that has since collapsed. But there are no tools, so people weren't living here. Maybe they inhabited the entrance to the cave, and since corpses smell, they dropped the bodies of their dead down here to dispose of them. Perhaps there was a ritual. Whatever the reason, they gave their dead special treatment. This tells us something about how their minds had evolved. Animals don't take care of their dead."

This practice was a harbinger of the simple grave offerings of the later Neandertals—perhaps one of many cultural behaviors they inherited. Like the front teeth of classic Neandertals, all those found in the chamber show extreme wear. Specialists say that Neandertals used their front teeth as a third hand, or vise, to hold objects they were cutting with stone tools. The teeth at Atapuerca suggest that the Neandertals' ancestors were doing the same.

ATAPUERCA'S beautifully preserved fossils will continue to yield clues about Neandertal beginnings. Meanwhile, recent dating has pushed back the age of the first people generally accepted as true Neandertals by 100,000 years—to 230,000 years ago.

An important cache of these early Neandertals was unearthed in 1976 at Biache-Saint-Vaast in northern France by workers excavating the foundation for a new steel mill. They found two partial Neandertal skulls, along with hundreds of flint tools and animal bones. The workers had apparently stumbled across a camp where Neandertals butchered animals. French scientists see evidence in these artifacts of a surprisingly advanced tool kit.

The many animal bones unearthed at Biache-Saint-Vaast were primarily from cave bears and aurochs, long-horned wild oxen that are now extinct. Many of the bear paws have cut marks on the bone, indicating that Neandertals had sliced the skin off with their sharp flints.

A decade ago these early Neandertals were widely viewed as scavengers, incapable of planning an activity as complex as a hunt, much less one involving such fierce quarry.

But Alain Tuffreau, an archaeologist at the University of Science and Technology of Lille, says such slaughters show that these people were more advanced. "I think it's evidence





Tough lives, tender mercies

Battered bones tell stories of woe—and kindness—in the late Pleistocene. Four out of six adult Neandertal skeletons found in a cave near Shanidar, Iraq, are deformed by disease and injuries. One man, called Shanidar I (left), suffered crushing wounds to his right leg, ankle, and foot; a blow to his skull that probably blinded him in one eye; and the shattering of his right arm, which was severed above the elbow. The rib of another individual (below) was notched, possibly by a stab wound. And painful arthritis, visible on the ankle bones (bottom), plagued several Shanidar cave dwellers. All the injuries show signs of healing, evidence that crippled members of the group were fed, protected, and helped to move by others—the dawn of empathy. Simple burials (inset) herald another milestone in human history: a glimmering sense of mortality. “Neandertal life was clearly very hard and very dangerous,” says paleontologist Erik Trinkaus, who believes that some Shanidar injuries may be the result of rockfalls. “They were tough survivors.” The oldest person at Shanidar lived about 45 years. Most Neandertals didn’t survive their 30s.



FOSSELS FROM SMITHSONIAN INSTITUTION

that they were hunting in groups,” he says. “Many of the bones belonged to young adult aurochs. They were very strong and dangerous. Animals of that age don’t normally die together in such large numbers. For humans to kill such big mammals before bows and arrows were invented, they needed a group and a strategy.”

THIS SCANT PORTRAIT of early Neandertals fades after about 180,000 years ago, when glaciers once again descended on Europe. For the next 50 millennia the continent appears largely uninhabited. Some Neandertals struggled through the cold, but they left almost no record. By the time the warmth returned, they had developed their full complement of characteristic features. They also left many more clues—bones, tools, and a few other artifacts—that sketch in the picture of who they were and how they lived. This was the beginning of the Neandertals’ heyday.

The Neandertals of Krapina, the Croatian cave discovered around the turn of the century and now dated at 130,000 years ago, had the barrel chest, robust limbs, broad, short body, and “occipital bun”—a bulge at the base of the skull—typical of classic Neandertals. Animal remains found in the cave testify to the Neandertals’ strength and prowess. Juvenile rhinoceros bones suggest that Neandertal hunters targeted the young of large species whose protective mothers could be extremely dangerous.

“Certainly by 125,000 years ago they had become formidable hunters as well as gatherers of edible plants, shellfish, and small reptiles,” says Mary Stiner, an archaeologist at the University of Arizona, whose research with her colleague and husband, Steven Kuhn, has broken new ground in understanding how the Neandertals interacted with other animals.

Neandertals, Stiner explains, had been competing for food with other predators—wolves, hyenas, and lions. As their hunting skills developed, Neandertals could start going after prey the other carnivores avoided—big, prime-age elk, bison, or even mammoths, whose meat provided more energy-laden fat. With enriched diets, Neandertal populations probably expanded, increasing their impact on other species.

But the Neandertals lacked elaborate



Ice age pursuit

"Once you get going, it's not so difficult," says Pekka Aikio, an ethnic Sami in Finland whose family raises and races reindeer, once common Neandertal prey. Scientists point out that Neandertals, far from being slow-witted primitives, had to be resourceful to bring down such large, swift quarry.

weapons; they had to kill through cooperation.

"Surrounding and confusing prey is a classic predatory tactic," says Kuhn. "A few cooperating hunters could have exploited natural landscape features like bogs and deep stream banks that put large animals at a disadvantage. They probably killed at close range with wooden spears that perhaps had a sharp stone point."

A wooden spear nearly eight feet long was found among the bones of a fossil elephant discovered in 1948 in a bog in Germany.

HUNTING wasn't the only form of cooperation Neandertals practiced. They bonded into close social groups, as a collection of skeletons from a cave called Shanidar in Iraq poignantly illustrates. There, around 100,000 years ago, a

man, two women, and an infant were buried together. Excavators found the pollen of early spring wildflowers in the soil around the corpses.

"I suspect they died of starvation in the late winter, when the stresses were greatest and the food resources leanest," says Erik Trinkaus, who spent the late 1970s studying the Shanidar specimens. "I think the flowers were set around them by the rest of their social group. That suggests that they were thinking and caring about their dead."

With Shanidar, for the first time, I begin to feel a kinship with these people. Is this flower burial a sign of love and compassion? At Atapuerca the Neandertals' ancestors left no evidence that they had felt such emotions. Maybe the later Neandertals were enough like us to recognize the void in their hearts.



Shanidar Cave tells other stories, and Erik Trinkaus weaves the tales well. Tall and scholarly, his eyes brighten and grow wide when his hands touch ancient bones. In his lab in Albuquerque, Trinkaus takes out four boxes containing his most precious specimen—the pieces of a man known as Shanidar 3, who was buried in the cave during a second Neandertal occupation, perhaps 50,000 years ago.

“He’s one of the few Neandertals we have over 40,” says Trinkaus. “They clearly had a tough life. For those who made it to adulthood, the average age at death was 30. These people were always on the move. Most older folks probably died trying to keep up with the group. They didn’t make it back to the shelters to be buried.”

Trinkaus hands me a rib from the man. Its weight and heft tell me immediately that its owner was no 98-pound weakling.

“Imagine the muscles that attached to that,” says Trinkaus. “These guys would have made Schwarzenegger look like a wimp. If I had muscles like that, all I’d have to do is

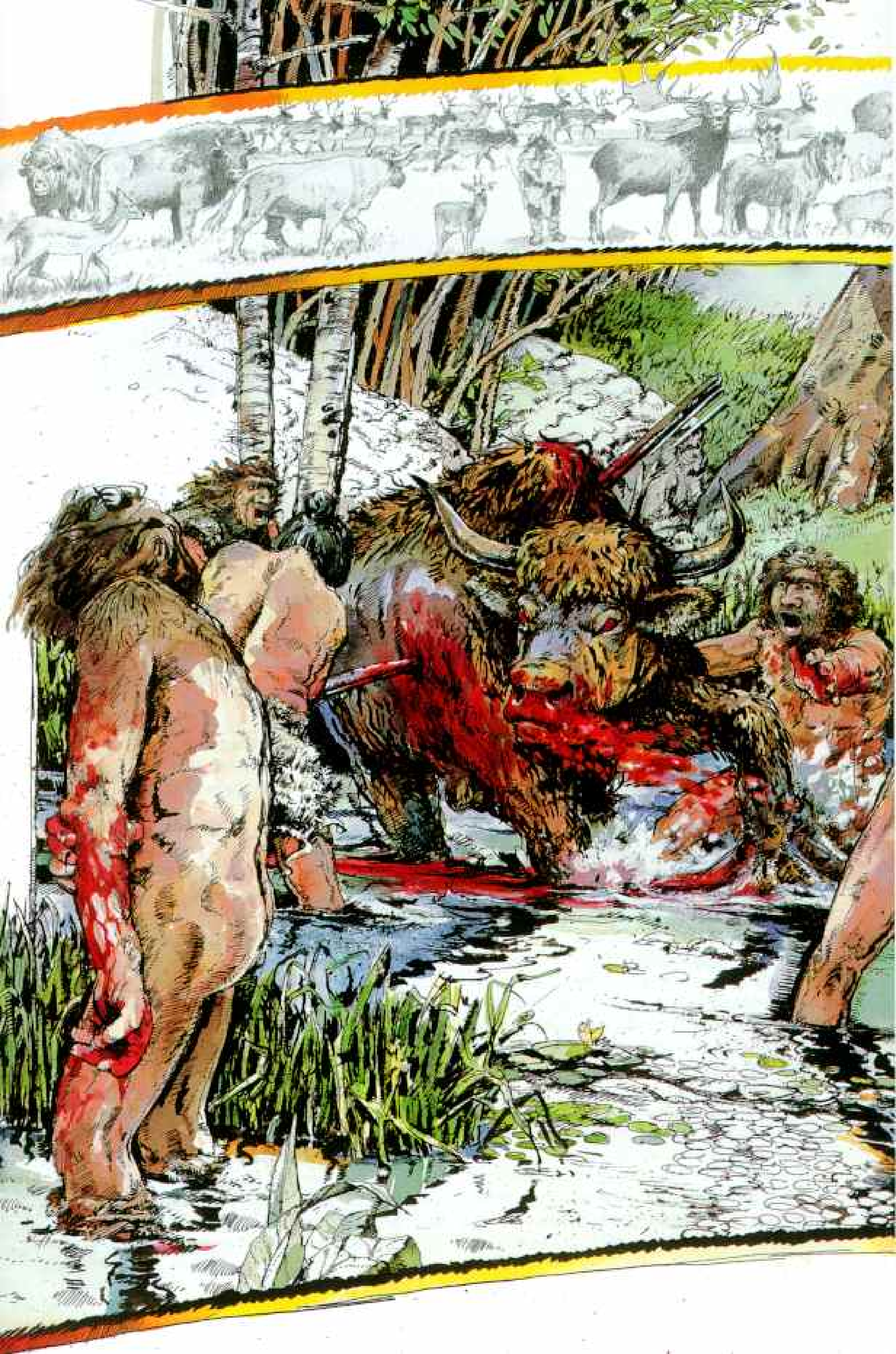
flex my pecs and I’d break my ribs. Their bones tell us they had a lot of strength and endurance. That must be what their lives demanded of them.”

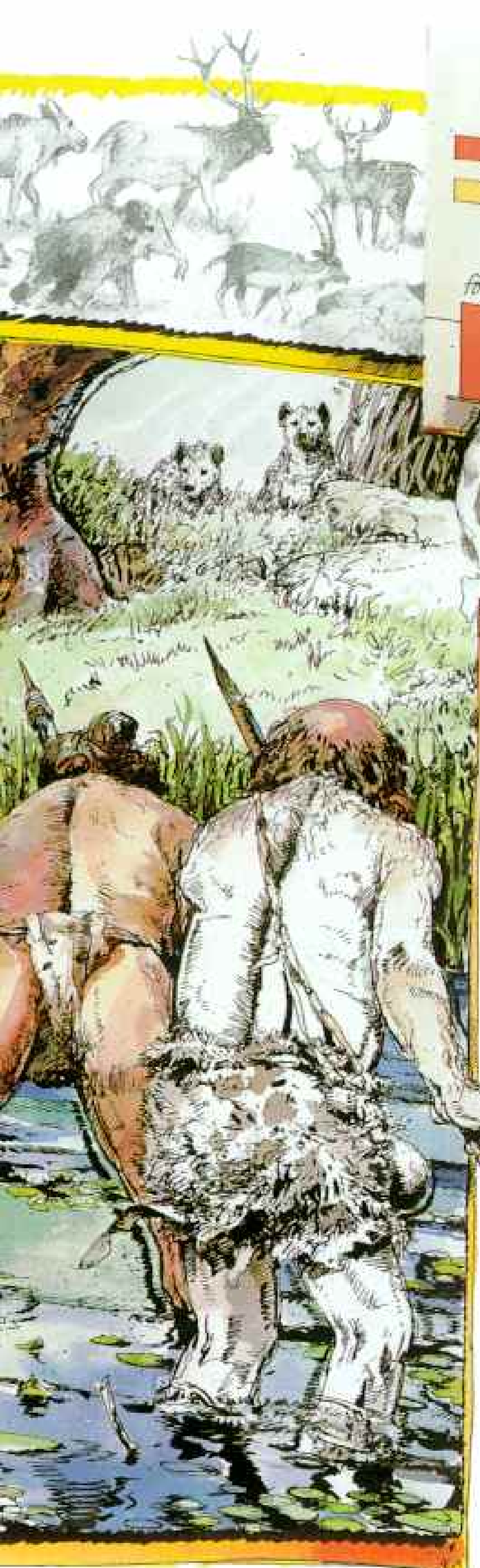
He points to a groove in the rib with a bony growth around it.

“Something pierced between the ribs and stayed there—at least a couple of weeks to get that much bone regrowth,” says Trinkaus. “He probably died eventually of infection following a punctured lung. It could have been murder, or he could have slipped on his spear. But he lived for a while. Someone must have taken care of him.”

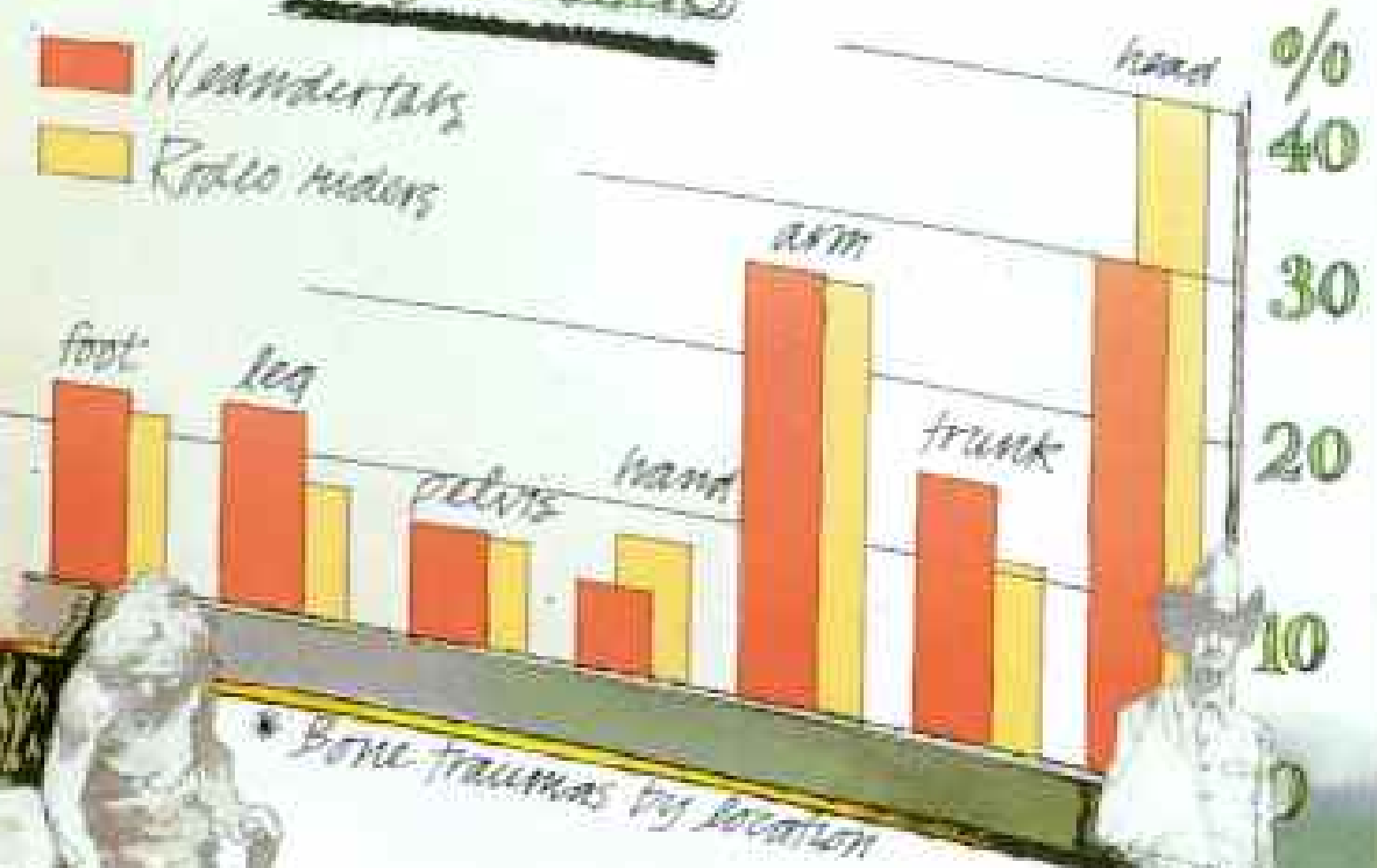
But his pain was fleeting compared with that of another skeleton, Shanidar 1, who Trinkaus calls the “most spectacularly injured Neandertal we know of—and a helluva survivor.”

“He was 40-ish and had lesions from head to toe,” Trinkaus says. “The bone around his left eye and cheek was crushed and had healed over. At the very least that injury gave him double vision permanently.





INJURIES *



High-risk hunting

Taking on trouble, Neanderthals drive aurochs, an extinct species of giant cattle, into bogs before closing in for the kill. The practice of hunting big animals in their prime is rarely seen among earlier hominids. The feasting came at a price. Erik Trinkaus and researcher Tomy Berger have compared Neanderthal injuries with those of modern populations. The closest match: rodeo riders. "They both suffered similar head and neck trauma," Trinkaus says. Neanderthal technology may have been at fault. "They were unable to conceive of projectiles; we don't know why," says French archaeologist Jean-Michel Geneste (below). Thrusting—rather than throwing—spears put hunters in harm's way.





The cutting edge

Honing his skill at humankind's oldest craft, Mikel Aguirre flakes a flint knife in the desolate mountains of central Spain. Produced in four minutes, his razor-sharp cutting blade will be used to butcher a goat—a lesson in ancient ingenuity he shares with students at his wilderness survival school. It was only in the waning days of the Neandertals' existence that more sophisticated blades—"backed" to snugly fit the index finger (right, at top)—began turning up in French rock-shelters. Personal decorations, such as elk and wolf teeth, at bottom, also appeared late among the Neandertals—innovations borrowed, perhaps, from the modern humans who would replace them.



He might have been blind in that eye.”

Shanidar 1 had more problems. His right arm was withered from the shoulder down. It was broken in two places above the elbow. The fractures didn't heal, and the lower arm was eventually lost. He had severe arthritis in his right ankle and big toe and a healed fracture on the outside of his foot.

“Dropping something on your foot is the easiest way to get that kind of injury,” says Trinkaus. “The bone had healed, so it happened many years before he died.”

That means Shanidar 1 would have limped painfully through life. Somehow he was mobile enough to keep up with his group. Others must have helped him.

“I'm sure he was contributing in some way to the society for them to keep him going,” says Trinkaus.

So many Neandertal bones show traumatic breaks that one of Trinkaus's graduate students, Tomy Berger, decided to investigate the patterns. He analyzed the bones of 17 Neandertals who had suffered a total of 27 traumatic injuries.

“I noticed that they were mostly injuries to the head and upper body—almost no lower limb injuries,” says Berger. He compared the Neandertal injuries with those suffered by a variety of active modern humans, such as firefighters.

“I got a statistical fit—one like you never get in science—with rodeo riders,” he says. “What happens to rodeo riders? They get thrown off big animals a lot. Neandertals had big, robust bones. They must have been doing something violent.”

I already knew that Neandertals probably hunted in groups, close to their prey. Berger's analysis suggests that the hunters often risked injury as they closed in on large animals to thrust their heavy spears into them.

EVEN THE WORLD'S most famous Neandertal—the fellow found in the Neander Valley—turned out to be a battered man.

“He had broken his left arm,” says Ralf-W. Schmitz, a graduate student from the University of Cologne. “He couldn't move it normally, so he had to do everything with his right arm. He also had lots of arthritis.”

Then Schmitz shows me pictures made with a microscope of mysterious cut marks on the skull of the Neander Valley man. Some experts

believe the marks were made after the skull's discovery. But Schmitz points out tiny crystal patterns called dendrites growing over the lesions. Since dendrites grow only when a bone lies buried in sediments, Schmitz sees them as proof that the cut marks are ancient. That means someone sliced the flesh away from the man's skull after he died.

Is this more evidence that Neandertals were cannibals? Not according to Schmitz, who notes that cannibals probably would have smashed the man's limb bones to suck out the marrow. This man's limbs remain intact. So Schmitz suspects that Neandertals cut his scalp during some kind of ritual.

Cannibalism seems far more likely in Croatia, where cut marks scar many of the bones from Krapina and Vindija. Here, Neandertals had smashed the bones of many of their dead.

At the Croatian Natural History Museum in Zagreb, I sort through some of the evidence—a thighbone broken through at the shaft, a piece of a man's temple bone etched by cut marks—with Jakov Radovčić, the scientist who had taken me to Vindija, and Fred Smith, his collaborator.

“We simply don't know whether this represents a ritualistic cannibalism or whether these people had a taste for their fellow men, so to speak,” says Smith.

“I think it was an honored way to treat their dead,” injects Radovčić. “The animal bones in their caves suggest there was plenty of game. Why would they have to eat each other?”

Later, I find others who disagree. “I think they wanted the meat and the marrow,” argues Tim White, a paleoanthropologist at the University of California at Berkeley who has studied the Croatian collection. “If it were part of a ritual to break open the bones, then all the bones would have been broken. But they smashed open only the large bones of the limbs—the ones with lots of marrow.”

White also points out that the Neandertals made the same patterns of cut marks on their fellow humans as they did on their animal prey. Moreover, those marks recur on bones from both Vindija and Krapina, sites occupied at intervals thousands of years apart. He sees cannibalism as one of a variety of ways Neandertals sustained themselves rather than an occasional act of desperation by starving humans.



BONE FRAGMENTS tell us what Neanderthals looked like and what they ate, but information on most other aspects of their lives is scarce.

We know they had fire to keep warm. Some cave floors are made almost entirely from compressed layers of ash many feet thick. Their hearths were simple, resembling campfires rather than the efficient, rock-lined fireplaces made by later humans.

One of the few indications of a Neanderthal shelter is a posthole at the site of Combe Grenal in southern France. Perhaps they built structures resembling tepees with wood or mammoth bones and animal hide. They probably wore unsewed hides. They left no tools for stitching, like the bone needles of early modern humans.

From studies of the tools Neanderthals did use, researchers have begun to fill in the details of their technological skills. This is one of the few windows into the Neanderthal mind.

To the uninitiated, Neanderthal tools—mostly sharp-edged flakes of stone that can be held in the hand—look as if they had been casually knapped off a piece of convenient rock with another stone. Not so. Neanderthals might have traveled many miles to procure just the right pieces of flint. Sometimes they would carry their kill to sites near those rock sources.

“You need a lot of brains for flint knapping,” says Jacques Pelegrin of the French Center for Archaeological Research. “It would be like playing chess for us. You have to plan and organize how you are going to flake off each piece from the core rock ahead of time. Rocks are never standard. You have to adjust to the differences. Flint breaks under certain conditions. You have to learn those. It takes months, if not years, to learn to do it well. I have worked flint for 15 years now and can say the techniques used by the Neanderthals are no less difficult than those used later by modern humans.”



Cave at a crossroads

Seared by today's climate, Amud Cave in Israel once offered a lush refuge for Neandertals, possibly refugees from Eurasian glaciations. Modern humans also migrated into the region, probably from Africa. If and how the groups interacted is unknown. "Neandertal sites can be maddeningly uninformative," says Lawrence Owens (above right), a British student who braved the heat at Amud to excavate ancient hearths. Yet even long-dead campfires can illuminate vanished lives. Early Neandertal hearths are crude, often just piles of ash. This may suggest a less structured, more nomadic existence than that of modern humans.

In the Vézère Valley of southwest France, where many classic Neandertals have been found, Jean-Michel Geneste, an archaeologist with the Ministry of Culture in Bordeaux, hands me a hand ax discovered there.

I grasp the ax, noticing it has notches for my thumb and fingers. It feels comfortable, as if it were an extension of my hand.

"This was a multipurpose tool," he says. "Different edges of it were used for different purposes—cutting, butchering, scraping, defleshing. It was the Swiss army knife of its day. We get lots of information out of these. We might detect 300 scars on an ax, each made

during its shaping. We know how to read the scars and then reconstruct how the ax was made. If I have only the by-products flaked off a piece of rock, I can tell you what kind of tool was made."

To make such tools, as well as to organize a cooperative hunt, Neandertals must have been able to communicate and pass on their knowledge. Scientists have long argued about whether Neandertals had the anatomical equipment for speech. Voice boxes and vocal tracts don't fossilize, but a small structure called the hyoid bone at the back of the tongue does. In modern humans the voice box hangs

from this bone. In 1983 an intact hyoid bone was discovered in a 60,000-year-old Neandertal skeleton excavated from a cave called Kebara in Israel. Yoel Rak, a hominid specialist at Tel Aviv University, shows me this inch-and-a-half-long bone, which looks something like a chicken wishbone.

"There's no way to distinguish this from one of our hyoid bones," says Rak. "So we can infer that Neandertal voice boxes looked very much like ours and could make the same sounds."

But did they have language—the critical tool we use to store and pass on information and make sense of our world?

"They may not have had a language as complex as ours," says Christopher Stringer, a paleoanthropologist at the Natural History Museum in London. "We have past, present, and future tenses. We have symbolism. They may not have had all that, but at least they could talk to each other."

People of the past often speak most eloquently to us through their art. And here again the Neandertals frustrate us. Before the last Neandertal disappeared, modern humans were carving exquisite bone ornaments to adorn their bodies and painting the caves of southern France with magical, hypnotic portraits of wild animals.

Yet many scientists now suspect that the Neandertals' ability to create art has been underestimated. They might have put their creativity into dance, costume, or carving wood, which usually decomposes.

One of the few surviving Neandertal "art objects"—a carved and polished ivory tooth from a baby mammoth—was excavated in 1958 at Tata in Hungary, a region that in Neandertal times was a rich grassland.

In Budapest, Viola Dobosi, an archaeologist at the Hungarian National Museum, takes this tooth from a safe and places it in my hand. The glistening ivory is oval-shaped and veined with ocher, its sides smoothly beveled.

"I'm sure that this was polished by humans," says Dobosi. "It has been dated at between 80,000 and 100,000 years old. It was not a tool. It had no practical use. But it was important. They worked very hard to make this. It had to have some spiritual meaning."

Was this a shaman's amulet? A healer's charm? Until recently most specialists believed only modern humans created such symbolic or ritualistic objects. But modern

humans had not yet arrived in Europe, though they were already in the Middle East.

AROUND the time the Tata ivory was being polished, another ice age was falling over Europe. It may have driven Neandertals south into the Middle East, according to Ofer Bar-Yosef, an Israeli archaeologist at Harvard University. "Always people go to the Holy Land," he says with a smile. "Even then it was a refugium."

In the 1980s scientists unearthed the remains of modern humans who had lived in the region at least 90,000 years ago. Recent dating of the bones of a Neandertal woman suggests that Neandertals may have lived there as far back as 170,000 years ago.

Perhaps the two peoples lived side by side for tens of thousands of years. Yet, during that time, the modern humans showed no signs that they had superior technology.

"Both peoples were living in the same way, hunting the same prey, burying their dead in the same manner," says Baruch Arensburg, a paleoanthropologist at Tel Aviv University.

Then, around 50,000 years ago, something profound happened. New technologies associated with modern humans—finer blades and projectile weapons—began to appear.

Scientists can only speculate on what triggered this technological spurt. "I think there was a mutation in the brains of a group of anatomically modern humans living either in Africa or the Middle East," says Richard Klein, an anthropologist at Stanford University. "Some new neurological connections let them behave in a modern way. Maybe it permitted fully articulate speech, so that they could pass on information more efficiently."

Whatever the cause, around 40,000 years ago modern humans moved into Europe, armed with innovations—such as tailored clothing, better shelters, and more efficient hearths—that let them survive the cold of glacial Europe, previously the exclusive domain of Neandertals. Nineteenth-century scientists named these newcomers the Cro-Magnon people, after a French rock-shelter by that name where three anatomically modern human skeletons were discovered in 1868.

What happened when this new culture met the Neandertals remains a hotly debated mystery. Our own recent history suggests that there would have been some violence.



PHOTOGRAPHED AT CROATIAN NATURAL HISTORY MUSEUM

Distant cousins or siblings?

Weighing the question of kinship, Croatian researcher Jakov Radovčić compares two Neanderthal chins—one ancient and receding (above, foreground) and another more recent and jutting. To some, such subtleties suggest that Neandertals and modern humans interbred and were thus one species. “They were like us,” one expert says. “They were just ancient hillbillies.” Others disagree, citing strong differences in specimens from Israel, where Neandertals (below, at left) and moderns overlapped for millennia.



FOSSELS COURTESY JERREL ANTIQUITIES AUTHORITY



All dressed up . . . and no place to evolve. A display at the Neanderthal Museum in Erkrath, Germany, near the original fossil discovery site, pays homage to the caveman of modern imagination. From his bestial 19th-century persona to just another guy in a suit,



Neandertals have been pigeonholed according to the times. "In a sense, Neandertals have been a symbol of how we perceive ourselves—a mirror of mankind," says one paleontologist. "Today we seem to be comfortable having them in the family."

Last stand

A woman's skull, some flaked tools, and the bones of an ibex—a wild goat—offer mute testimony to the Neandertal presence on Gibraltar. The Iberian Peninsula may have been the last refuge of these enigmatic people. Not so long ago in our history, humans of another kind walked the glacial shores here. And looking back, we can almost make out their footprints, hear their voices fade.

"I see confrontation," says Ofer Bar-Yosef. "People who grow up in the Middle East understand that. We don't like each other. We rarely intermarry, and we kill each other whenever we can. I don't think you can prevent competition among societies."

Many scientists, such as Fred Smith, see a more gradual replacement—not by people but by modern genes that spread viruslike around the world, slowly transforming populations. In this scenario, gene pools of the Cro-Magnons and the Neandertals would have blended to create today's Europeans.

Some bones at Vindija, for instance, appear slightly more slender and graceful than classic Neandertal bones. Does that imply that Neandertals in central Europe were beginning to interbreed with groups of modern humans arriving from the Middle East?

"Neandertal genes persist in modern Europeans today," insists Milford Wolpoff, a University of Michigan paleoanthropologist.

Others reject this idea. "They were a different species," argues Fred Spoor of University College London. "There is no convincing evidence of interbreeding on any significant scale." Spoor bases his conclusion on studies of the skulls of both peoples, which he claims are too different anatomically to belong to the same species.

THE POPULATIONS OF BOTH PEOPLES were small and scattered. But while the modern humans began to thrive, the Neandertals dwindled. Jean-Jacques Hublin, a paleoanthropologist at the Musée de l'Homme in Paris, thinks that falling temperatures around 35,000 years ago may have forced Neandertals to flee south into Spain, where the last traces of them have been discovered in isolated seaside caves.

I meet Hublin just inland from Spain's Costa del Sol. We climb a rugged slope to a cave called Zafarraya and gaze back at the



Andalusian countryside toward Gibraltar. "This is where we have found the final evidence of Neandertals—a few jawbones and femurs that date back to 33,000 years ago and even younger tools that tell us they still came here as recently as 29,000 years ago."

The Rock of Gibraltar, pocked with some 140 caves, may have been the Neandertals' ultimate refuge. Apparently they never ventured beyond here, even though Africa lies only a few miles away across the strait.

"The proximity of Africa raises one of the great mysteries of the Neandertals," Clive Finlayson, director of the Gibraltar Museum, told me. "By this time humans elsewhere in the world were crossing much greater



ARTIFACTS AND FOSSILS FROM GIBRALTAR MUSEUM

distances of water. They were already in Australia, for instance. Yet there's no evidence of the Neandertals—or their modern contemporaries—having made it across the strait. There are very strong currents that would have made such a crossing difficult, but people have swum the strait in modern times.”

I climb down cliffs and cross surf-washed boulders to reach yet one more cave, a vast chamber in the Rock called Gorham's Cave. In Neandertal times, when sea levels were lower, this grotto would have been situated high in the Rock rather than at water's edge. The last Neandertals looked out across a sandy plain several miles wide. I see them again, chipping at flints and gazing down at herds of

elk and aurochs that grazed the rich grasslands below. Now, where their prey once wandered, the ships of many nations anchor. Beyond them, Africa looms through the haze, filling me with wanderlust and questions.

Weren't they curious? Maybe that was one of those inscrutable differences between them and us. We are compelled by curiosity, the need to explore, and an obsession for change. Perhaps the thought of moving on never occurred to them. Maybe they simply accepted the present, without a past or future tense. Who knows? What we can say is that for more than 200,000 years the Neandertals adapted to their challenging world. Will we say the same for ourselves? □



Requiem for the Edmund Fitzgerald

By **THOMAS L. FARNQUIST**

Photographs by **EMORY KRISTOF** and **JEFFREY CREE**

Two decades after a storm sent the ore carrier *Edmund Fitzgerald* to the bottom of Lake Superior, a team equipped with advanced underwater gear visits the wreck to record her condition and honor her lost crew. Clad in a self-propelled NEUTSUIT, Bruce Fuoco examines the propeller shaft of the inverted stern section, as his image is recorded by a high-definition video camera.



In the early evening of November 10, 1975, during one of the worst storms to hit Lake Superior in 30 years, the 729-foot *Edmund Fitzgerald* vanished without one signal for help.

Launched in 1958, the ship set many cargo records and proved to be a profitable investment for her owners. In one of the last scheduled trips before winter closed shipping lanes, the *Fitzgerald* departed Superior, Wisconsin, for Detroit, Michigan, loaded with 26,116 tons of taconite pellets destined for steel mills.

Battered by 30-foot seas and 90-mile-an-hour winds, the ship abruptly dived to the bottom with her crew of 29. Only ten miles away, crewmen aboard the 767-foot *Arthur M. Anderson* watched



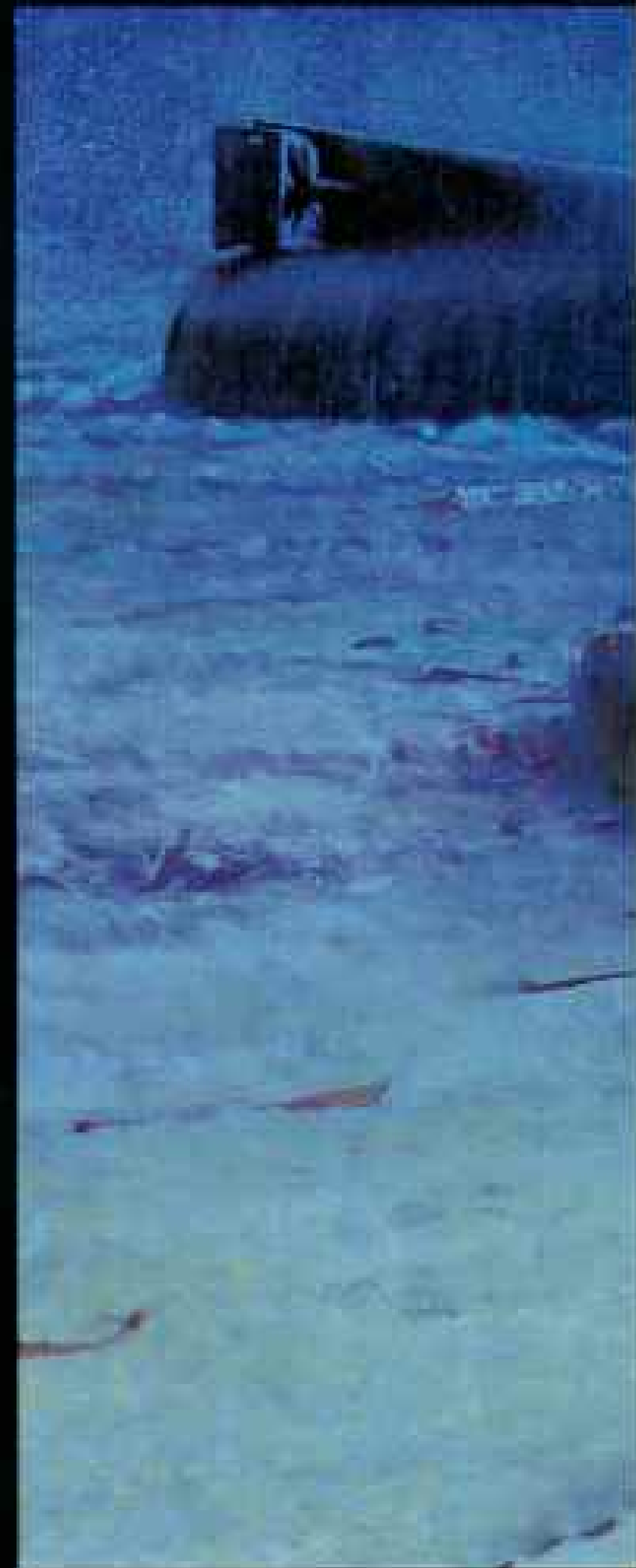
U. S. WEIS COLLECTION, © BIRDS SAMPSON

in disbelief as the *Fitzgerald* disappeared from radar. Although other ships in the area joined the U. S. Coast Guard in attempts to locate survivors, none were found, and no bodies were recovered.

The following spring the Coast Guard began an extensive investigation, but experts could not agree on why the *Fitzgerald* sank. Even after 20 years and five diving investigations, the cause remains a mystery.

Last summer, at the request of still grieving family members, an expedition was assembled to recover the ship's bell to commemorate the missing crew.

Thomas L. Farnquist is executive director of the Great Lakes Shipwreck Historical Society. Emory Kristof specializes in deepwater photography.



The Wreck Site

With both her radars disabled and the light and radio beacons on Whitefish Point out, the *Fitzgerald* was 17 miles from the shelter of Whitefish Bay when she sank in Canadian waters. The ship slammed into the bottom with such force that 200 feet of the midsection disintegrated, causing the stern to twist off and roll to port, where it settled upside down 170 feet away. Debris lies scattered over three acres.

The planned memorial to the *Fitzgerald's* crew will be in the Great Lakes Shipwreck Museum at Whitefish Point.



PAINTING BY DAVE CONKLIN, GREAT LAKES SHIPWRECK MUSEUM



The usual course of the *Fitzgerald* was south of the more protected route it chose during the storm.



A Dive of Remembrance

Technology and sentiment share a moment as powerful lights aboard the Canadian Navy submersible *SDL-1* illuminate the wreck. Cheryl Rozman, daughter of Ransom Cundy, watchman on the *Fitzgerald*, had told us: "Dad enjoyed having a beer; too bad you couldn't bring him one." Gently operating manipulators at the end of NEWTSUIT's arms, Bruce Fuoco holds a beer can (right) and places it in the pilot-house (above), a gesture that surprised and delighted Cheryl.

"It's cold and dark at 530 feet," says Bruce, "but with all the help we're getting from the submersibles, it's like 10 feet. It feels good knowing you're not alone." Without lighting and safety support from *SDL-1* and another Canadian Navy submersible, *Pisces IV*, the dives could not have been photographed. The NEWTSUIT was developed by Canadian inventor Phil Nuytten of Hard Suits Inc.



New Imaging Focused on Maritime History

To record the *Fitzgerald* required technology that could produce both still and moving images of great clarity and the lighting to bring them to life. The first choice was a high-definition video system, or HDVS. Sony Corporation contributed an HDVS camera; Sony videographer Jeff Cree volunteered to operate it. With six times the resolution of conventional television (comparison below) HDVS's images closely approach the quality of still photographs.

Though relatively clean, Lake Superior's water is cloudy enough to make lighting difficult. With its powerful beam, *Pisces IV* moves into position near the pilothouse (right).

To rehearse for the taping of the bell's

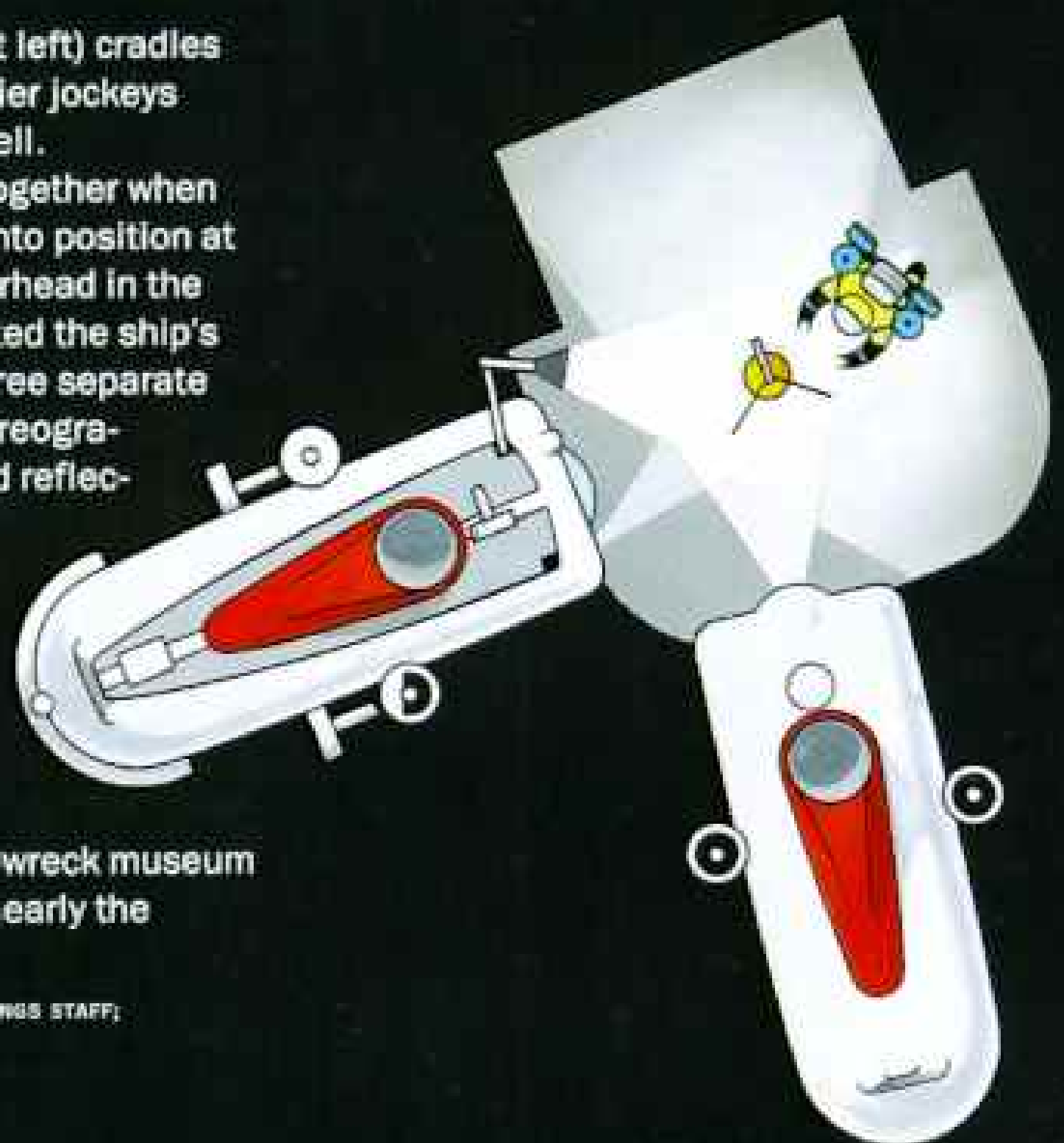


recovery, Jeff Cree (far right, at left) cradles the HDVS camera, as Phil Frazier jockeys *SDL-1* into position near the bell.

All elements were brought together when the two submersibles moved into position at right angles, as seen from overhead in the diagram at right, and illuminated the ship's bell and the NEWTSUIT with three separate light sources. This careful choreography helped minimize unwanted reflections from particulate matter suspended in the water.

The HDVS concept proved itself. It produced the images printed in these pages. And we will be able to project the running video onto a large screen in the shipwreck museum at Whitefish Point, achieving nearly the visual impact of an IMAX film.

TECHNICAL ASSISTANCE BY R. MICHAEL COLE, NGS STAFF;
ILLUSTRATION BY WILLIAM H. BOND







The Riddle Remains

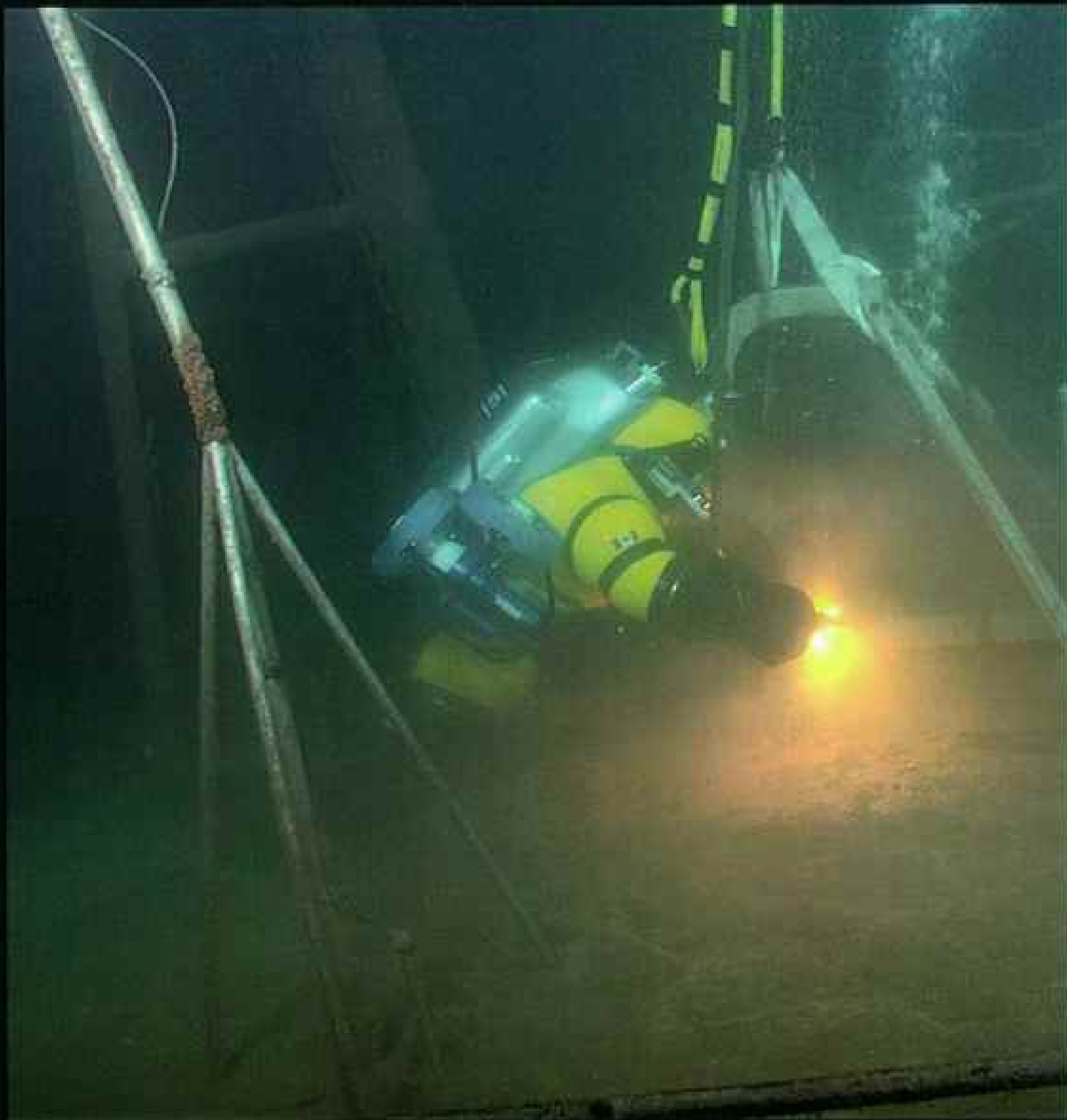
The icy fresh water and great depth of Lake Superior inhibit rusting and marine growth, so the exterior of the *Fitzgerald* shows little change even after 20 years. The crow's nest above the pilothouse (above) still displays the letter C, the emblem of the Columbia line, which operated the ship; the lightbulbs that illuminated the letter remain intact. Lettering across the inverted stern section identifies the vessel's home port. Above the name, the stern anchor—undamaged by the sinking—remains securely fastened in its chock. Inspecting for hull damage, NEWTSUIT pilot Bruce Fuoco approaches a gudgeon (right), a socket that held one end of the rudder in place. One theory for the sinking is that the ship scraped bottom while navigating uncharted shoals near Caribou Island, causing flooding and eventual

foundering. However, we found no damage. Another theory, put forward by the Coast Guard, is that she took on water through leaking hatches, developed a list, and then was swamped by storm waves.

Out of respect for the lost crew and their families, we made no attempt to enter the hull or otherwise violate their resting-place, and we will search no further.







The Bell Tolls for All

"Does anyone know where the love of God goes when the waves turn the minutes to hours?" So sings Canadian songwriter Gordon Lightfoot in his celebrated ballad "The Wreck of the Edmund Fitzgerald." For those who waited that night for loved ones to return, the hours became 20 years of sorrow and pain.

With the extraordinary support of the Canadian Navy and the Sault Ste. Marie Tribe of Chippewa Indians, who co-signed a loan to cover the expedition's cost, our team was able to meet the technical challenges of the project. Bruce Fuoco took on the dangerous assignment of cutting away with a torch the last stanchion holding the ship's bell to the pilothouse (above). We then brought the bell to the



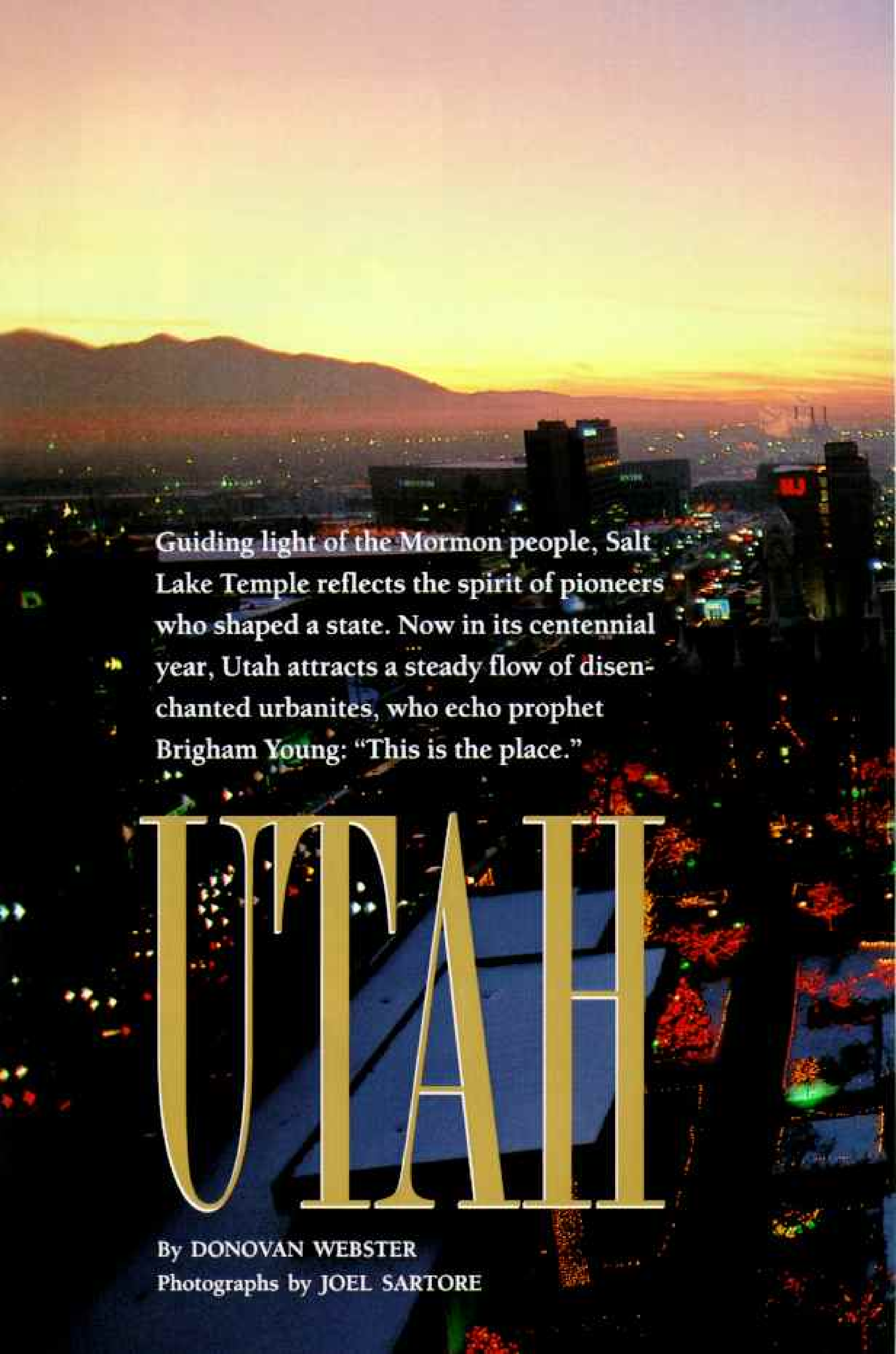
EMORY KRISTOF (ABOVE AND BELOW)



surface, where it will be installed as the centerpiece of a memorial. In its place on the *Fitzgerald* we secured a replica (bottom) inscribed with the names of the 29 crew members.

Christopher Armagost, son of Michael Armagost, the third mate, quietly tossed a wreath of 29 daisies on the waves over the wreck. Jack Champeau (top) said of his brother: "Since I can't bring Buck's remains home for a proper burial, I'm here to do the next best thing."

Ruth Hudson, who lost her only son, Bruce, said: "Finally, we had our funeral. It's a grave now. There is no reason why anyone should dive to the *Fitzgerald* again. Let them rest in peace." □



Guiding light of the Mormon people, Salt Lake Temple reflects the spirit of pioneers who shaped a state. Now in its centennial year, Utah attracts a steady flow of disenfranchised urbanites, who echo prophet Brigham Young: "This is the place."

UTAH

By DONOVAN WEBSTER

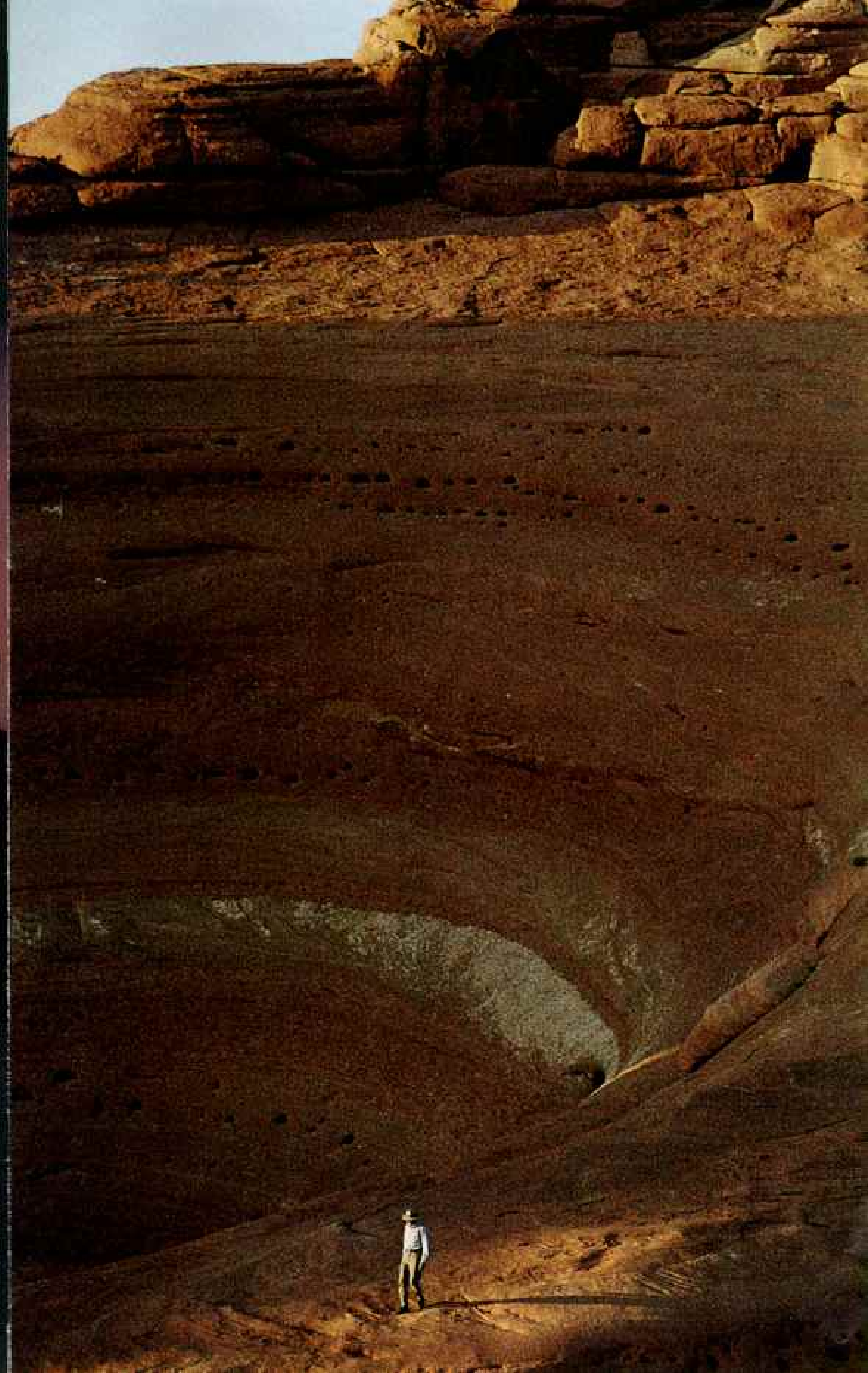
Photographs by JOEL SARTORE

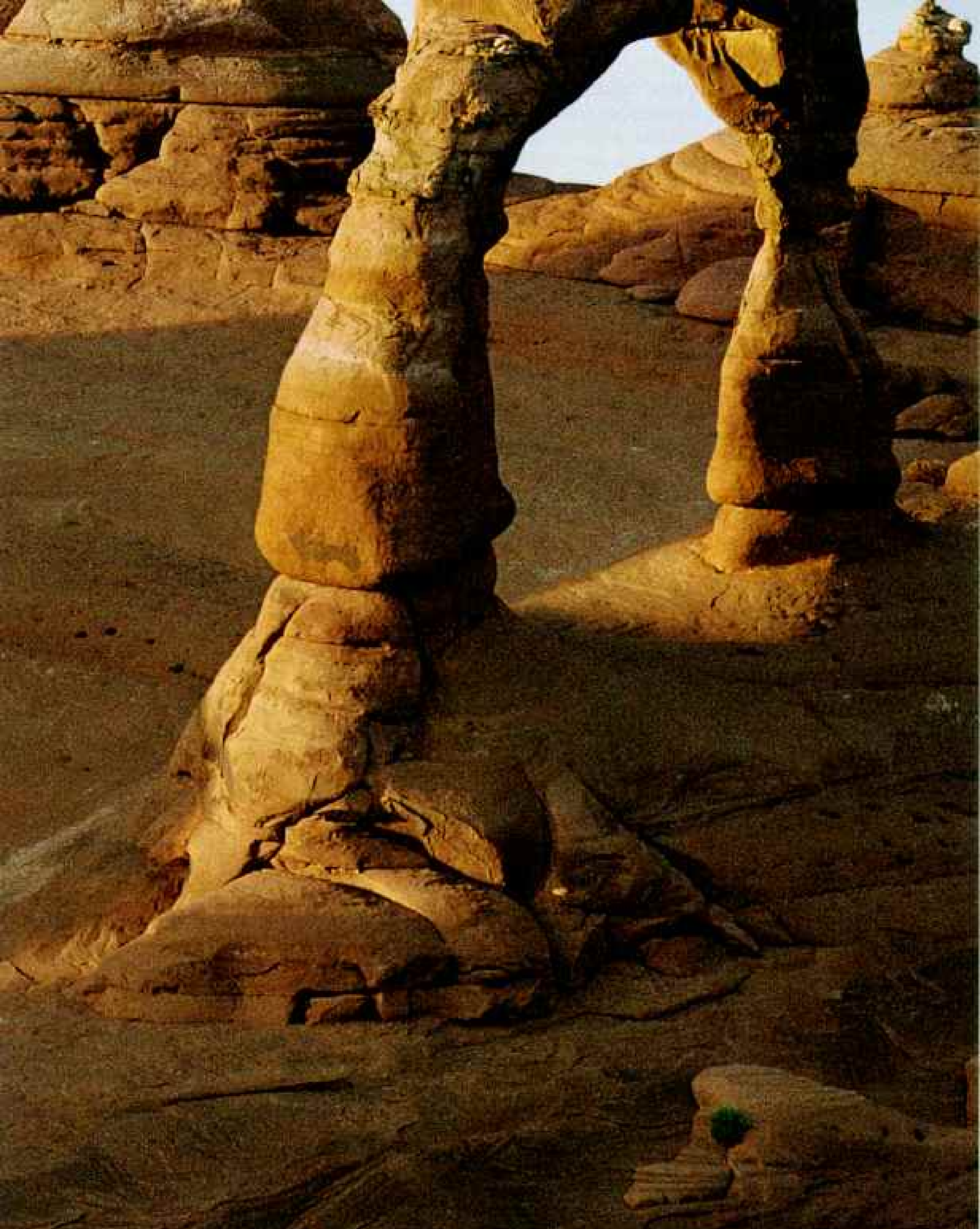


Land of Promise



Kingdom of Stone





Red-rock masterpiece, Delicate Arch is one of 2,000 in Arches National Park. Utah counts five national parks, all variations on the motif of sand, uplift, and erosion. Freezing and cracking further refine the parks' natural sculptures.

IT'S SUNSET ON A WEDNESDAY, and at Salt Lake City International Airport Craig Larson is finishing up his commute. The plane arrives, and the chiseled, 38-year-old printing executive is one of the first passengers off. Having left Los Angeles an hour and a half ago, he is almost home. Larson has traveled nearly 600 miles and one time zone to get here, but for him and his co-fliers, the commute is well worth it.

Today, as he strolls into the terminal, Larson is talking to a regular shuttle partner: a retired Los Angeles Police Department officer who teaches three days a week in California. Behind this pair come the others. Like rail commuters on a trudge home, the group may include a Disney studio executive, an anchor for Los Angeles Channel 5 news, a handful of small-business owners, a dentist, an accountant, and a quartet of consultants. All work in California and live in Utah, happily paying \$49 in airfare each way.

"Hundreds, maybe thousands of us commute to California," Larson says. "Architects. Attorneys. Media and movie people. We moved to Utah because it has good schools and an exceptional quality of life—things southern California was offering in lessening amounts. And the commute is no worse, timewise, than many in L.A. For us, my wife and two children, Utah feels like the perfect place to be."

I look through the airport's floor-to-ceiling windows, and the view underscores Larson's sentiments. To the east, in the day's last sun, the snowcapped Wasatch Range rises to 11,750 feet. Between the airport and mountains, the skyscrapers of Salt Lake City are backdropped by glowing rock and snow. A near-empty ribbon of interstate runs alongside the airport, pointing to the city's gleam like the road to Oz. There is no smog. No scrambling sense of crowds. Other American cities may have runaway crime, pricey housing, and snarled freeway traffic, but in Salt Lake all that seems far away.

For thousands of years, whether the hopefuls were Native Americans, mountain-man

pioneers, religious pilgrims, or today's urban refugees, the peaks and valleys of Utah have seemed a promised land. And now, as roughly 20,000 newcomers arrive here each year, the final migration to this frontier may be afoot. Soon, the critics say, Utah will be as crowded as everywhere else in America.

They may be right. In the past decade a thousand new high-technology companies have sprung up in the Salt Lake City-Provo-Ogden area. With these companies has come an educated, well-paid workforce, one that has spawned countless construction and service businesses and has converted this trio of sister towns into a metroplex of nearly 1.5 million people. This explosion, plus the emergence of southern Utah as a Sunbelt retirement mecca, has spurred a boom across most of the state, stretching municipal services to their limit. And yet, compared with places like California, which lost almost 50,000 jobs in 1993 alone, the promise of Utah keeps the people coming.

"As a newcomer I consider the state's growth a lot," Larson says. "I know I'm part of what's happening here—both the good and the growing pains. Then I think, hey, this is a terrific place. Maybe in Utah, where society has yet to slip into an unworkable mire, we can take advantage of the clean slate."

This is not the first time such thoughts have been pinned to Utah.

LAY A MAP OF THE STATE flat on your table, and mountains jump out. Corrugated, crenulated, they course up, down, and across Utah. It's the same when you see it in person. Away from Salt Lake City the place seems overrun with lonely peaks and desolate highways, where the only other vehicle may be an 18-wheeler huffing up a grade a dozen miles distant.

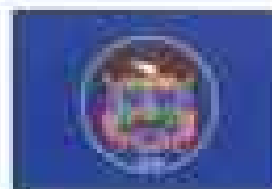
The mountains are everywhere, but it is the valleys that have always drawn people here. The state's largest national park is Canyonlands: a Technicolor labyrinth of 300-million-year-old valleys and a destination for some 400,000 tourists every year. Then there's the mineral-rich soil of the Great Salt Lake Basin, which was irrigated to lasting lushness by religious pilgrims.

Utah's valleys drew me to the state in the summer of 1972, when I was 13. I drifted in from Colorado on the Green River, riding a rubber raft. I've been returning ever since to

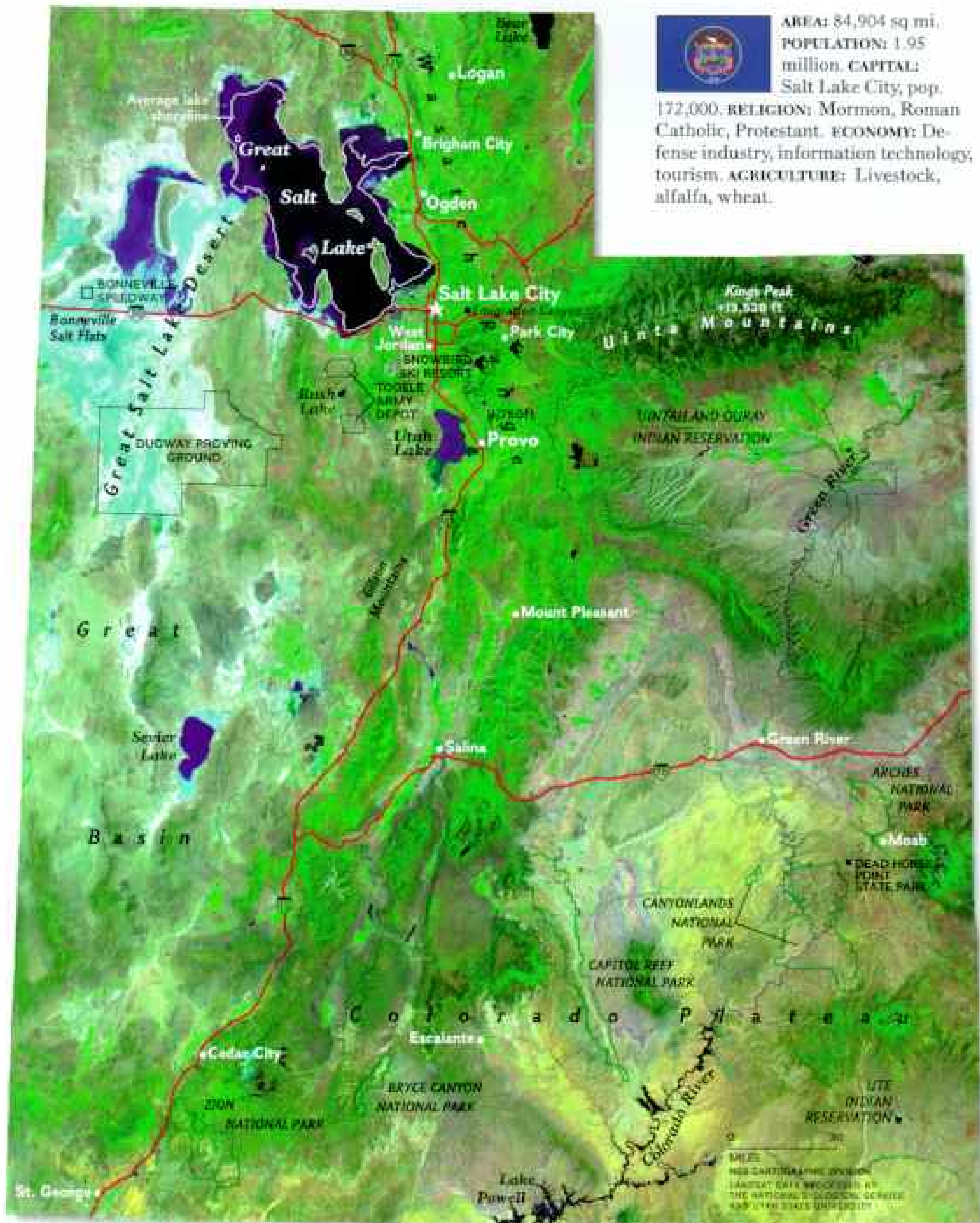
DONOVAN WEBSTER, a former senior editor at *Outside* magazine, is the author of *Aftermath*, a book about the lasting effects of war on landscapes and cultures. It will be published by Pantheon this year. Contract photographer JOEL SARTORE lives in Nebraska with his wife and son.

Deluge in the desert

A satellite mosaic from the summers of 1988 and '89 shows the state swamped by four years of heavy snowmelt and rainfall. To stop the Great Salt Lake from inundating land along the Wasatch Front—where 80 percent of Utahns live—engineers pumped lake water into the desert, soaking the Bonneville Salt Flats.



AREA: 84,904 sq mi.
 POPULATION: 1.95 million. CAPITAL: Salt Lake City, pop. 172,000. RELIGION: Mormon, Roman Catholic, Protestant. ECONOMY: Defense industry, information technology, tourism. AGRICULTURE: Livestock, alfalfa, wheat.





The Old West is served hot and fresh daily at Mom's Cafe in Salina, where travelers and townspeople stop for chicken-fried steak and mashed potatoes. "I was worried when some of my regulars started trying the new Denny's on the freeway," says owner Carolyn "Mom" Jensen, "but they don't stay away for long. They come back to the home cooking."

the orange canyons of southern Utah. That fine wild country keeps drawing me back.

Bands of Paleo-Indians roamed this same land as early as 11,000 years ago. These Ice Age people lived in caves above the receding shores of Lake Bonneville, the larger, freshwater ancestor of today's Great Salt Lake. Their descendants collected seeds and plants, hunted with atlatls, and created rock paintings and petroglyphs. Their desert culture would last some 6,000 years.

By the time of Christ the Fremont people, known for their elaborate clay figurines, occupied the northern two-thirds of the state. Their contemporaries, the Anasazi, inhabited the canyons of southern Utah. Growing corn, beans, and squash and building spectacular cliff dwellings, they flourished for more than a thousand years, until changing weather

patterns made farming impossible and forced them to abandon the region. Around that time, modern-day tribes first appeared—the Goshute, Shoshone, and Ute, for whom the state is named.

To white explorers Utah was considered a difficult place to stake your life. In 1827 Jedediah Smith led a group of fur traders toward the Great Salt Lake from California. Smith sought the Rio Buenaventura, the river fabled to link the Great Salt Lake and the Pacific. On June 20 he entered Utah from the west, finding himself in the 20,000-square-mile emptiness that had once been the floor of Lake Bonneville. Seven days later Smith and his men stumbled out of the desert's eastern side and into the Salt Lake Valley, having had to eat one of their packhorses to survive. In a letter he described the place as "a country completely barren and destitute of game."

TERRY TEMPEST WILLIAMS and her husband, Brooke, live in Emigration Canyon, in the Wasatch foothills above Salt Lake City. From their living room she can look into the valley below, where the city sprawls toward the shore of the glittering lake. To Williams, what's most



amazing about this view is neither the buildings nor the lake. Instead, it's something far more personal. This vista is the same one the original Mormon settlers saw in 1847, when they arrived in this valley with their leader, Brigham Young.

Williams, 40, is a fifth-generation member of the Church of Jesus Christ of Latter-day Saints (also called the Mormon Church, for the Book of Mormon, an additional text to the Bible). A poet, author, and the resident naturalist for the Utah Museum of Natural History, she says that like many Mormons she owes her identity to Utah.

"It's more than history or religious affiliation, or even this landscape," she says. "It's all these: Family. Religion. Place. They can't be divided."

To grasp what Williams is talking about, it helps to know the history of her church. In 1846, after nearly two decades of religious persecution in New York, Ohio, Missouri, and Illinois—where the church's founder and Prophet, Joseph Smith, was killed by an angry mob in 1844—a party of 148 Latter-day Saints headed west in search of their promised land.

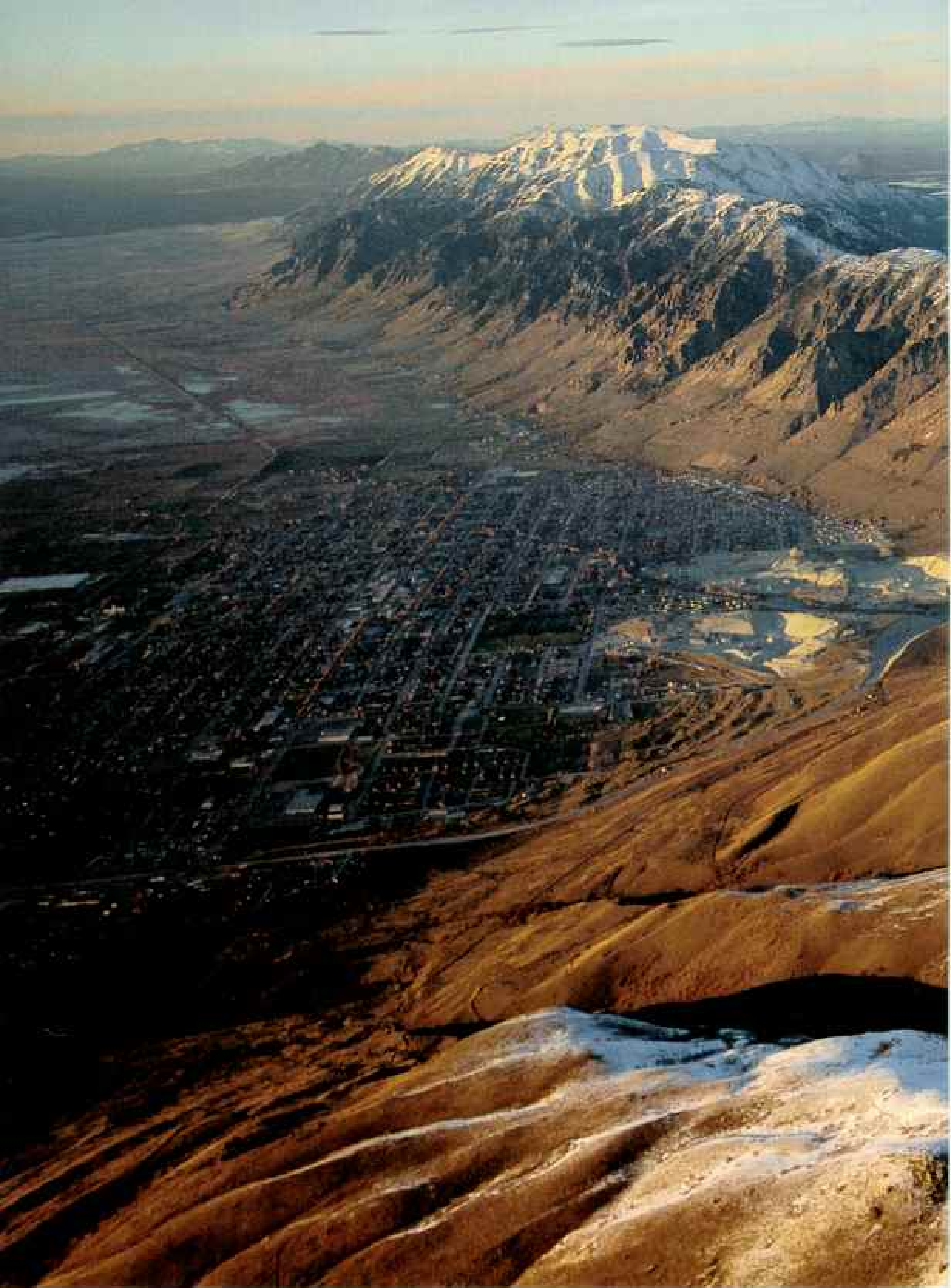
The church's new leader, Brigham Young,

Rhinestone cowgirl Amber Trapp sparkles in Salina's Fourth of July Parade. A college student, Trapp believes her central Utah hometown is immune to the growing pains—crowds and crime—that afflict cities in northern Utah. "We're a real churchy community that sticks together," she says. "That big city stuff can't reach us down here."

guided the faithful on a rugged journey toward the barren valley of the Great Salt Lake. Once there Young was convinced the Saints could make the desert bloom.

On July 24, 1847, legend has it, Young led his followers through a gap in the Wasatch Range called Emigration Canyon; he pointed to the broad valley below and said, "This is the place."

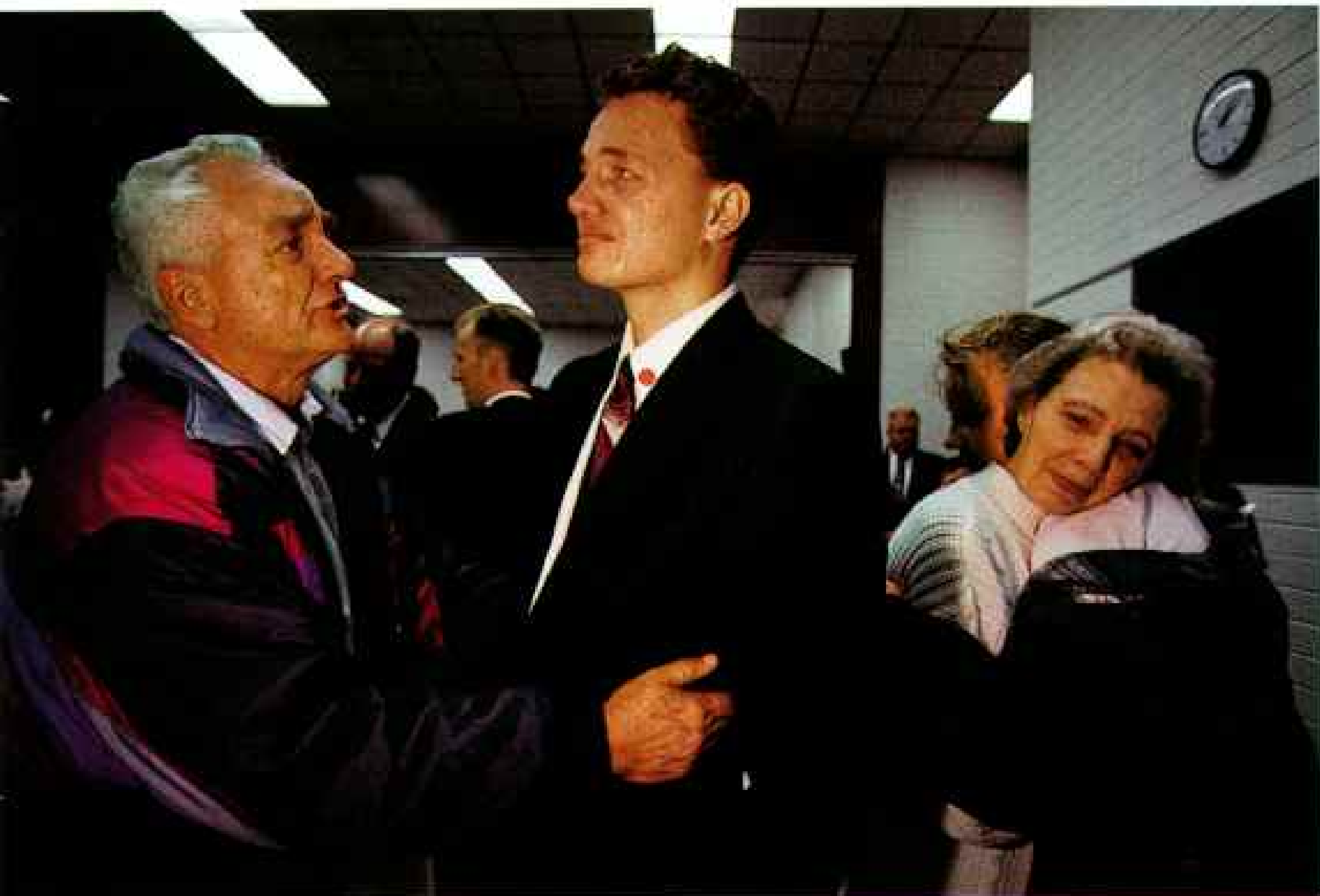
In reality, things were less dramatic. According to historical documents, an advance party had arrived a few days earlier, and Young, who was "ill with mountain fever," did not see the valley until they had already planted crops. Still, the legend persists, and a monument to the pioneers stands at the mouth of the canyon, complete with a bronze likeness of Young, his hand stretched toward the Mormon Jerusalem.



Broad shoulders cloaked in snow, the Wasatch Range embraces Brigham City, one of a string of Mormon communities settled by handpicked craftsmen, laborers, and schoolteachers. When these pioneers arrived in 1847,



they channeled mountain streams to coax life from the thirsty soil. Now as then, the range shelters residents from winter's northern winds and summer's tornadoes, which sweep across the plains to the east.



Brokenhearted yet bound to serve, Maurey Johnson, center, bids good-bye to his family. Off to India for two years of Mormon missionary work, he knows he will never again see his terminally ill mother, right; she has since died. Worldwide, door-to-door recruiting has raised membership in the Church of Jesus Christ of Latter-day Saints to nearly ten million people.

"What's most intriguing about the Saints," Williams says, "is that they came here for religious sovereignty and found isolation and a landscape nobody else wanted. It was the challenge of making a life in a barren valley, plus their faith, that transformed this desert. Everyone worked together."

After a rocky start the Mormons took little time in turning the parched landscape into a garden. Each family was given five acres or more to tend at the edge of town, and by diverting the snowmelt from the Wasatch for steady irrigation, wheat and corn quickly sprouted from the desert soil.

By the turn of the century Young's followers had spread far into Nevada, Idaho, and Arizona, carving 500 new towns from the sagebrush and calling their new territory Deseret, after a Book of Mormon term for

"honeybee." To secure statehood for Utah in 1896, the church was forced to abandon the traditional Mormon practice of polygamy.

MOST OF THE MORMONS I met remain deeply committed to the "cause of Zion," which includes honoring large families and hard work, while eschewing the use of alcohol and tobacco (such vices are both legal and easy to find across the state, however).

The "cause," in fact, has kept many Mormons close to home, and seven of every ten Utahns are Mormon. Because of this optimistic, family-oriented lifestyle, the state has one of the highest literacy rates in the U. S. (94 percent) and its lowest average age (26 years); it has an unemployment rate of only 3.6 percent, well below the national norm, and its 78.4-year life expectancy is three years longer than the national mean.

Given these statistics, it might appear to outsiders that Utah is a closed Mormon society. But I discovered that Utahns are remarkably open-minded. The mayor of Salt Lake City, for example, is Deedee Corradini, a Presbyterian Democrat raised in Lebanon.

"Many of my biggest supporters are male



members of the Mormon Church," Corradini told me. "None of them have ever used our friendship to attempt to bend my decisions as mayor."

This acceptance of non-Mormons isn't just for solid citizens and politicians, however. One midnight, in a rock-and-roll bar called Club DV8, the punk rocker Iggy Pop roared through an hour-long set as young, tattooed fans careened across the floor. A University of Utah student named Darcy, resplendent in dark rouge that made her face look bruised, sipped a beer and expounded on her new home. "I'm from California," she said, "so it took a little time for the Mormons and us to get used to one another." She regarded her black jeans, black shirt, and black boots. "We're, like, from different planets," she added. "But they're cool. They're even pretty nice, which is something I can't always say for people in Los Angeles."

On the other side of the relationship are people like Mark Menlove, a 34-year-old Utah native I spoke with one spring morning while riding a chairlift at the Park City ski area, 40 minutes outside Salt Lake. "There's always been talk of newcomers changing old-style, Mormon Utah," he said, as light snow

"I quit going to church—then they traced me down," says a polygamist (above, with four of his five wives), telling how Mormon Church officials excommunicated him for following the church's original tenet of plural marriage. Utah Mormons gave up polygamy in 1890 for statehood, yet tens of thousands still live the life discreetly.

sifted onto our skis and parkas. "But the only change I've seen is a general loosening up toward outsiders. Utah's closed society was always more of a rumor than it was real."

This open-mindedness may be Utah's most abundant natural resource. Mormonism has spread to 155 other nations and territories and nearly ten million followers, and Utah Mormons are quick to welcome other religions into their home. In downtown Salt Lake City are both a Zen Buddhist center and a 126-year-old Episcopal church. And as you walk the streets of Salt Lake, a gentle friendliness greets you on every sidewalk. Mormonism, optimism, and the history of Utah seem to wind around one another like strands of a rope.

As Terry Tempest Williams told me, "By looking to the lake or mountains or into the

"A civil marriage is just 'til death do you part,'" says Amy Beales, right, with husband, Jason, at Salt Lake Temple. One of 52 couples married here this day, they believe exchanging vows in the temple joins them for eternity. Only Mormons who keep the church's covenants may enter the 47 temples worldwide.

eyes of a relative, I'm reminded who I am and why I'm here. Could you ask more from a home than that?"

YET WILLIAMS'S HOME STATE is far more than an increasingly urban city at the edge of a salty lake. So on a Friday afternoon I put the city in my rearview mirror and head south along empty desert highways. What I'm after is the storied Utah frontier, that place that seems to have been forgotten with the explosive growth of the north.

As my car rolls down the two-lane, the sky is deep blue, the spring winds are warm, and it doesn't take 40 miles before the houses thin in number and the landscape starts to change. Slowly the tall, jumbled peaks of the Wasatch take on thinner, lower silhouettes until, at the southeastern town of Green River, they have become mere fins of rock protruding above a sage-dotted desert floor. This universe is an endlessly orange, green, and red place, with its Jurassic and Cretaceous periods shown in sedimentary strata.

At Arches, one of the five national parks in Utah, I turn off the highway. Tall spires and balancing rocks are everywhere, as are rock arches sculpted by millions of years of erosion and freeze-thaw cycles. As the sun goes down, I hike the mile and a half out to Delicate Arch, a 52-foot-tall curve of salmon-colored sandstone that seems to pulse with the day's last light.

It was this Daliesque landscape — and the rains and rivers that made it — that brought Ken Sleight here in 1951.

"I was training to be the manager of a tire store up north, in Logan, and some friends and I took a rafting trip down the Green River. I was hooked."

By 1955 Sleight had set up shop in the town of Green River, just above Canyonlands National Park, becoming a pioneer of modern river rafting in the West. "There were just a few of us then," he says, "and we each had a couple of old, war-surplus rubber



boats that hadn't been used at the Normandy invasion, and we took to running the rivers as guides. We'd take anybody down the Colorado or the Green, through the white water and the canyon depths, and we'd just let them discover the beauties of this place for themselves." Though Sleight eventually relocated from tiny Green River to the larger mining town of Moab, those trips served as the match strike of a tourism explosion.

These days it's not unusual for 10,000 river-rafting, mountain-biking visitors from all over the U. S. to congregate in Moab on a weekend. Lean and suntanned young people examine the newest cycle components at Rim Cyclery while sipping coffee bought from an espresso cart just outside the store. Most



of the patrons look like students, and many likely are. Their muscular legs seem veined with garden hoses, and many of their knees and shins are scabbed from high-speed falls taken on the smooth stone, called slickrock, that makes Moab's landscape perfect for fat-tire bikes.

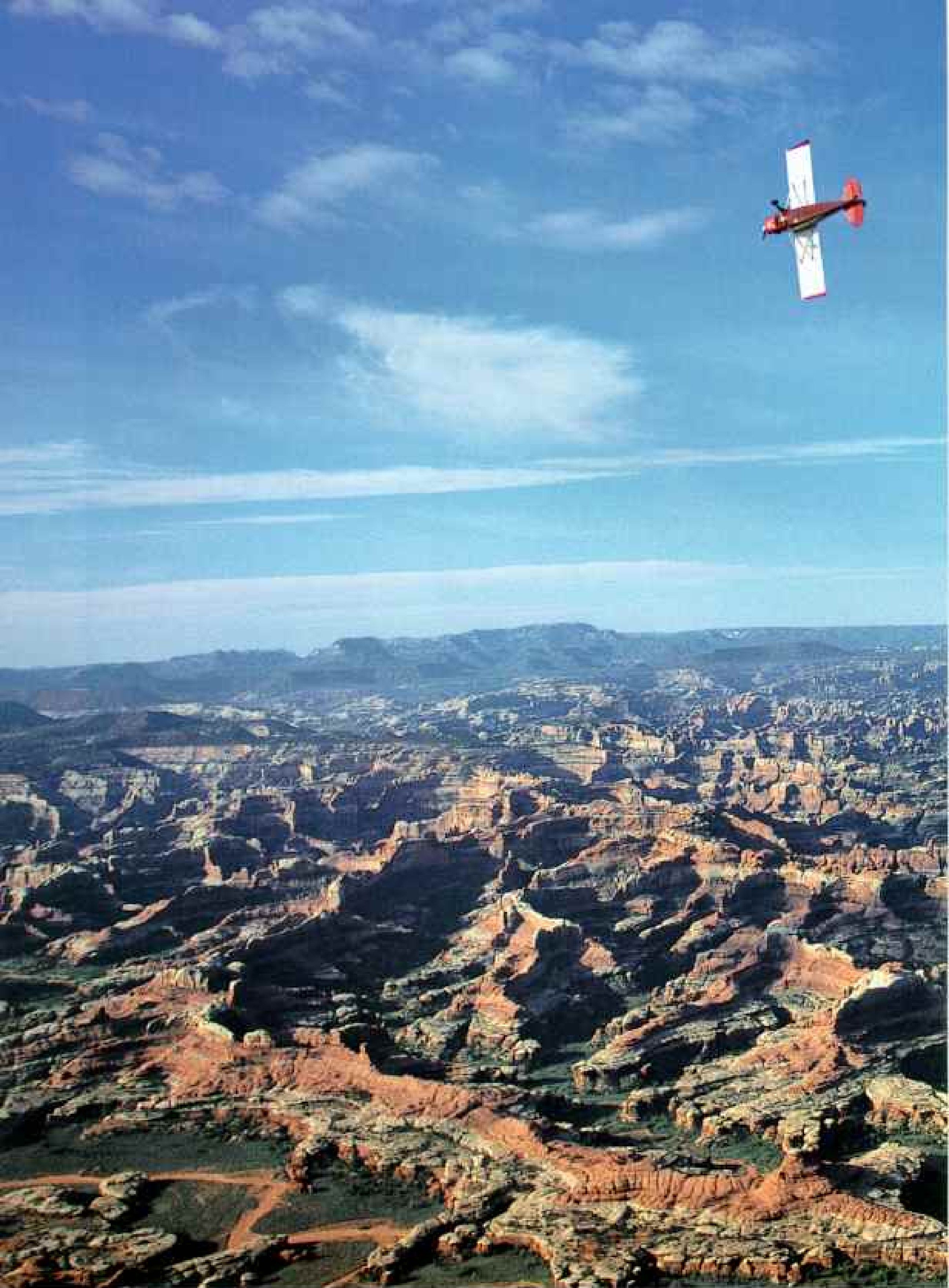
Steve Brock, who's worked at the store for almost four years, watches his customers and smiles. "You'd think in this little town of 5,000 there wouldn't be this many people visiting every weekend," he says, "but it's a regular thing. Unbelievable."

Because of this, life around Moab has become less controllable for the local police. "Most weekends we'll have to hunt for a biker," says Arthur Hines of the Grand County

Sheriff's Department. "They go out in some canyon and get lost; then they fall and bust their hips or legs. It's expensive for the town to rescue them, and some of the older locals are resentful of that. They see the tourists driving up local prices and taxes. They see a boom that may crash and leave us worse off than before."

Others, however, take a shorter view. One Saturday in the Rio Colorado Restaurant, as I sit at the bar and sip a beer, bartender Michael McCormack tells me he enjoys the cyclists and rafters.

"It isn't like these tourists are neo-Nazis or Hell's Angels. They're respectful, they don't drink too much—and they tip well," he says, serving up a bean burrito. "This was a dying



Practicing spin control, a pilot puts his plane through dizzying paces over the Needles of Canyonlands National Park. With its twists of sandstone, the 128,848-acre region is an easy place to get lost—and a tough place to get



found. "It has taken days to locate people who get turned around in here," says park official Larry Frederick. In the 1890s, cowboys were at home in the canyons, grazing cattle near streams that snake through the labyrinth.



Party's over for a young guest at a quince años celebration, the traditional debut of 15-year-old Hispanic girls. Latinos headed for Utah in the 1940s, lured by defense and mining jobs. Another wave came in the 1980s, mostly urban refugees and migrant workers ready to put down roots. Today 100,000 strong, Hispanics are Utah's largest minority.

uranium town before guys like Ken Sleight brought people here."

After 40 years in the canyon country, the gray-haired, 66-year-old Sleight remains conflicted about encouraging people to visit. It's a dilemma he first discovered in the early 1970s, on an afternoon when he befriended a gangly National Park Service employee—and sometime writer—named Edward Abbey.

Striking up a conversation about the growing number of rafters on the Colorado, Sleight and Abbey became fast friends in the course of a single hour. Abbey occasionally joined Sleight on his river trips. Often the two sat around the campfire after the paying guests had gone to sleep, talking about environmental issues surrounding southern Utah.

"We'd end up asking the big questions," Sleight told me when I visited his home,

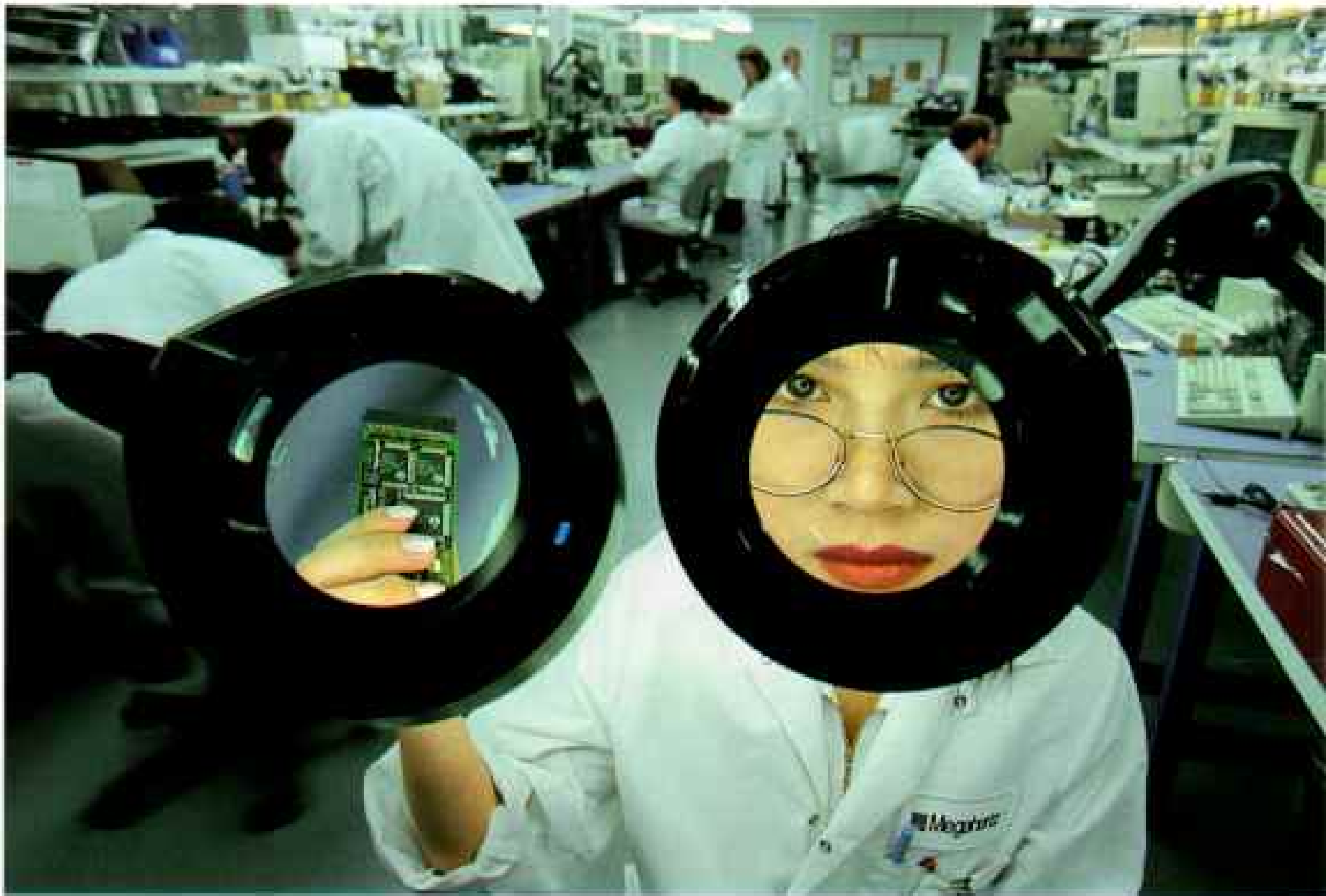
across a large pasture from his dude ranch and country inn, about nine miles south of Moab. "Is development of this desert moral? Is it right? And if not, what are we going to do about it?"

In 1968 Abbey had addressed those questions in *Desert Solitaire*, one of the finest collections of naturalist essays ever published. Each chapter, with hard-eyed, loving detail, served as a subtle call to arms for the Southwest.

"That book brought a whole lot of people's heads around," Sleight says, as we stand on a hillside beneath the stars after dinner. "It put land-use issues smack into people's minds."

These issues are at the heart of a battle in which Sleight and other conservationists are seeking wilderness status for 5.7 million acres of federal land in Utah. The state's governor and senators propose to designate less than a third that amount.

Sleight tells me he hasn't been on the water since 1990. When I ask why, he shakes his head and looks to the dirt. "I don't blame anybody for wanting to go down these canyons," he says, "but I'd rather remember them as they were. All those people on the water at one time, it makes me sad."



TWO HUNDRED AND FIFTY MILES southwest of Moab, in the real estate boomville of St. George, the growing crowds make most locals anything but sad. Retirees throughout the U. S. are deciding that southwest Utah—with its dramatic scenery, warm sunshine, and low cost of living—is the ideal place to settle.

Since 1970, when St. George had only 7,097 people, the population has more than quintupled to 37,500. Last year the number of building permits issued was eight times that of 1980, and there are boosters who estimate that 700,000 people may live in St. George by the year 2030.

"It's that Sunbelt phenomenon," says Bob Nicholson, community development director for St. George. "People are learning that they don't have to be in California to live well."

As Nicholson says this, he's bent over his desk in City Hall. On the desk is a map, a grid of the city's streets, and Nicholson is in the midst of trying to rework traffic patterns. Beyond him, outside his office windows, cars are gridlocked in the March afternoon's shimmering heat.

Nicholson stands and looks out toward the red-rock mountains in the distance. "We're

All eyes scan for defects in the quality-control lab of Megahertz, a Salt Lake City modem manufacturer. Clustered on the Wasatch Front, Utah's 1,700 high-tech companies draw newcomers by the thousands. What's the attraction? Says Megahertz president Spencer Kirk: "Plenty of jobs, low crime, solid values, and a great view."

in a desert," he says, "so, obviously, water will be the limiting factor in how many people can live here. But we've got enough water for at least another 10 or 15 years of growth. Which means," he turns back to his desk and slaps a hand down on the map, "managing growth and traffic are foremost in my mind."

It is no small task. Each morning at sunrise the streets of St. George fill with cars, and nothing goes well. It takes 20 minutes to make the four- or five-mile drive across town, and at those edges of St. George where streets meet the desert, construction equipment whips up tall clouds of red dust. The houses go in as fast as the stucco can dry.

"It's money lust that's got everybody here working now," says Steven Kirkland, a resident of St. George for more than 50 years.

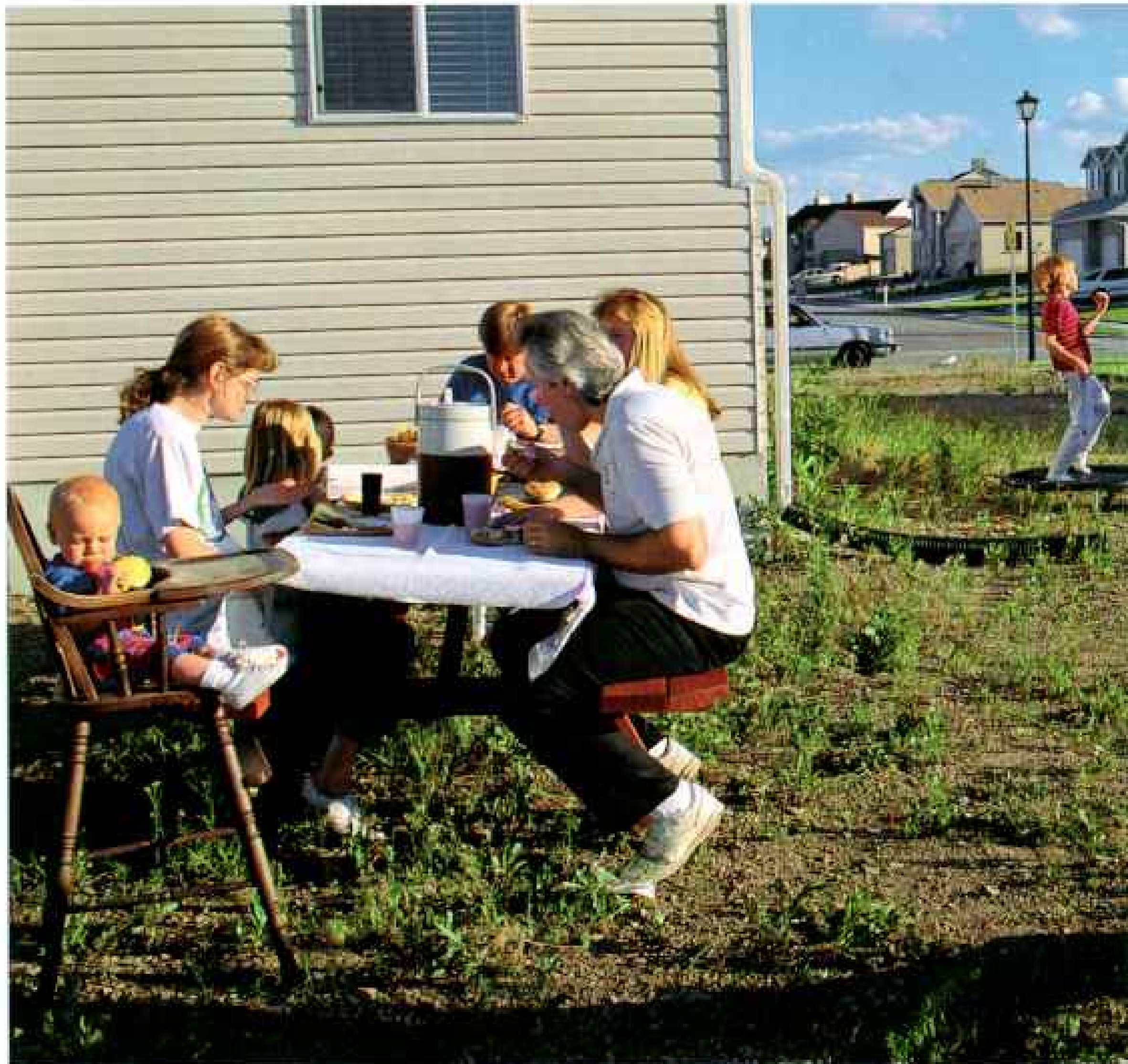
"The old Mormon culture, the thing that first lifted our community up and held it together for so long, all this new money is killing it."

The 80-year-old Kirkland strolls into the parlor of his house from the kitchen, where the newer of his two wives is making lunch. A Methodist from Georgia, he converted to Mormonism in 1941, then relocated to Utah with his wife, Mary, a year later. Since 1952 he has been a polygamist. His second wife, Sylvia, hails from a town to the east. "Those hills over there are still full of 'poligs' [as he calls polygamists], and when I met Sylvia and picked her out as wife number two, Mary never made a fuss. She knew it was the will of God, and I've had an unusually fruitful life because of it."

Kirkland shows me a photograph of his 18

children and 98 grandchildren. "I've had four more grandkids since this was snapped," he says, his hand stroking a white-haired woman at the picture's center. "This is Mary; she died a few years ago," he says. "I miss her very much."

He tilts the photo against a chair and stands back to regard it. "This has been my life's work," he says scratching his thick gray beard. "Of course, my choice to remain a polygamist split me from the church. They excommunicated me, so I no longer practice the religion today's so-called Mormons follow. They passed the manifesto to outlaw polygamy so they could become a state and join the union and make money. I tell you, it's the love of money that drives this place now."





Not for everyone. When Ken Rait, of the Southern Utah Wilderness Alliance, or SUWA, walks the red sand desert outside St. George, he doesn't do so to appreciate the new condominiums sprouting everywhere. Instead, he thinks about the animals that are being run out of St. George and Washington County by the human deluge.

"There are nine different threatened or endangered species living in Washington County," he says. "So when I look at what's going on in St. George, in terms of development, I can only predict an ecological and environmental train wreck."

In the past half dozen years, Rait notes, better than 10,000 acres of the county have been chewed up by the growth. "St. George sits amid the most biologically diverse ecosystem in the state," he says. "Washington County is where the Great Basin and the Colorado Plateau meet the Mojave Desert. It's home to at least 300 different species, maybe more than anywhere else in the West."

Like many southwest Utah environmentalists, Rait is concentrating his antidevelopment fervor on the threatened desert tortoise, a federally protected species that lives almost

It was no picnic living in the urban hubbub of Salt Lake City, so Lance Smith (in white shirt) moved his family out to the suburb of West Jordan. The only problem, says Smith, is "everybody else had the same doggone idea." In St. George (above), in southwestern Utah, development takes to the hills as retirees flock in for sun, scenery, and nearby Las Vegas casinos.



"I wanted to be in the parade, but Grace sure didn't," says Adam Pate, who gets help pulling the reluctant pig down the main street of Mount Pleasant. The young people play characters in the Sanpete Youth Pioneer Pageant,



reenacting the Mormon trek to Salt Lake Valley. Led by Brigham Young, the original 148 settlers bore a heavy load: 73 wagons, one boat, one cannon, 93 horses, 52 mules, 66 oxen, and 19 cows—but no pigs.



A squeegee-clean snowscape greets skiers who thaw in the hot tub at a Snowbird lodge. Claiming "the greatest snow on earth," Utah attracts close to 500,000 skiers annually, not counting the locals. The world's top athletes will put the slopes to the test in 2002, when Salt Lake City and surrounding ski areas host the Winter Olympic Games.

exclusively in the Mojave and Great Basin deserts below 5,000 feet in altitude, the level of St. George. The tortoise, a prehistoric native about the size of a halved cantaloupe, is slow moving and slow to breed, traits that make destruction of its habitat doubly damaging to its survival.

Lately, Rait says, people have been destroying tortoise burrows, an act that could earn the vandals a year in prison. I saw a tortoise tunnel that had been wrenched apart by a length of galvanized pipe. The narrow entrance was ripped away, the interior demolished. "I know of four burrows that have been destroyed on private land. Someone is vandalizing these animals' homes in an effort to stop the tortoises from reproducing. That's pretty low to stoop so you can add a couple of new condominiums."

Rait's views put Quentin Ence, co-owner of Ence Homes, Inc., in St. George, on the defensive. "You've been talked at by a fanatic," he says of Rait. By Ence's estimation, antigrowth forces in the county are only using the tortoise as a high-minded tool to accomplish their real goal: keeping newcomers out.

"Those no-growth people are elitists," he says. "They say: I'm here now, so I don't want anybody else here. It's human nature, I guess, but that doesn't make it right."

DESPITE THE GROWTH across Utah, and the debate it's spawning, there's one part of the state where nobody is going to be migrating very quickly: the Great Salt Lake Desert, which spreads some 5,000 square miles across Utah's north-west corner.

In the summer of 1846 the ill-fated Donner party, bound for California, presumed the level landscape could be crossed with relative ease. Four days and 80 miles later, having lost 4 of their 20 wagons to mires of sticky salt, the group reached the desert's western side, parched, hungry, and exhausted. It took them a week to recover and push on—a costly



delay. Months later, halted by early winter blizzards in the Sierra Nevada, they would begin to eat their dead.

The desert is easier to negotiate now—Interstate 80 allows travelers to cross it in less than an hour—but the place is no more hospitable. The Morton Salt Company, of course, finds it wonderful, as they simply flood a few hundred acres with Great Salt Lake brine, wait for it to evaporate in the heat, and package the residue as road salt. The world's speed drivers are partial to the Bonneville Salt Flats, a blindingly white plain that is one of the flattest, most obstacle-free places on earth. They gather there several times a year, to chase the land speed record along a ten-mile strip called the Bonneville Speedway. Most of the time, however, the desert remains as desolate as it was when Jed Smith or the Donner party crossed it.

It was this desolation that lured the U. S. military to the area in 1942. With war aflame in Europe, the War Department took 235 square miles and parceled it into two high-security bases.

The first, Dugway Proving Ground, served as a testing range for toxic munitions and an open-air test site for dispersions of biological

Unimpressed with the view, a young hiker belts out a cry that echoes across Dead Horse Point State Park, named for a herd of mustangs said to have died of thirst there. Some 200,000 people a year visit the park, between Arches and Canyonlands National Parks. Statewide, tourism racks up 3.3 billion dollars a year and employs 69,000 Utahns.

weapons. The second, Tooele (pronounced Too-WILL-uh) Army Depot, stored much of America's supply of chemical weapons. The bases still exist.

At Dugway it's estimated that 15 percent of the soil has been contaminated, either by deadly bacteria such as those causing anthrax and tularemia or by dud artillery shells, some of which have been rusting beneath the salty soil since 1942.

Yet Dugway's troubles are small compared with those at Tooele, which is only 25 miles away from the Salt Lake metropolitan area and its million inhabitants. Inside the depot, 40 percent of America's chemical-weapons stockpile sits inside 208 igloo-shaped warehouses—enough poison to kill everything on the planet.

But thanks to a congressional order to



Bear hugs and kisses are all in a day's work for animal trainer Doug Seus and Bart, his 1,500-pound Kodiak brown bear. "Fairness, trust, and bonding are essential for safety when you're working with a big carnivore," says



Seus. Bart is a hot property in Utah's exploding movie industry, starring in such hits as White Fang and Legends of the Fall. Off the set, he serves as poster bear for Vital Ground, a group working to preserve grizzly habitat.

Catching a whiff of approaching rain, two Ute girls watch the clouds roll in. The state took its name from their ancestors, a people whose domain reached parts of Colorado, New Mexico, and Arizona. Today the Utah band of 2,900 call reservations in the northeast and southeast home, remaining wed to the land they love. For them, Utah is still the place.

destroy all America's toxic weapons by the year 2004, a huge 475-million-dollar incinerator has been built at Tooele to burn the stockpile. The job is scheduled to begin this year and will continue 24 hours a day for at least six years.

On an overcast spring morning I arrive at the depot. First the Army issues me a gas mask and shows a videotape on its use, just in case the base's air-monitoring sirens begin to wail. Finally, Tim Thomas, a 45-year-old engineer who manages the base's chemical-weapons demilitarization, shows me his baby: the ultimate in high-tech incinerators.

The toxic weapons are dismantled using computer-controlled equipment while human operators watch on computer screens and closed-circuit television. The furnaces' kilns are designed to contain any potential explosions. The toxic liquid will be incinerated at temperatures reaching 2700°F; the smoke will be reburned and filtered before being released into chimneys.

"Safety is our primary objective," Thomas tells me, pointing toward sensors at the smokestack tops that will shut down the furnaces if any toxic agent is detected. The Environmental Protection Agency requires a 99.99 percent incineration rate for toxics at the plant. "It's as safety-minded as anything ever built," Thomas says.

It better be. With Salt Lake City lying just one valley to the east, Thomas knows he's got a public relations problem on his hands. A prototype of the incinerator on Johnston Atoll in the Pacific has been plagued by design flaws and equipment failures.

"Transporting the stockpile only relocates the problem," he says. "If we take care of the burn here, and do it safely and correctly—with no expense spared for safety's sake—then the stockpile should be expunged from the earth by the year 2002. Not a bad way to start a millennium."

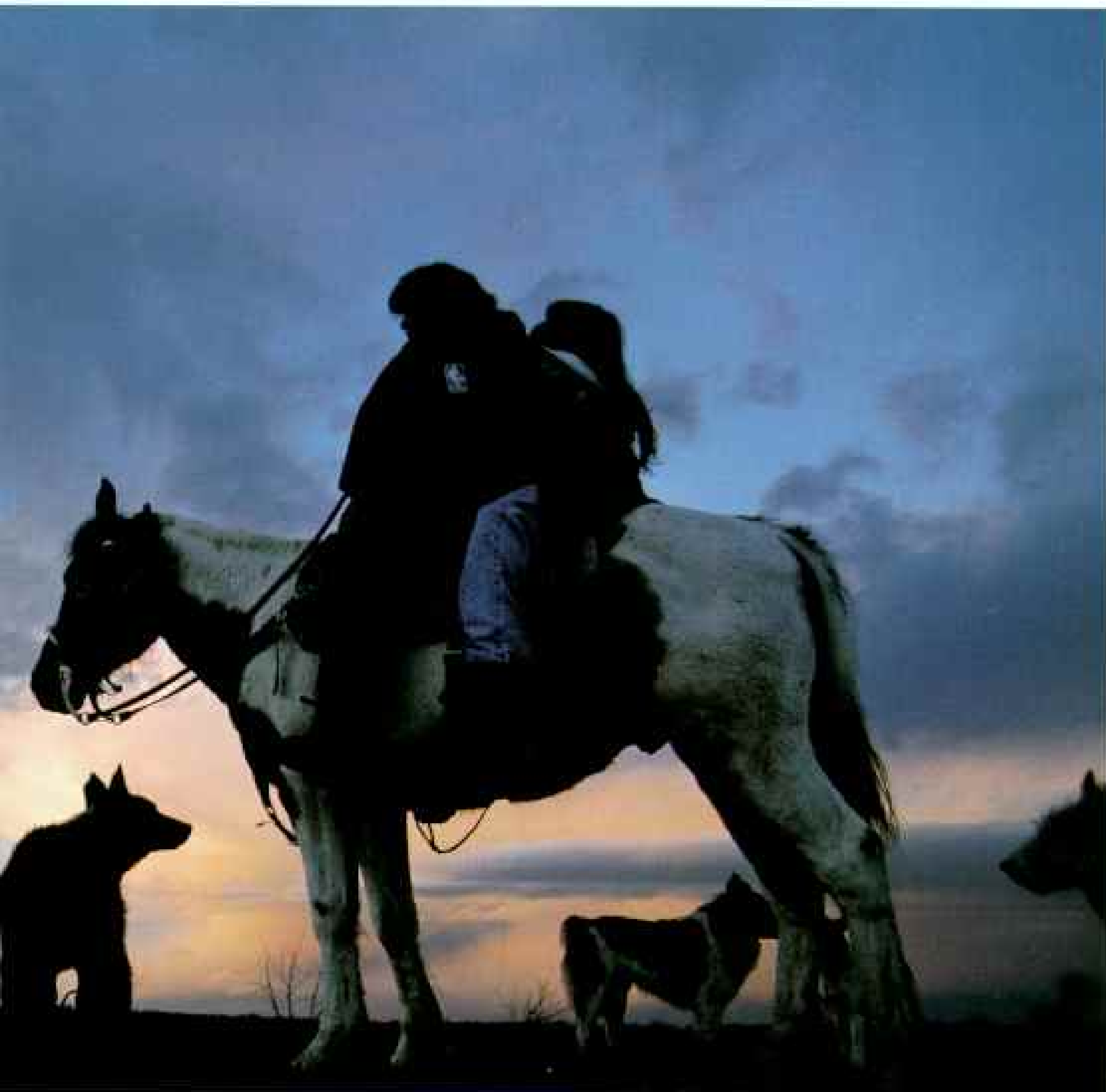
And with that—and an assuring smile—the tour is over. As I drive off, stopping to watch



two bald eagles playing above the waters of Rush Lake, I think maybe Utah will be able to start the next thousand years free of the shadows of past hostilities. Maybe, in this starkly beautiful place, future Utahns will benefit from a clean slate.

UTAH REMAINS a paradox. As prosperity has come to the desert, bringing human promise to a place long deprived of it, a stockpile of poison rests near the state's heart. Retirees and tourists discover the slickrock beauty of the canyons, but their arrival begins to destroy it. Everywhere you look in Utah, you find a place battling the issues of change.

But for me the most memorable places in



the state will always be the unchangeable valleys. It is the thrill of cresting a mountain and dropping into an empty valley that sends my thoughts soaring like those of a newly converted pilgrim. Fortunately, it isn't a sensation reserved only for California executives or Mormon pioneers—or me.

About two hours south of Salt Lake City, in a valley of the lonely Gilson Mountains, a shepherd named Enrico enjoys a life that the valleys of Utah helped reclaim. Driven from his native Peru by civil unrest, the 44-year-old shepherd is happy to be doing his chosen work in a place where he doesn't have to worry about dying in a guerrilla war.

Enrico lives in a neat, Conestoga-style trailer that stands alone above the broad,

sage desert. And in the mornings, as his dogs rouse in the ruby light, he knows that this difficult land has given him a better life. With free room and board, plus about \$700 a month in salary from a local ranch, Enrico earns roughly ten times what he would in Peru. And the high valleys remind him of his Andean home, which, he says, makes him lonely occasionally. "But," he adds, "I know that a lonely feeling is part of a shepherd's life in Peru too."

As he smiles and stares across the valley dotted with livestock, he tells me that Utah may be his promised land, as it has been for so many others. "Back home," he says, "when people hear of my life in this place, they can only think I am a millionaire." □

Dispatches From

BY WILL STEGER

PHOTOGRAPHS BY GORDON WILTSIE

The sled was going down. If the dogs couldn't save it, our journey from Russia to Canada would be finished only halfway across the Arctic Ocean. This time we were lucky. Our huskies were strong, and we pushed on.



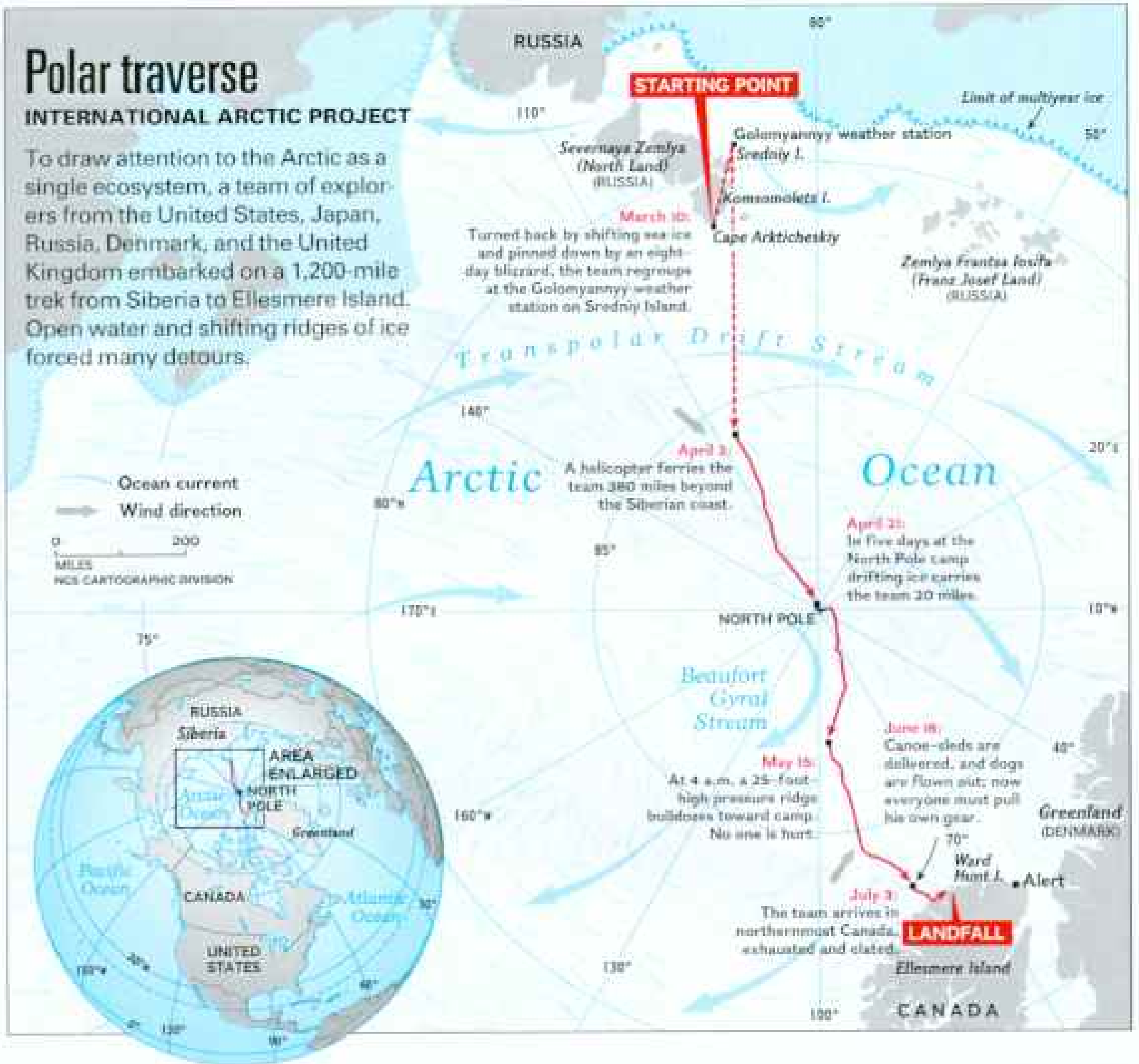
the Arctic Ocean



Polar traverse

INTERNATIONAL ARCTIC PROJECT

To draw attention to the Arctic as a single ecosystem, a team of explorers from the United States, Japan, Russia, Denmark, and the United Kingdom embarked on a 1,200-mile trek from Siberia to Ellesmere Island. Open water and shifting ridges of ice forced many detours.



FRIDAY, MARCH 10, 1995

Position: 81°8'24''N, 96°27'36''E

Temperature: -40°F

Weather: cloudy

EVERYTHING THAT COULD GO WRONG DID during the first 24 hours of our journey across the Arctic Ocean. Only five miles from our starting point on the Siberian coast, where a Russian helicopter (facing page) had dropped off our team of two women and four men, Ulrik Vedel's dogs plunged through thin ice. Still in their harnesses, the dogs were sinking. Victor Boyarsky fell into the water while trying to save them as Ulrik lay flat on the ice to cut the animals free with his knife. Then Ulrik went in. By the time I got there, the huskies were running loose, Victor was stranded on a chunk of ice, and Ulrik (right) was turning into an icicle. It took a full day for him to thaw out.

All around us the ice was shifting, tilting, and bobbing. The sea was chaotic, shattered into a mish-mash of unstable pans. When we encountered a zone of open water and broken ice hundreds of miles long to the north the next day, we had no choice but to retreat. No sooner had we worked our way back to our starting point near Cape Arkticheskiy, however, than we were pinned down by a blizzard for eight days. Most of us came down with bronchial infections.

Then Ulrik decided he did not want to continue on the journey. We had to come up with a new plan. We had hoped to make the 1,200-mile crossing from shore to shore on foot, but that wouldn't be possible now. Instead we would leapfrog by helicopter over the open water and unstable ice off Siberia and begin our journey closer to the North Pole. There would only be five of us, a third fewer dogs, and less gear. Yet our morale was high. We would make it work.



FRIDAY, APRIL 21, 1995

Position: $89^{\circ}57'18''N$, $154^{\circ}19'37''E$

Snow cover: 8 inches

Drift: 7 miles NW in 24 hours

DESPITE our early setbacks, we reached the North Pole on Earth Day as planned, aiming to focus attention on the Arctic environment, which is being polluted by contaminants carried by wind, river, and ocean currents from the south.

To raise awareness of such issues—as well as to share stories about our adventures—with millions of schoolchildren in more than a dozen countries, Takako Takano and Julie Hanson (right) composed daily messages on our computer, then

transmitted them to a polar orbiting satellite, which relayed them to a ground station in Virginia. Within hours of being sent, the messages were electronically zapped to classrooms worldwide. Our team portrait (far right) was the first image transmitted from the North Pole over the Internet. From left are Martin Hignell, Julie, me, Takako, and Victor.

Students sent us lots of questions by satellite e-mail. Among the most frequent: How do your dogs survive in the cold? Do

they sleep in your tents? Our answer: No, they are happier outside. Their inner layer of fur, which is as fine as goose down, keeps them warm in subzero temperatures.

Of all the eerie sounds on the frozen sea, the one I never got used to was the ice groaning beneath our polar camp (below) as we drifted at night. It reminded me of freight trains bumping together, hitching and unhitching. My teammates compared it to a drawbridge going up and down or the song of whales.





IMAGE TRANSMITTED BY THE SYSTEMS ENGINEERING SOCIETY,
SPACEQUEST LTD., AND SATELLIFE



Our Russian snowman, Victor scrubbed himself clean every morning. Though the Arctic usually gets very little precipitation, we had snow almost every day during May and June. As our point man, Victor skied ahead of the sleds, probing drifts for cracks. "Ice pushes us to East / Ice pushes us to West . . .," he penned in a poem. "My God! Why have we chosen frozen?"





FRIDAY, JUNE 16, 1995

Position: 83°33'N, 82°7'24''W
Pressure ridges: 17 feet high
Leads: 15-30 feet wide



ZIGZAGGING around leads—lanes of open water 10,000 feet deep (right)—was like sledding through a maze. At times, to make a few miles, we had to spend a day traveling in the opposite direction. At other times we battled gusting winds for hours and ended up losing miles. Whiteouts added to the puzzle, disorienting us with a blinding brightness.

No matter what the conditions, our dogs never lost their eagerness to run, not even after we were resupplied and our sleds groaned with more than 700 pounds each. Following a hard day of pulling, Julie's dog Woody (left) snored peacefully beneath a blanket of snow.

The ice was always playing tricks on us. Once a crack opened in the middle of a dog team staked out next to Martin's tent. We heard a pop, then saw his sled being dragged forward as a sheet of ice drifted away from camp. Julie released the dogs closest to the crack, while Martin leaped across the water gap to pull out the ice screw and free the other dogs.

We were sorry to see the dogs go in mid-June, when the ice started to melt and we had to replace them with canoe-sleds. My dog Rex, who had also gone to the South Pole with Victor and me in 1989, watched from the cargo door of the plane as the others were loaded for the flight out.



WILL STEGER



Three other teams reach the Pole

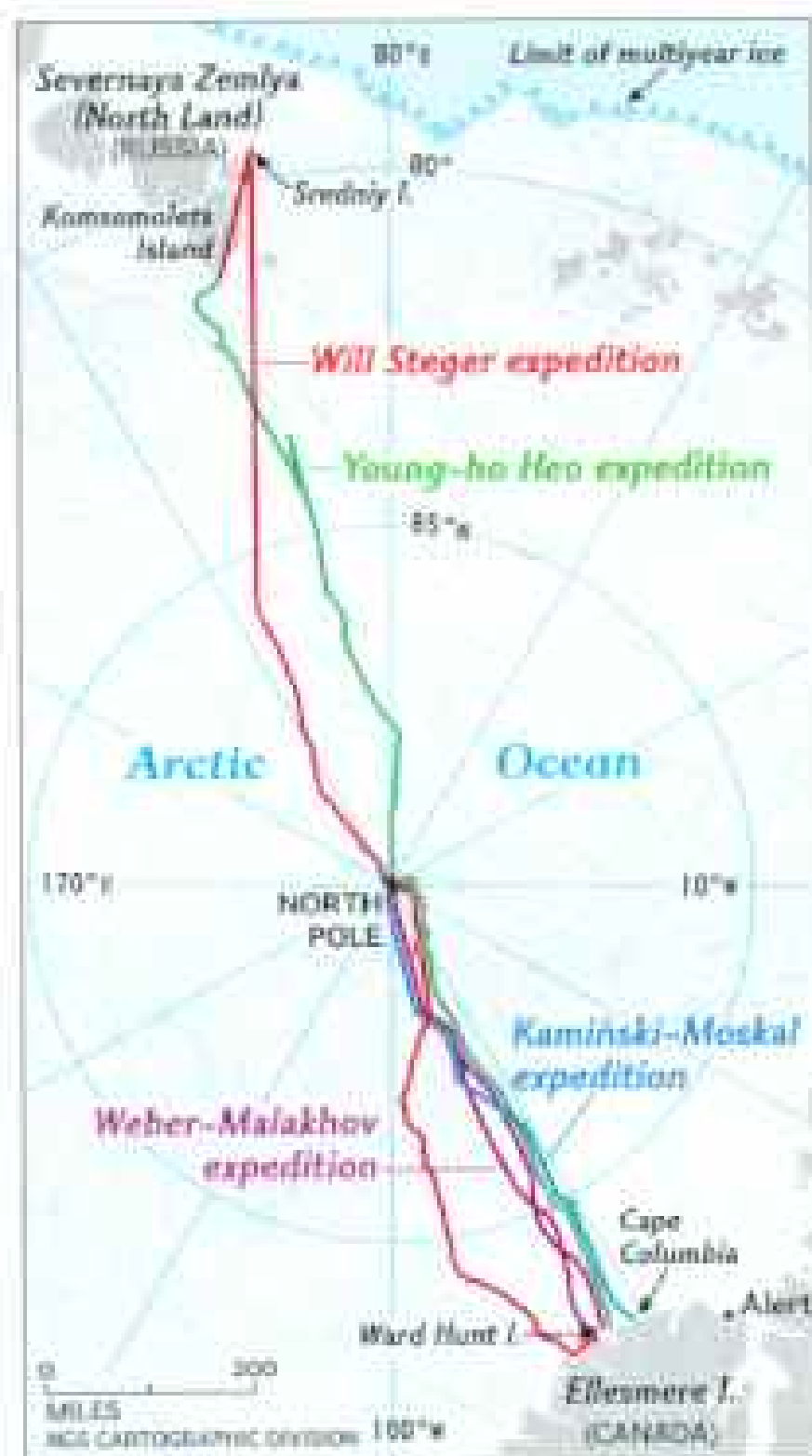
Despite treacherous ice, punishing blizzards, and a dangerous early thaw on the open sea, the far north was crowded with adventurers in 1995.

WEBER-MALAKHOV EXPEDITION

Not since Adm. Robert E. Peary slogged to the North Pole in 1909 had anyone



made such a journey there and back without resupply until Canadian Richard Weber and Russian Mikhail Malakhov completed a 940-mile trek on skis. Pulling 300-pound sleds, the pair left Canada's Ward Hunt Island February 14, reached the Pole May 12, and returned to their starting point June 15, racing for solid ground as the sea melted beneath them. Weber, trained as an engineer, and Malakhov, formerly a thoracic surgeon, credited their success partly to a high-fat diet including chocolate truffles.



YOUNG-HO HEO EXPEDITION A five-man Korean team led by Young-ho Heo of Seoul crossed the Arctic Ocean on skis in 99 days, leaving from Komsomolets Island in Siberia and arriving off the coast of Canada's Ward Hunt Island on June 19. Buried



by a blizzard during their first days on the ice, the team, made up of Gi-chan Jang, Beum-taek Kim, Sung-hwan Kim, and Keun-bae Lee, pulled sleds 1,100 miles.

KAMIŃSKI-MOSKAL EXPEDITION Marek Kamiński and Wojtek Moskal on May 23 became the first adventurers from Poland to reach the North Pole on foot without resupply. Leaving Ellesmere Island's Cape Columbia March 14, the team almost quit after the ice gave way and Moskal fell into the water. During the first month the men covered only 25 miles; the second, 435 miles. The pair, both from Gdańsk, were awarded medals by President Lech Wałęsa.



OUR FIRST STEPS on land—after 116 days on the ocean—were planted on Canada's Ward Hunt Island (above). Paul Pregont joined us for the last hundred miles, making our team an even six, two per canoe-sled. As the ice turned to slush and leads widened, we were glad to have canoes to paddle, although the 20-foot-long craft were a burden to haul through waist-deep snow. Sometimes we made only three miles in seven hours. But when we found a field of flowering



saxifrage, we knew our journey was really over (right).

Back in Siberia I had imagined that I knew the Arctic Ocean pretty well. But the sea continually astonished us, from pressure ridges of ice piling up before our eyes to delicate snowflakes parachuting through icy fog. As a teacher as well as an explorer, I'm glad we had the chance to share these moments with so many young people, who may now understand a little better the importance of adventure in every life. □



WILL STEEBER

Feast of the Tarpon

**ARTICLE AND PHOTOGRAPHS
BY DAVID DOUBILET**

Slashing like cutlasses, a platoon of tarpon attacks an immense school of dwarf herring. So begins a silent, graceful, and lethal assault as lightning-fast predators gorge themselves in the Caribbean Sea.





A silvery veil swirls in the shallows near Carval Rock off St. John in the U. S. Virgin Islands. At midday dwarf herring gather to rest in large numbers for safety. In late afternoon they migrate to reef beds to feed on countless tiny zooplankton.





At times you can feel the pulse, the heartbeat of the ocean. Late in the day vast schools of dwarf herring and anchovies—which local fishermen call silversides—begin to feed, covering reefs, filling coral caves, and choking the iron hulls of rusting shipwrecks. Between Carval Rock and Congo Cay, about a mile off the coast of St. John, the schools become so thick that they nearly blot out sunlight from the shallows.

I was shown this place by diver-naturalist Bob Carney. The water was hazy from plankton and dust driven by trade winds. I saw the small silversides hugging Carval Rock like clouds touching a mountain range.

Then came *Megalops atlanticus*, the tarpon, patrolling on the first pass, attacking on the next. The

DAVID DOUBLET's byline has appeared in NATIONAL GEOGRAPHIC 40 times over the past quarter century.

silversides parted and regrouped. The tarpon came again, moving singly (above), then in squads. The enormous schools massed over my head, and the blue light of the surface became gray. Suddenly more predators appeared: A group of jacks attacked, compacting the silvery fish against the rock. In the confusion a dozen tarpon charged through. Thousands of tiny fish moved at once, making a sound like a rug being beaten.

An ancient fish, the tarpon has large, almost armor-like scales and a protruding, forward-thrusting jaw. The mouth turns upward, and sometimes when the fish feeds, it half-rolls into its prey. The tarpon I saw were small ones, about three and a half feet long and weighing about 40 pounds, though they can grow to more than 250 pounds.

The big ones, prized by anglers, live in reefs and near river mouths,



mangrove forests, and salt marshes. Their range in the western Atlantic extends from Brazil through the Caribbean and north to Cape Hatteras. Occasionally they stray as far north as Nova Scotia.

When tarpon slice through a school, they move their heads from side to side. At dusk I watched a formation fly through a dense cloud of silversides (above).

The schools disperse along the reef at nightfall, but I wanted to extend the day. Just before dark, while the sky was still blue, I lowered a 6,000-watt light onto the reef at the end of Congo Cay. The silversides arrived in small groups until hundreds, thousands—and finally tens of thousands—swam wildly around in the cone of light.

The tarpon came, lurking in the shadows, making quick, tentative strikes. Then they grew bolder

and attacked straight into the middle of the light. The whole gyre of fish and light spun, a living carousel in the night sea.

After four hours the generator ran out of gas and the light died. Suddenly the sea went from brilliant to black. The silversides, now totally disoriented, crashed into me like hail.





Only inches from my camera a tarpon fires past like a torpedo, seemingly heedless of my light or anything but its prey. Squid too took advantage of the light and flew out of the coral reefs to feed on the silvery fish.



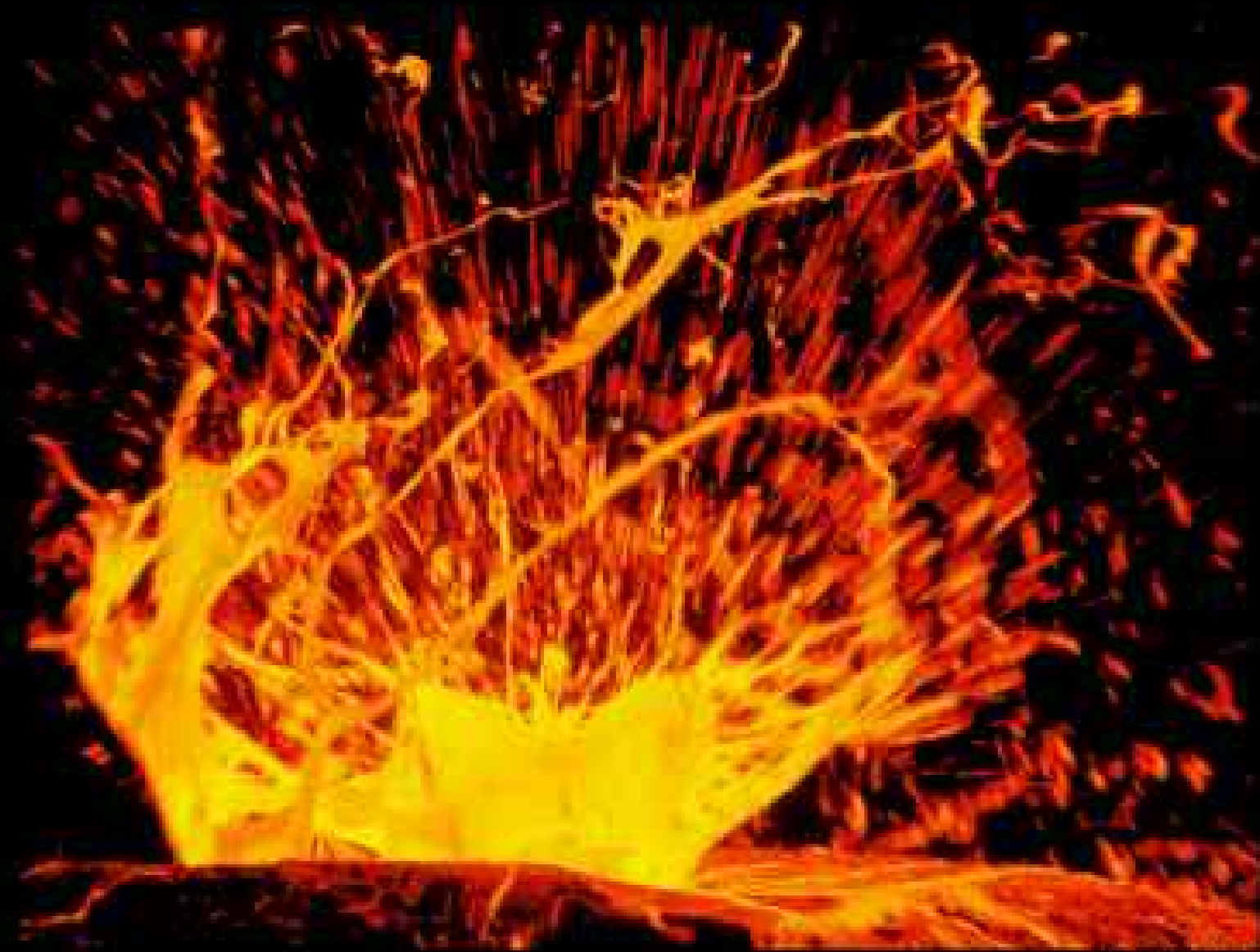


Tarpon on patrol drill tunnels through living walls of silversides. In a moment feeding will start. The tiny fish will flinch, and I will again feel the throb of predator and prey, another beat in the pulse of the sea. □



UNDER OUR SKIN

**HOT THEORIES ON THE
CENTER OF THE EARTH**



G. BRAD LEWIS

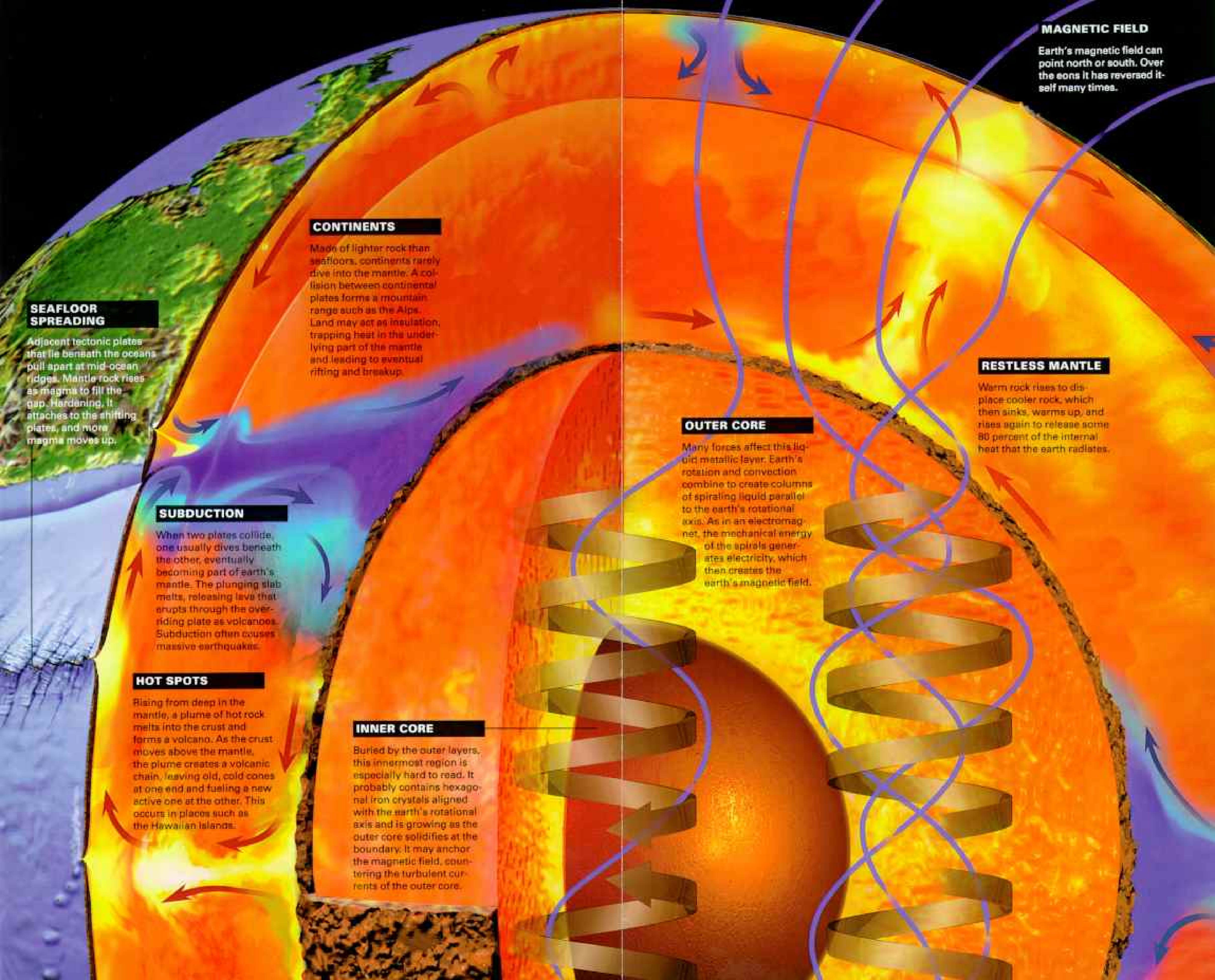
Some 4.6 billion years ago a cloud of dust condensed into planet earth, which soon turned molten from meteorite impacts and radioactive decay. As it cooled, heavier materials sank, forming a layered globe 8,000 miles in diameter (overleaf). Still cooling, the earth roils from its core (right), bringing heat to the surface for release. This convection creates earthquakes and volcanoes — such as Hawaii's Kilauea (above) — that shape our life-bearing lands and seas. Scientists have long pondered what lies beneath the earth's surface. New technology yields some answers.

By KEAY DAVIDSON and A.R. WILLIAMS

NATIONAL GEOGRAPHIC SENIOR STAFF

Illustrations by CHUCK CARTER and ALLEN CARROLL

SENIOR ASSISTANT EDITOR



MAGNETIC FIELD

Earth's magnetic field can point north or south. Over the eons it has reversed itself many times.

CONTINENTS

Made of lighter rock than seafloors, continents rarely dive into the mantle. A collision between continental plates forms a mountain range such as the Alps. Land may act as insulation, trapping heat in the underlying part of the mantle and leading to eventual rifting and breakup.

SEAFLOOR SPREADING

Adjacent tectonic plates that lie beneath the oceans pull apart at mid-ocean ridges. Mantle rock rises as magma to fill the gap. Hardening, it attaches to the shifting plates, and more magma moves up.

SUBDUCTION

When two plates collide, one usually dives beneath the other, eventually becoming part of earth's mantle. The plunging slab melts, releasing lava that erupts through the overriding plate as volcanoes. Subduction often causes massive earthquakes.

HOT SPOTS

Rising from deep in the mantle, a plume of hot rock melts into the crust and forms a volcano. As the crust moves above the mantle, the plume creates a volcanic chain, leaving old, cold cones at one end and fueling a new active one at the other. This occurs in places such as the Hawaiian islands.

INNER CORE

Buried by the outer layers, this innermost region is especially hard to read. It probably contains hexagonal iron crystals aligned with the earth's rotational axis and is growing as the outer core solidifies at the boundary. It may anchor the magnetic field, countering the turbulent currents of the outer core.

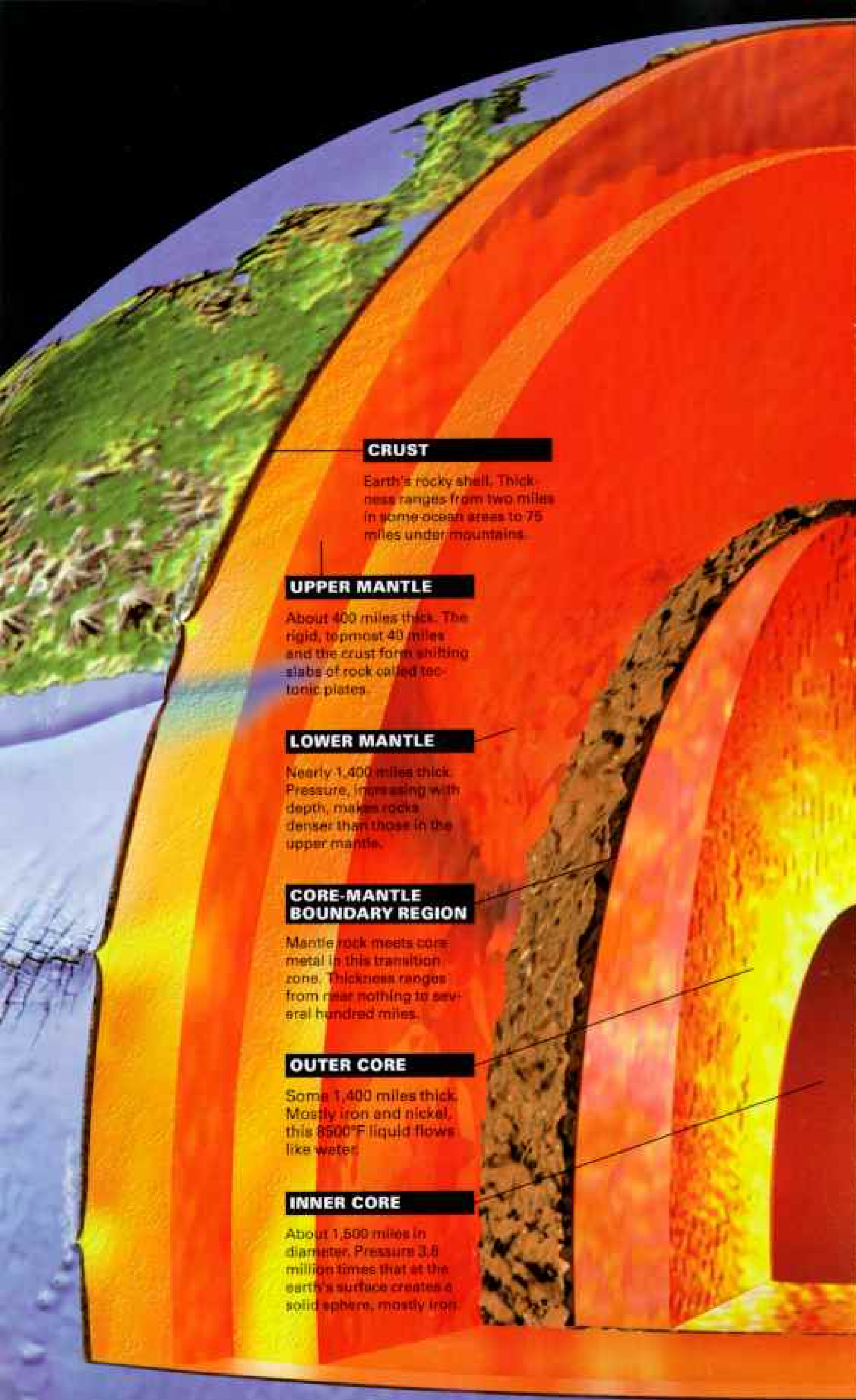
OUTER CORE

Many forces affect this liquid metallic layer. Earth's rotation and convection combine to create columns of spiraling liquid parallel to the earth's rotational axis. As in an electromagnet, the mechanical energy of the spirals generates electricity, which then creates the earth's magnetic field.

RESTLESS MANTLE

Warm rock rises to displace cooler rock, which then sinks, warms up, and rises again to release some 80 percent of the internal heat that the earth radiates.

Eons of earthly turmoil have fueled centuries of scientific debate.



SEISMIC ENERGY EXPLODED in all directions as the earth moved deep beneath Bolivia in June 1994. As shock waves rippled through the crust, high-rise offices swayed in Iowa. Houseplants shook in Minnesota. Even eastern Canada trembled. At magnitude 8.3, it was the biggest earthquake in decades.

More than a million quakes jolt the earth each year. Most don't make much of a stir. Perhaps a few are devastating. Yet even those are small stuff in the big geologic picture. "We humans are self-centered, so we worry about what will affect us," says Raymond Jeanloz, a geophysicist at the University of California at Berkeley. "But hazards like volcanoes and earthquakes are very superficial results of the grand motion of this whole planet."

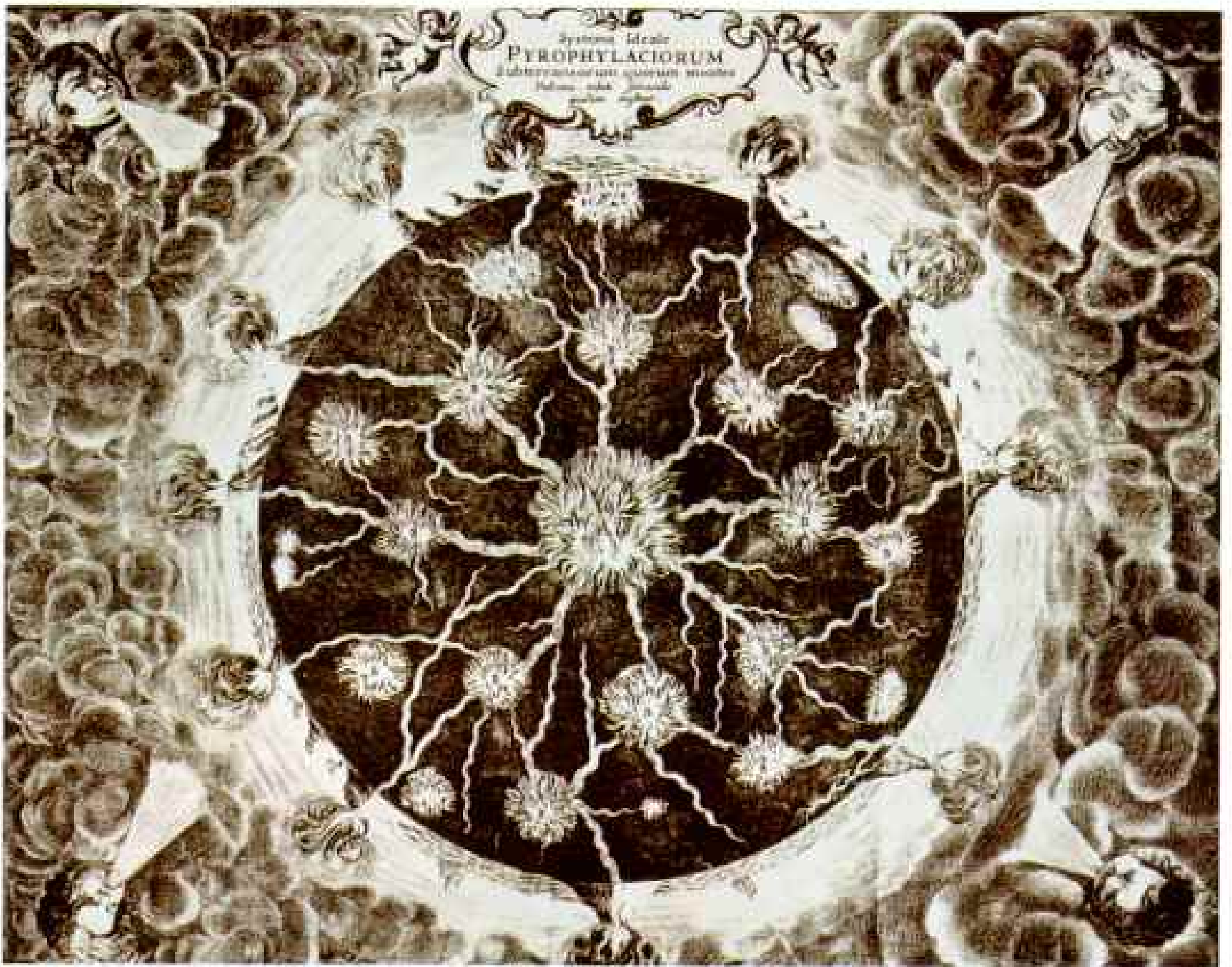
Jeanloz and his colleagues have no hope of exploring inner earth in person. There are no secret volcanic passages to the core like the one that guided Jules Verne's characters on their fictional *Journey to the Center of the Earth*. The real world's deepest borehole reaches only seven and a half miles beneath Russia's Kola Peninsula.

Lack of access hasn't hindered conjecture, however. In 1665 German scholar Athanasius Kircher drew an early cross section of the earth. In his view (right), winds fan subterranean reservoirs of fire, inflaming volcanoes around the globe.

Three decades later English scientist Edmond Halley suggested that the earth held concentric spheres inside. Glowing gas that illuminated these inner worlds escaped from the North Pole to form the aurora borealis. Isaac Newton's explanation of gravity soon helped prove his friend Halley wrong. It enabled scientists to calculate the earth's density, which increases with depth.

By the late 19th century, physicists realized that the earth was radiating heat into space. Lord Kelvin estimated its rate of cooling and calculated that the earth was between 20 million and 100 million years old. Naturalist Charles Darwin disagreed. His theory of evolution required a much longer time span.

Lord Kelvin and other Victorian scientists figured that the earth was as rigid as steel. Not so, argued German meteorologist Alfred

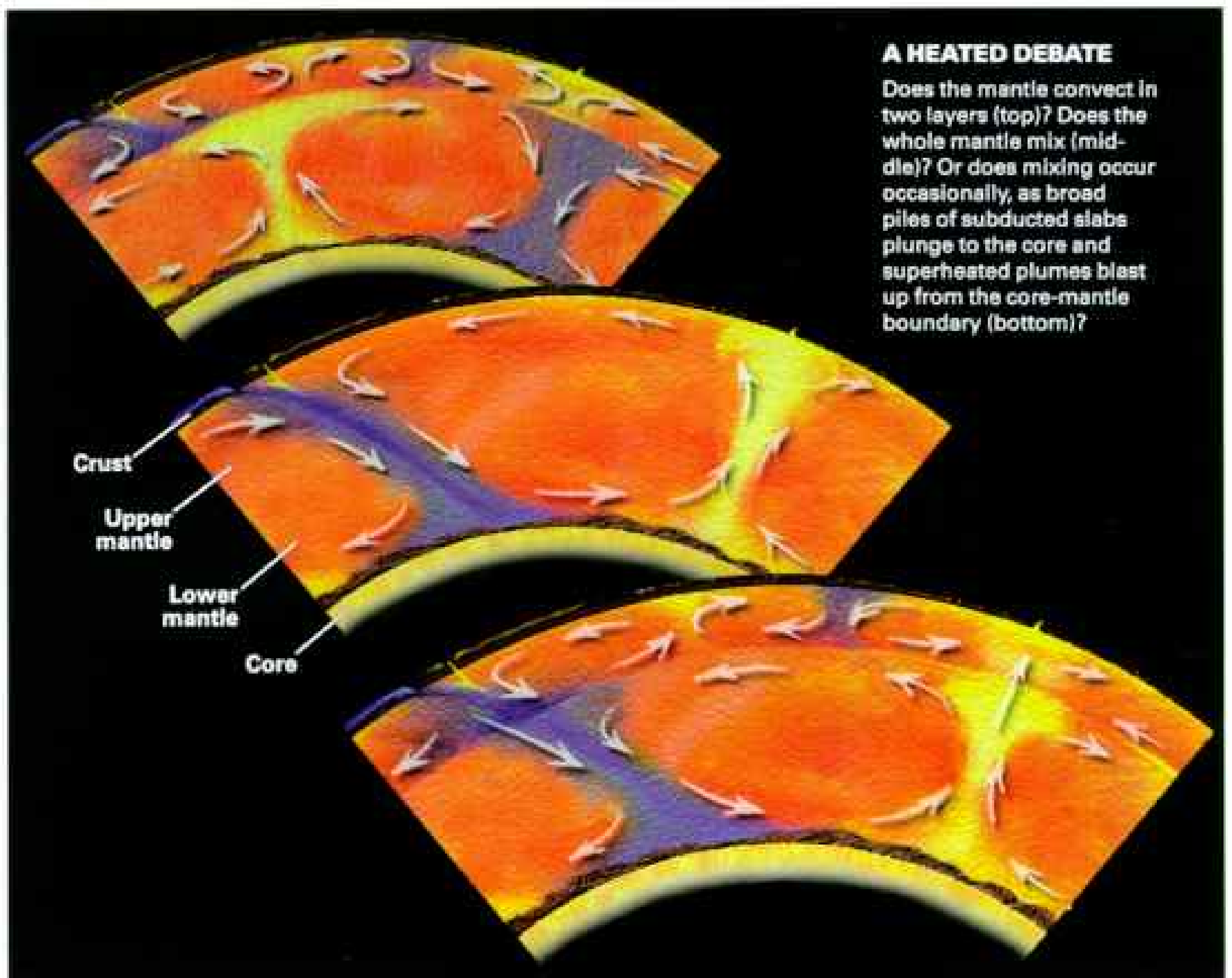


Wegener in the early 1900s: The continents moved around the planet. His idea stirred rancorous debate for decades.

Rebounding in the 1960s as the central concept of plate tectonics, continental drift revolutionized geology. Scientists now know the earth is dynamic and enormously complex. At the surface ride more than a dozen huge, stiff fragments, or plates. They move at a slower-than-snail's pace—only inches a year—but cover thousands of miles over millions of years. As they collide and separate, they change the face of the globe by deforming and rearranging its features.

The engine that propels tectonic plates lies below: hot inner layers that churn like thick soup simmering in very slow motion. The details are nowhere near that simple, though, and researchers are only beginning to close in on them. Working in fields such as seismology, geodynamics, geochemistry, and mineral physics, they ponder where this planet has been and what will become of it.

Interpretations vary greatly. Disagreements are rife, and tempers flare. "It's amazing how emotional people get about the inside of the earth," says Jeanloz. "I can think of a few individuals who won't even speak to me because of my conclusions."



A HEATED DEBATE

Does the mantle convect in two layers (top)? Does the whole mantle mix (middle)? Or does mixing occur occasionally, as broad piles of subducted slabs plunge to the core and superheated plumes blast up from the core-mantle boundary (bottom)?

Theories of Motion

Push South America and Africa together, and the fit leaves no room for argument. They were locked together as part of a large landmass, Pangaea, until some 200 million years ago, when it began to break into the mobile continents of modern times.

Ever since, the Atlantic Ocean has widened along a hot, crust-producing seam that runs through Iceland toward Antarctica. (At right, deep blue marks the oldest seafloor, red the youngest.) This process of seafloor spreading adds about an inch a year between the Eastern and Western Hemispheres.

The currents driving these

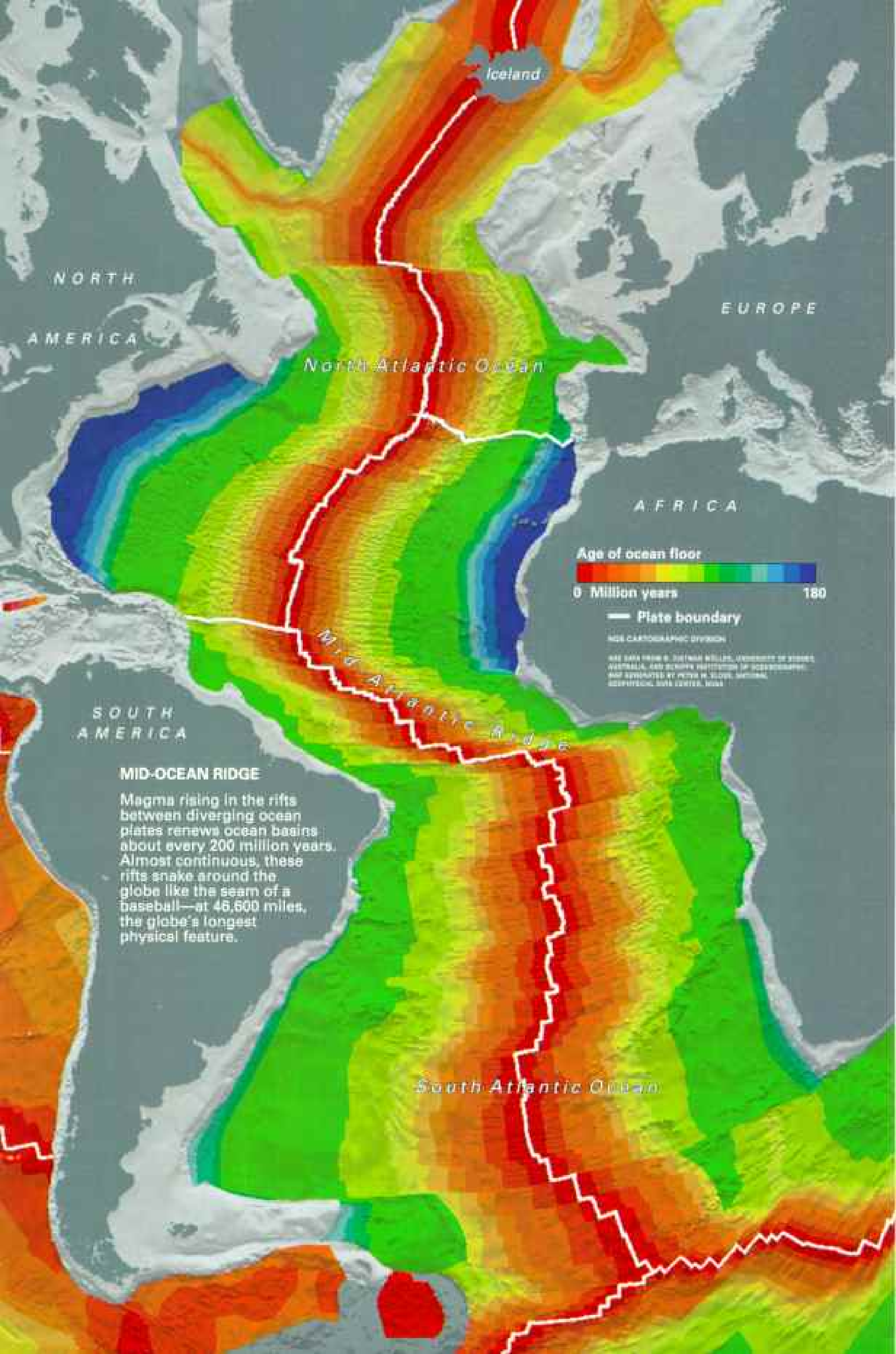
vast tectonic changes sweep through the underlying mantle rock about as fast as fingernails grow. The idea that solid rock can flow is hard to grasp because rock seems immutable in the human time frame. Yet over millions of years rock can move like glacier ice.

Heat makes the rock in the mantle flow. Most comes from decaying radioactive isotopes in the layer itself. Some comes from the outer core, as from the bottom of a double boiler.

Experts agree on all these points. Yet as Caltech geophysicist Don Anderson points out, "The paradigm behind the science of geology is, 'Life is a mess.'" And scientists

have yet to sort out completely the mess in the mantle.

Its pattern of movement remains the most contentious issue. Some researchers believe that the upper and lower mantles convect separately, exchanging little or no material. Others think currents sweep through the whole mantle. Increasingly, though, scientists see in the newest studies evidence for both patterns. Richard Carlson, a geochemist at the Carnegie Institution, compares the earth to a layered drink. "It's like alcohol and orange juice. If you stir them gently, they will form layers, but with a lot of stirring they'll mix."



Iceland

NORTH

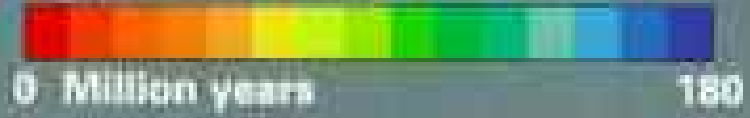
AMERICA

EUROPE

North Atlantic Ocean

AFRICA

Age of ocean floor



— Plate boundary

NOIS CARTOGRAPHIC DIVISION

AGE DATA FROM R. DUSTWIG WELLS, UNIVERSITY OF TEXAS AT AUSTIN, AND SCIENTIFIC PARTITIONING OF OCEANOGRAPHY. MAP APPROVED BY PETER H. SLOPE, NATIONAL OCEANOGRAPHIC DATA CENTER, 2004

SOUTH
AMERICA

MID-OCEAN RIDGE

Magma rising in the rifts between diverging ocean plates renews ocean basins about every 200 million years. Almost continuous, these rifts snake around the globe like the seam of a baseball—at 46,600 miles, the globe's longest physical feature.

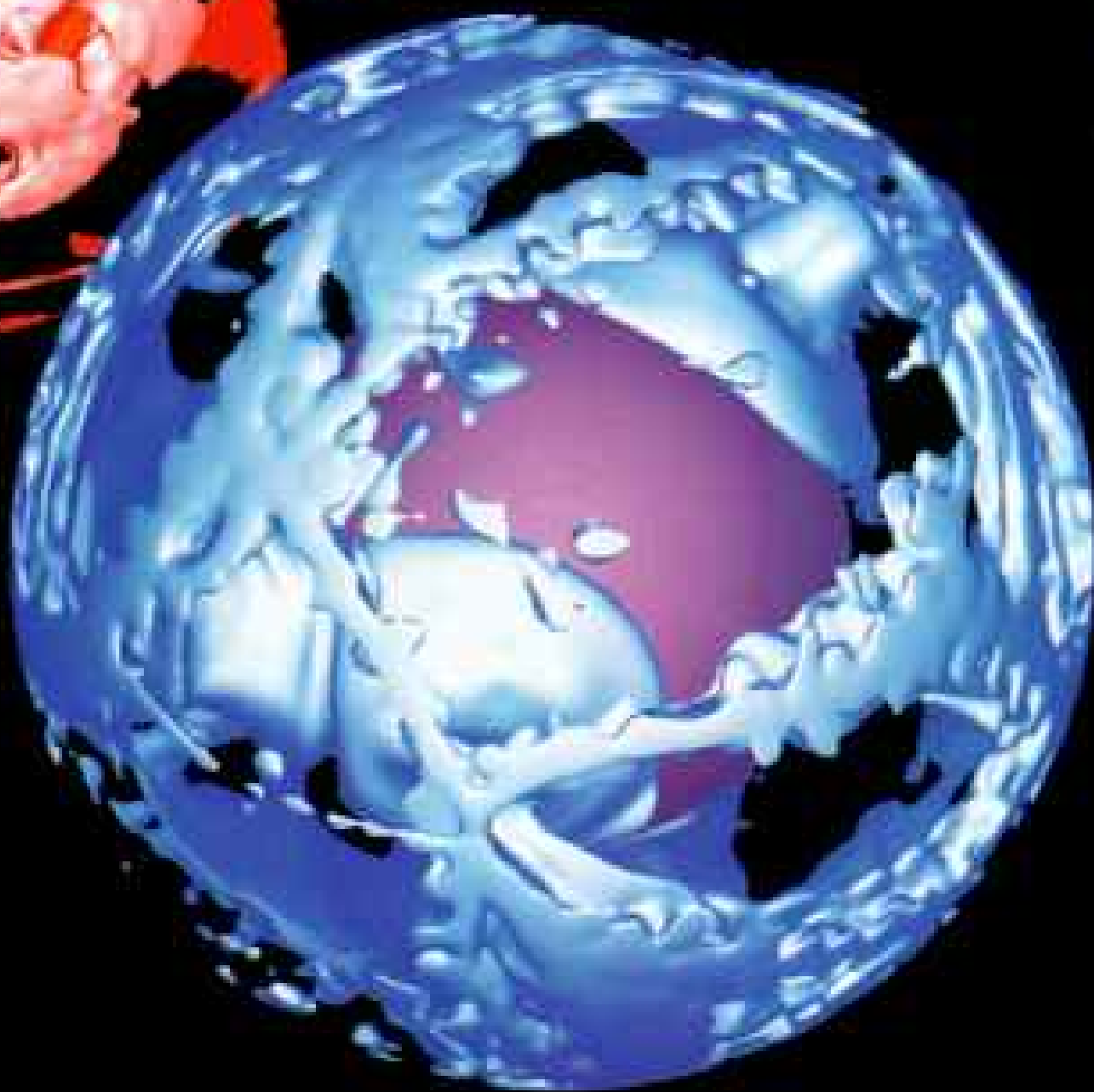
South Atlantic Ocean



COMPUTER MODELS

Over millions of years cold, subducted plates avalanche toward the bottom of the mantle (right). Hot mantle rock rises in mushroom-shaped plumes (above). The process drives the endless movement of the surface plates.

PAUL J. TACKLEY, UCLA



Tools of the Trade

Advances in technology allow a clearer look into the earth. Supercomputers, for example, now provide geophysical images in three dimensions, crunching numbers that sum up how scientists believe the earth's insides work. A team led by UCLA geophysicist Paul Tackley used such computer power to simulate two billion years of mantle movement (above). By convention, red shows hot rock rising; blue shows cold rock sinking.

Such computer models need information about buried rock. To search for clues, geophysicists study the rocks

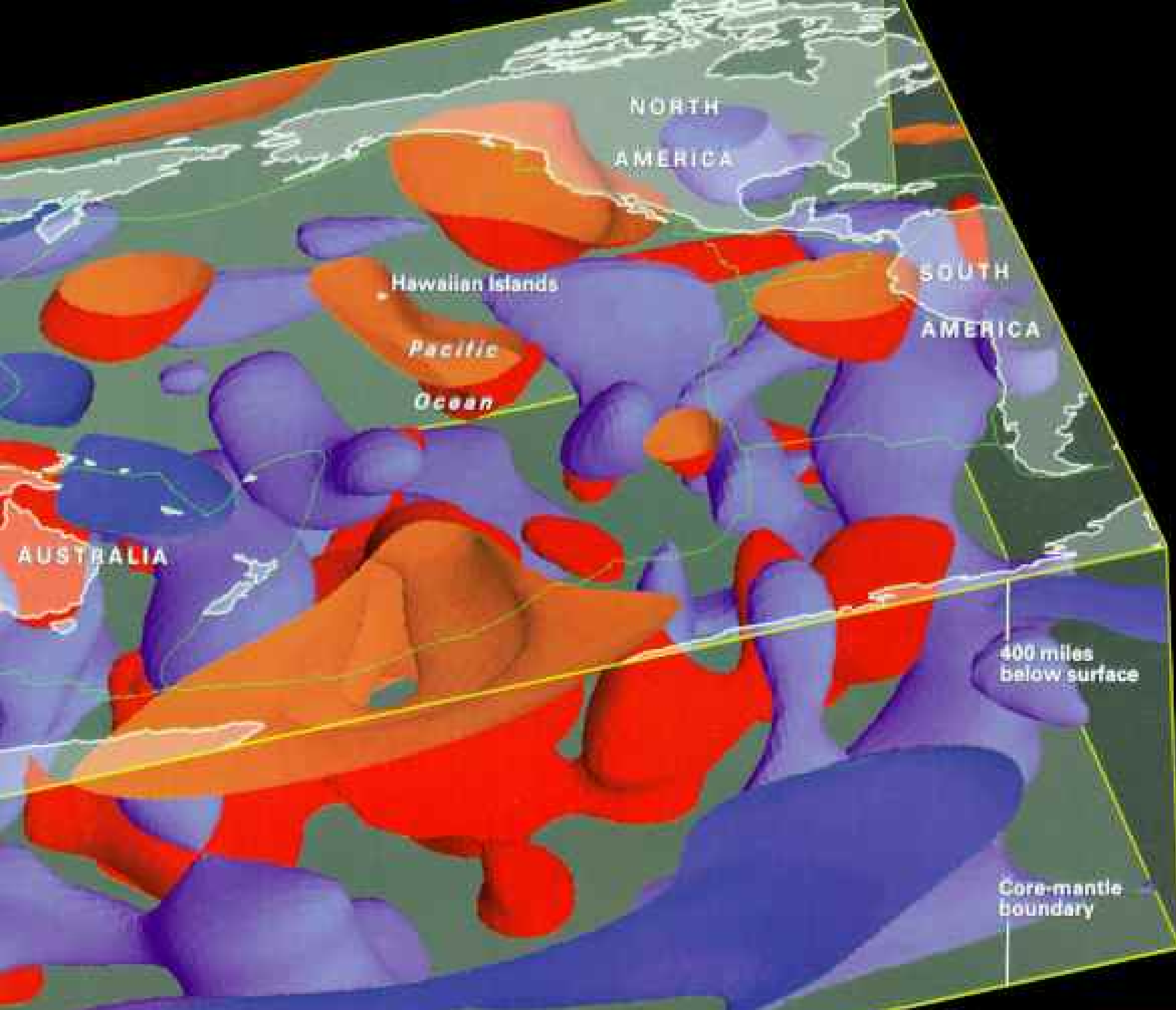
themselves. With a diamond anvil (right) they replicate deep-earth pressures and heat and observe how the mineral content of the rocks changes.

Earthquake vibrations offer another view of what lies underfoot. As they travel through the earth, these seismic waves pass more quickly through cooler areas and more slowly through warmer ones. Monitors around the world record their arrival (far right). Computers then turn arrival data into images resembling sonograms.

This technique, seismic tomography, shows one

moment from cycles lasting millions of years, and that presents a challenge. "It's almost like trying to figure out the plot of Humphrey Bogart's *The Big Sleep* by looking at a single frame of the movie," says Michael Wysession, a Washington University seismologist.

Tomography pioneer Adam Dziewonski finds evidence of lower mantle movement in an image he helped create at Harvard University (top right), including a number of cold slabs, subducted long ago, beneath the Pacific, and rising, hot rock under Hawaii.



WU-LIA SU AND ADAM BIEWOMSKY, HARVARD UNIVERSITY

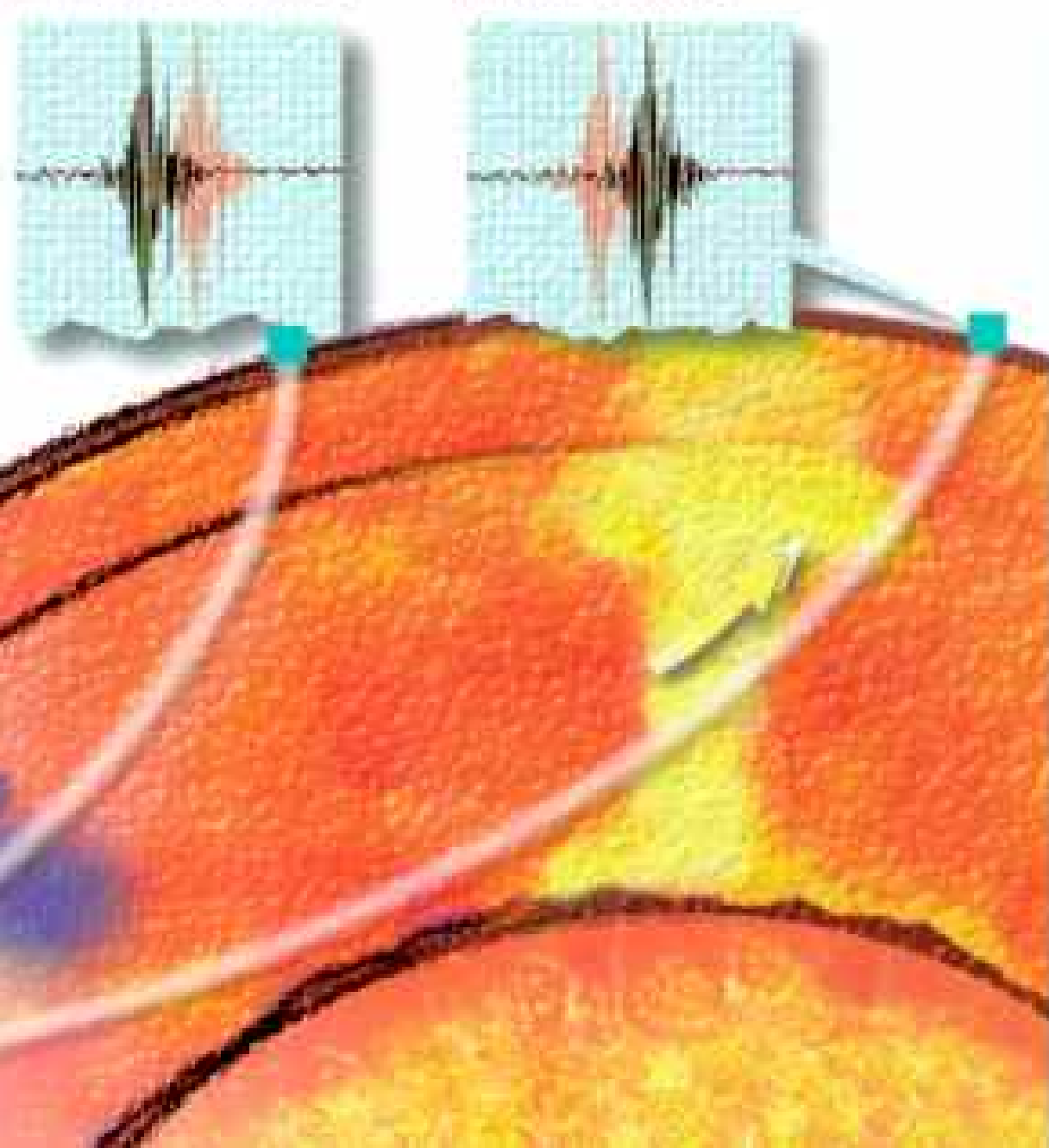
SEISMIC TOMOGRAPHY

Quake waves echo through the earth (below), reaching seismic monitors at different

times depending on what they encounter. From arrival times and other data, computers locate hot and cold rock in the lower mantle (above).

DIAMOND ANVIL

Diamonds are a geophysicist's best friend: Two cut gems, each about a fifth of an inch long, put inner-earth pressure on rock placed between their tips. A laser shone through them can duplicate terrestrial heat.





Creative Fires

A Kilauea skylight offers a look at magma that has risen in a seething mantle plume. Similar, larger upwellings are thought to have caused periods of great volcanic activity in the past. Some 120 million years ago a superplume (top right) probably formed many of the volcanoes that bristle on the floor of the Pacific Ocean. Their eruptions laid down vast lava plateaus (orange, map at right).

Other superplumes blasted upward about the same time. From ancient crucibles they

lifted the diamonds found in many of today's mines. They also may have helped create petroleum fields: Carbon dioxide from volcanoes made a natural greenhouse; plankton thrived and died, forming layers that later became oil.

Geologists hope to dig up more connections. "We need a broader understanding of how the planet operates over time periods that are not the four-year political cycle or the 60-year human cycle," notes Raymond Jeanloz. "Millions of years is the framework for

understanding all global processes, from climate variations to what will happen to the various wastes we create."

Sixty-five million years ago another plume reached the surface—about when dinosaurs disappeared. One more connection? Some scientists think so, envisioning clouds of ash and gases that blocked sunlight and cooled the climate. If they're right, the evolution of life itself may be linked to the slow, ceaseless flow of rock thousands of miles beneath our feet. □

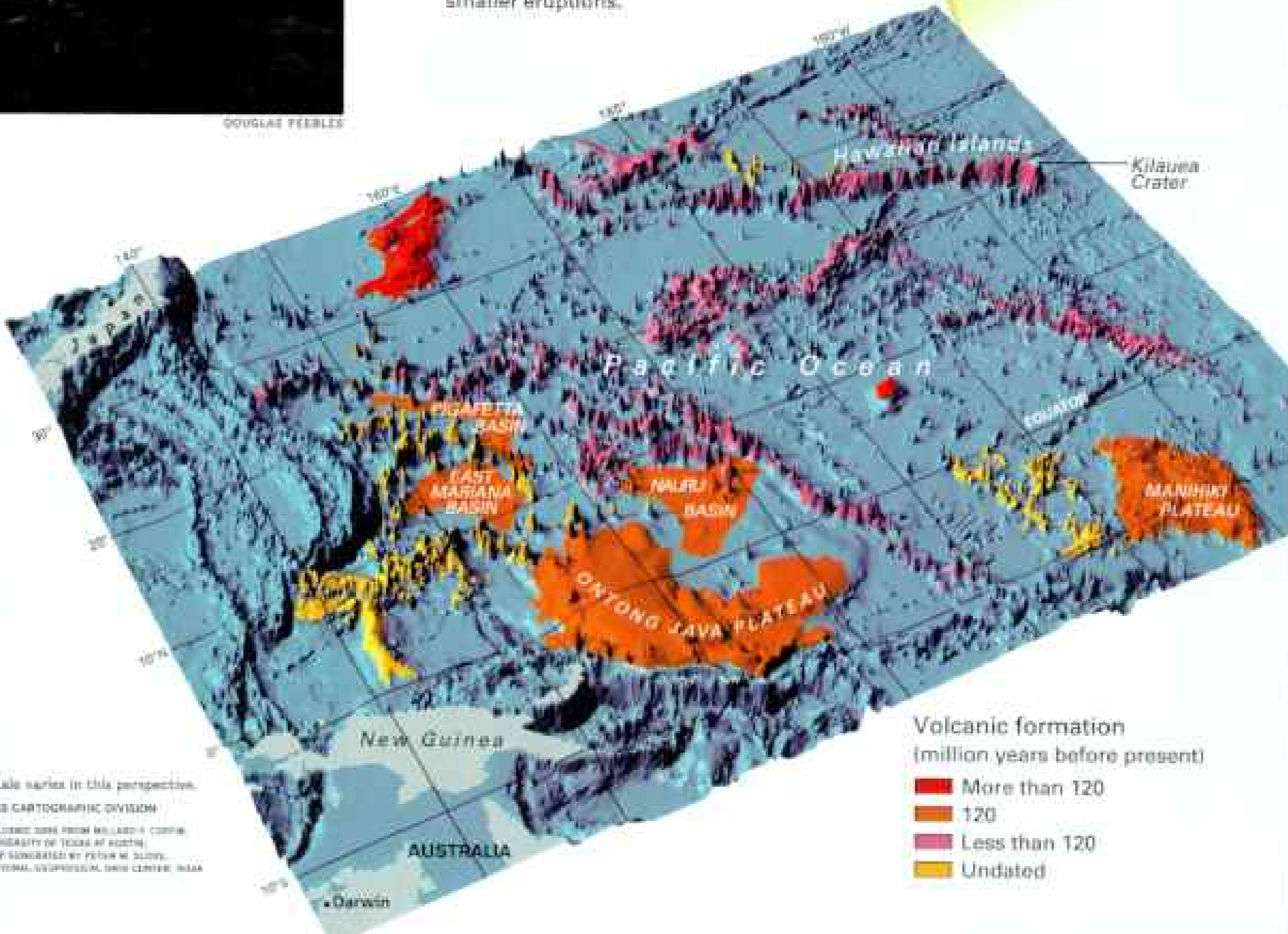


DOUGLAS FEEBLES



SUPERPLUME

Volcanoes rip through the crust (top) across hundreds of miles as the head of a superplume bulges underneath (far right). The stem, which feeds the plume rising in the mantle, later produces smaller eruptions.



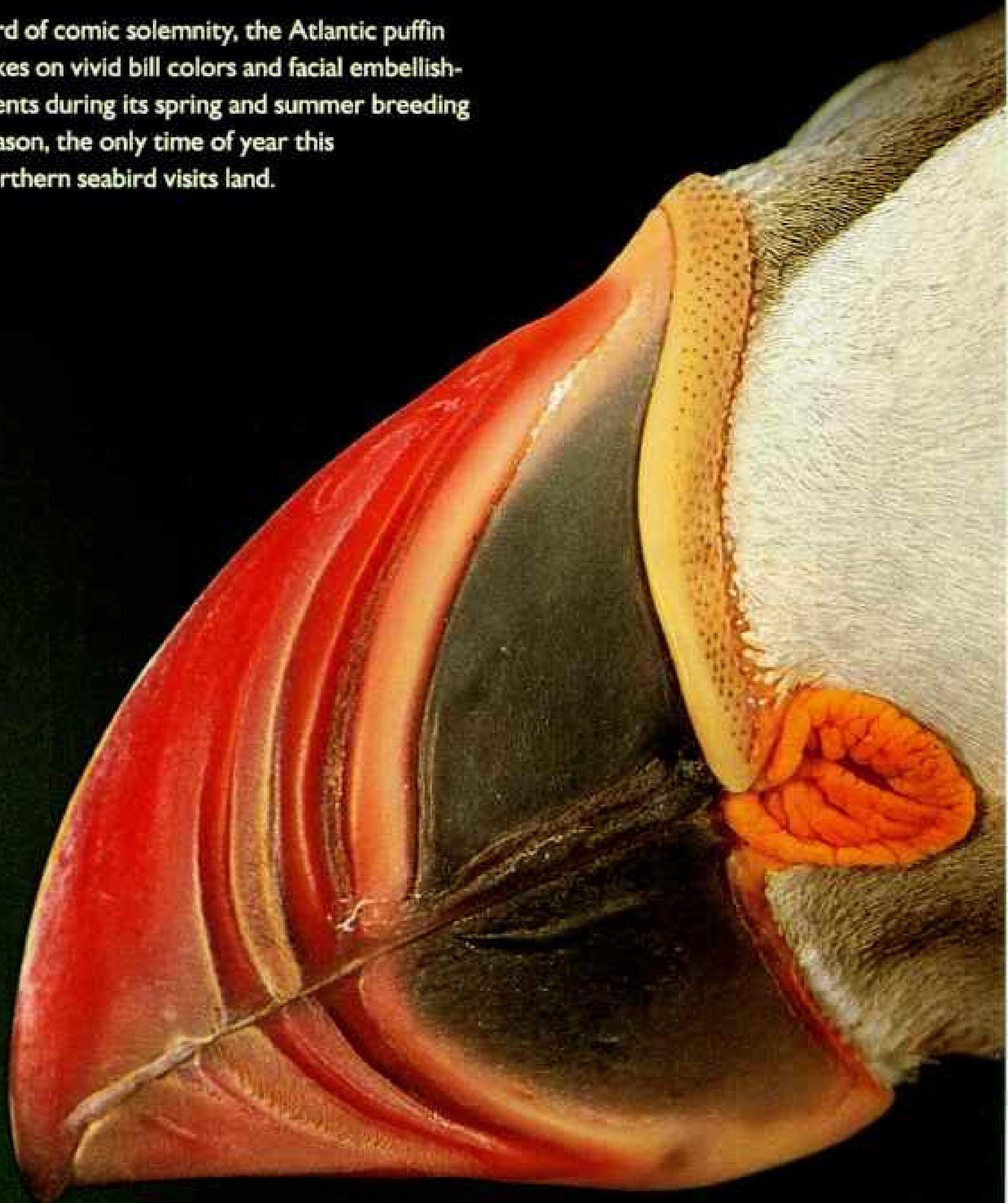
Volcanic formation (million years before present)

- More than 120
- 120
- Less than 120
- Undated

Scale varies in this perspective.
 NGS CARTOGRAPHIC DIVISION
 SOURCE: DATA FROM WILLARD P. COFFEY,
 UNIVERSITY OF TEXAS AT AUSTIN.
 MAP SIMULATED BY PETER W. DUNN,
 NATIONAL GEOSPHERICAL DATA CENTER, NASA

PUFFIN

Bird of comic solemnity, the Atlantic puffin takes on vivid bill colors and facial embellishments during its spring and summer breeding season, the only time of year this northern seabird visits land.

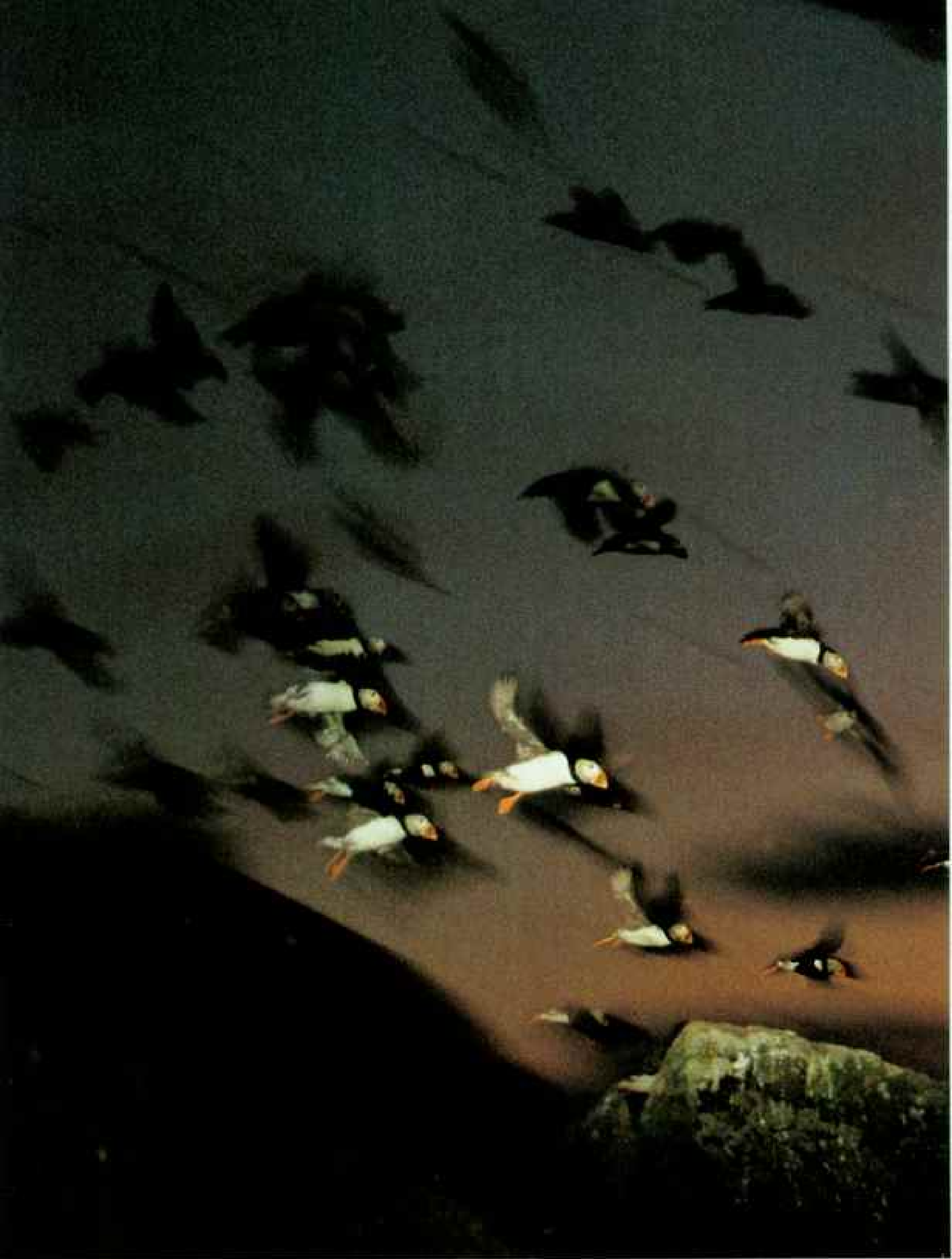


TINS

BY KENNETH TAYLOR

PHOTOGRAPHS BY
FRANS LANTING





Stacked like jets over a busy airport, puffins wheel above a nesting colony in the Scottish Hebrides. With their starched-shirt-and-dinner-jacket plumage, puffins are often confused with penguins. In fact, the two are unrelated and live in opposite hemispheres but share similar adaptations to cold aquatic environments: two-toned camouflage, short wings, and stocky bodies.





Adding sex appeal to staid plumage, a puffin's rainbow beak, duller and slightly smaller for most of the year, grows bright plates and ridges during courtship and nesting. Both sexes flaunt the triangular bills, using them like semaphore flags to communicate at a distance. During close encounters, slight eye movements accentuated by markings around the eye relay personal messages. Says photographer Frans Lanting, "A lot of subtle signaling goes on that's apparent only to a puffin."

National Geographic, January 1996



THE AFTERGLOW of a June sunset in the Scottish Hebrides is a lavish display. Yellows, oranges, reds, purples—a palette of seemingly infinite hues—fade in and out above the darkening hulks of the cliffs. This evening, though, the real spectacle is in the air around me, which is filled with whirling, hypnotic motion. It is as if a huge wheel were spinning about a point directly above the slope where I am standing. Flashing by are thousands of silhouettes—a blur of birds flying seaward, turning inward, veering out over the water again, each apparently locked in place in the gyre. Some fly round and round in pairs, wing tips almost touching, like perpetual motion machines. The crowd slowly thins as puffins go to roost ashore and at sea, but I watch until the last circling shapes vanish in the gathering night.

Weeks later I find myself standing on the foreshore of a wave-lashed island in the Røst archipelago in Arctic Norway. During the spring and summer these islands attract one of the largest breeding populations of puffins in the world, a supercolony of more than a million birds. But where are they now? The five-month season is far from over, yet the sky is empty. The only puffins I see—a mere handful—are bobbing about on the waves.

Around me, hidden among shin-high tussocks of red fescue, are countless burrows not unlike rabbit holes. They are puffin hatcheries. I reach deep into one and lift out a tiny body. An Arctic gust opens gaps in the chick's gray fluff, and I feel the chill of its feet against my palms. The bird, which must have hatched about a month ago, is one of thousands of baby puffins that have starved here already this year. I gently return the dead chick to the ground in the sad realization that soon every occupied burrow in the Røst archipelago will be a puffin tomb.

These contrasting scenes encapsulate the story of the puffin today—a bird that in many places can be admired in full social swing but in some others is in a disturbing decline.

Overfishing of spring-spawning herring, which provide ample nourishment for nesting birds, is a prime suspect. After a severe decline Norway's herring fishery became regulated in the early 1970s but the fish stocks have not fully recovered. Nor have the puffins, says Tycho Anker-Nilssen, an ecologist with the Norwegian Institute for Nature Research. Tycho spends every summer monitoring the Røst population, and his work stands as one of the very few long-term studies of a puffinry anywhere. He notes

KENNY TAYLOR traces his conversion to puffinology to a discussion about the birds in a pub when he was at Scotland's St. Andrews University studying psychology. This is his first article for the GEOGRAPHIC. Photographs by FRANS LANTING, a native of the Netherlands who lives by Monterey Bay in California, have illustrated numerous GEOGRAPHIC articles, including one on macaws in January 1994.

that most years the herring shoals fail to materialize, yet adult puffins, driven by some powerful attachment to this place, keep coming back to breed. The food shortage forces parents to abandon their young and lately even seems to have affected laying and hatching rates. During the past quarter century the yearly die-off of chicks has shrunk the Røst supercolony by hundreds of thousands of puffins.

WHY DO PUFFINS MATTER? To Icelanders and Faroe Islanders, who hunt these birds for meat, there is a practical motive to conserve them. For me, a more compelling reason lies in what we can learn from the link between puffins and the sea. In studying puffin societies—how they function, evolve, and decline—we also find out about the well-being of the oceans. Such knowledge is crucial, for ocean waters are to the planet as blood is to the human body.

But there is more to puffins than that. I have a soft spot for puffins just because they are puffins. It could be the swaggering Chaplinesque walk. Or the horn-rimmed stare from behind the painted wedge of a beak, which makes a vivid complement to the tangerine-colored feet. Or the fat little body—a puffin looks about as aerodynamic as a potbellied pig.

Contrary to popular belief, the puffin is not a flying penguin. There are four species, all related to the great auk, which was hunted to extinction last century. Members of the auk family live in the Northern Hemisphere and can fly; penguins live in the Southern Hemisphere and cannot. The tufted puffin, the horned puffin, and the rhinoceros auklet—an oddity whose skeletal structure places it in the puffin camp—are spread throughout the North Pacific, along with most of their 20 auk relatives, including auklets, murrelets, murrelets, the dovekie, and the razorbill.

But the bird of my affections is the Atlantic puffin, *Fratercula arctica*, the only puffin found in the Atlantic Ocean, where it is widely distributed. I have studied the social behavior and feeding habits of Atlantic puffins for 20 years—about five years less than the life of a healthy puffin.

Judging from the overall numbers, the Atlantic puffin is not about to follow the great auk into oblivion. The total breeding population probably exceeds ten million, and there are several million immatures and nonbreeders besides. Even in the Faroe Islands and northern Norway, where populations are diminishing, many of the colonies are still large. A puffinry can remain viable if as few as two chicks survive from each pair's lifetime breeding effort.

Despite the robust state of the puffin nation, local losses have spurred people to rally around this popular bird. In the Gulf of Maine, where hunters all but obliterated Atlantic puffins in the U. S. during the late 1800s, the National Audubon Society is conducting an ambitious restoration project. And in the Shetland Islands puffins are thriving again after a series of disastrous seasons led to a temporary ban on fishing for sand lances in 1991. These small fish, a food staple of Shetland seabirds, are processed into livestock feed. But there may have been more to the decline of the sand lance than overfishing. It is also possible that natural changes in ocean currents reduced the population,

Province of the Atlantic Puffin

The puffin's cuteness belies a resilience demanded by its unforgiving territory, the North Atlantic and adjoining seas. One of four puffin species worldwide, the Atlantic puffin, *Fratercula arctica*, spends most of its life in open ocean, coming ashore to nest and rear a

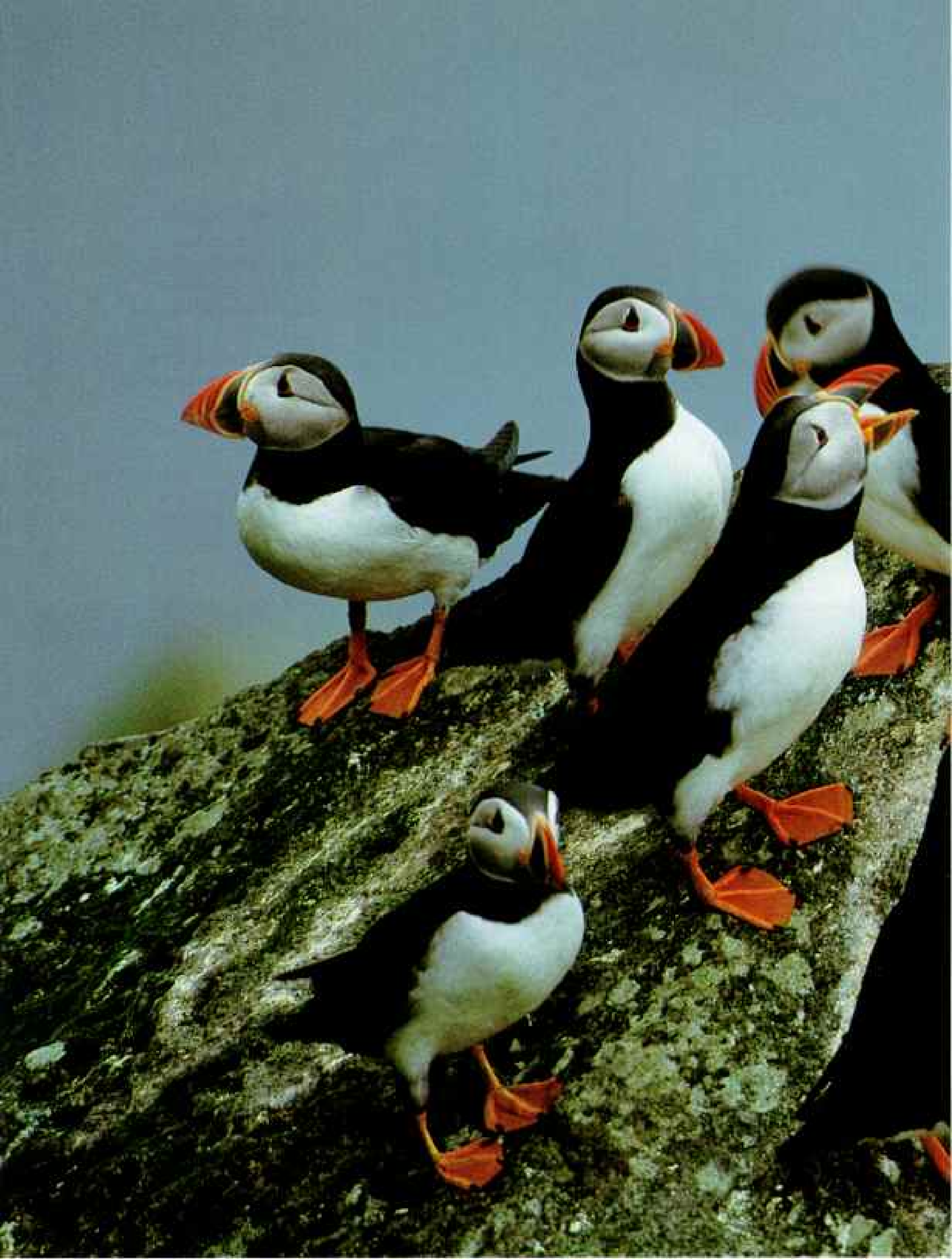




single chick annually in large, seaside colonies.

Honeycombed with burrows, nesting sites such as this slope in the Outer Hebrides (below) resemble bunkered hillsides. Chicks snuggled belowground grow in relative security, safe from aerial attack by gulls. In some colonies, turf nourished by the birds' guano provides winter grazing for sheep, which in turn compact the soil, preventing landslides.





"Too close" is probably the message given by an open-beaked puffin at the avian equivalent of a private club. "Certain rules of polite puffin society apply at these gatherings," says author Kenny Taylor. Upon landing, each puffin must assume the proper posture: wings up, head partly raised, one foot forward. The others signal their welcome by stomping in place.



causing the famine. This uncertainty—and the apparent recovery of the sand lance—led to the reopening last June of a much reduced fishery.

PUFFINS TYPICALLY ESTABLISH their colonies at or beyond the limits of what most humans (my fellow Scots excepted) find tolerable. Go to the edge, then to the edge of the edge, where water finally smothers land, and perhaps you'll be lucky enough to see a puffin. Windblown islands like Shetland, close to the rich fishing grounds of the continental shelf, make ideal breeding sites. A gale of wind suits the heavy-set puffin, allowing it to save energy in flight. (On the Shetland Islands, even a puffin would have been grounded on New Year's Day, 1992, when a 201-mile-an-hour gust ripped through.)

If the obvious appeal of the puffin is its clownish look, a deeper attraction may lie in its connection with wildness, of which it has become something of a symbol. Hence the boatloads of day-trippers who alight on Lundy Island off the southwest coast of England. They rarely see a live puffin, but Lundy's only store does a roaring trade in plaster statuettes, puffin-label wine, and other puffinabilia.

It was on the opposite side of Britain, on a speck of land in the gray channel where the River Forth meets the North Sea, that I discovered puffins. The Isle of May is one of the largest puffinries in eastern Britain. It is also the place where Adrian, a Celtic saint, was killed by Viking raiders in the ninth century, an event that made the island a destination of Christian pilgrims during the Middle Ages.

Going there as a St. Andrews University student more than a millennium later was a kind of pilgrimage for me. Those summer weeks helped me understand the meaning of some puffin postures. I noticed, for example, that a bird landing in a group uses a wings-up, foot-forward display to keep bystanders at bay. And that a high-stepping march with head tucked against a plumped-out chest means that a puffin is guarding its burrow or approaching a mate.

Observations about individual birds whetted my appetite to investigate puffin communities. Why, I wondered, do puffins come together in huge flocks? From the large puffinries in Scotland and Scandinavia, I learned that the swarming flights, or wheels, above nesting areas are a remarkably effective form of self-protection. When a puffin makes a move from sea to land, or vice versa, it first makes several circuits above its part of the colony. Other puffins immediately join in, flying in the same direction to avoid head-on collisions. The spinning mass gives the impression of constancy, but with individual birds always dropping in and out

Disaster victims, week-old "pufflings" in Arctic Norway are given a post-mortem exam by the author. Cause of death: starvation due to scarcity of local herring. Since fish stocks collapsed in the late 1960s, Norway's largest puffinry has dwindled by more than half, underscoring the vital link between puffins and ocean resources. Says Taylor, "As go the fish, so go the birds."



of the wheel, it is more like a relay race.

If a predator such as a great black-backed gull is hunting, puffins in the wheel bunch together like schooling fish under attack. This confuses the gull, making it harder to select a puffin target. The more puffins in the air, the more likely the predator will strike wide of the mark. Rather than tire themselves in fruitless aerial attacks on dense swarms, the gulls pick at the bones of leftovers from a catch made when fewer puffins were wheeling.

On land, puffins in the same area of a colony take time to socialize in small groups. Rocks and tussocks are the clubhouses where adults and immatures alike meet to impress potential mates or, it seems, just hang out on neutral ground. Older puffins struck me as being better acquainted with one another than most people are with their neighbors. Puffins ashore are always watching one another or poking a beak into another bird's business. There is nothing more fascinating to a puffin than another puffin.

This inquisitiveness and sociability may look amusing, but it has a serious purpose: to synchronize activities in different parts of the colony and thus discourage predation. By boosting the chance of an individual's survival, curiosity about the puffin next door may have played a part in the evolution of the large breeding colony—a hallmark of puffin society.



Nosy by nature, a puffin peeps from its burrow at an unexpected human caller, its sense of caution overcome by curiosity. Stronger still is the bird's homing instinct. After roving far from land in fall and winter, breeding adults (which usually pair for life) return in spring to the precise location of their burrow—even if the entrance is invisible under late snowfall or the burrow has been obliterated altogether. In one instance, puffins returning to Iceland's volcanic island Heimaey perished when they landed on hot lava covering their former nests.

THE PAST FEW SUMMERS I have focused my attention on puffins off northwest Scotland. With help from members of the Scottish Wildlife Trust I have been recording the diet and growth of chicks and tracking changes in the seasonal shoals of fish. This information is crucial for reasoned decisions about how to manage fisheries.

Collecting data on the fish loads in puffin beaks takes teamwork. One person flicks a fine-mesh net into the path of a fish-carrying puffin, carefully extracts the bird, bands it, and releases it. Someone else stands by to collect every fish that drops. Another person weighs and measures the fish.

Studying puffin chicks is a different challenge. Some scientists use fiber-optic viewing devices to look into nests, but I still prefer the hands-on technique learned years ago from my mentor, Mike Harris. Mike, a puffin expert at the Institute of Terrestrial Ecology at Banchory, Scotland, is examining how changing food supplies affect the health of entire seabird colonies.

Mike's method: Lie at the entrance to a burrow and extend an arm into the nest chamber. If you're lucky, it contains one chick, which you gather up as best you can. If, as is often the case, the chamber is more than an arm's length deep, use a short bamboo stick to coax the bird out. This work is uncomfortable. The ground is usually sodden and guano-spattered, and it becomes



dangerous when a puffin parent with a powerful beak is at home. Mud-stained clothes, grazed elbows, and bloodstained fingers are the insignia of the Harris school.

At about six weeks of age, fledglings, or “pufflings,” leave their parents and fly out alone to the open sea. The adults head out soon afterward, as the autumn storms approach and the small fish move away.

WHERE ALL THESE BIRDS GO in winter is a big puzzler. A few puffins banded in Britain and Ireland have been found dead on beaches in the Mediterranean, but there are virtually no winter records of adult birds from other major breeding grounds, such as Iceland. “Out of 60,000 birds ringed over many decades, we didn’t have a single winter record of an adult Icelandic puffin until 1993,” says Ævar Petersen, director of the Icelandic Institute of Natural History in Reykjavík. “Then one bird was found in southwest Greenland.”

Immature puffins show up more often. In more than four decades Óskar Sigurdsson, keeper of the lighthouse on Iceland’s Heimaey Island, has banded some 45,000 puffins with metal anklets that give the address of the Reykjavík program. Over the years he has received hundreds of reports from people who have found his birds as far away as Newfoundland, Greenland, Norway, the Faroe Islands, and the Azores. He in turn has caught puffins that had been banded in Scotland.

So puffins seem to be Atlantic rovers. But roughly two-thirds of the puffins that survive their first winters at sea return to their birthplace two or three springs later when they are ready to come ashore. The rest settle into colonies elsewhere, perhaps having chanced upon a vacant lot for burrow development. Breeding pairs form at about five years of age, and most partners stay together for life, raising, at best, a single chick each year. Pairs excavate a burrow on a grassy slope near the sea, using their powerful beaks as pickaxes and their sharp-clawed feet as scrapers and shovels. Puffins sometimes nest under rocks at the foot of coastal cliffs. If one partner dies, the other may seek another mate from the floating population of unattached adults. Delayed maturity, low birthrate, attentive parental care, and long life span—traits typical of seabirds—help puffins survive in a world of prolonged lean times.

During the first weeks of dependence, chicks get four or more food drops a day from their parents. We do not yet know exactly how puffins locate fish, but they are expert hunters, diving as deep as 200 feet. Back-slanting spines on the roof of the mouth allow a puffin to hold numerous small fish at once. The published record holder had 62 in its beak.

A bounty of fish helps explain why Iceland’s Westmann archipelago is the hub of the puffin universe, with upwards of four million birds. Approaching Heimaey, the only permanently inhabited island, by ferry one cool August afternoon, I see clouds of wheeling puffins. They rise and fall against a backdrop of



Its beak draped with sand lances (opposite), a puffin in the Outer Hebrides returns with a feast for its growing chick. Spines on the roof of the mouth help secure slippery payloads, allowing puffins to airlift dozens of fish at once. (The biggest beakful on record is 62 tiny fish.) But weight and fat content of prey are more important than number. A mouthful of larval herring captured by a puffin off Norway (above) does not contain enough nutrition to sustain its starving young.



Snatching puffins from midair with a net called a *lundahdur*, Sigurgeir Jónasson is Iceland's top fowler, having once brought down 1,204 birds in eight hours. Slain puffins set up as decoys exert a fatal attraction. By avoiding birds ferrying fish to chicks, hunters kill few breeders and pose little threat to the country's six million-plus puffins as they harvest the birds for meat.





Seabirds were the staff of life for the fowlers of St. Kilda, Britain's most remote archipelago and home of its largest puffin colony. "In the mornings men would gather in the street to discuss the day's work," says historian Mary Harman. Today, soldiers stationed on this bleak outpost—whose residents were removed in 1930—socialize with tourists at the island's lone bar, named (what else?) the Puff Inn.

steam clouds venting from the ash fields of Eldfell, the volcano that engulfed one-third of the town of Vestmannaeyjar with lava in 1973.

Puffins also gather around the rim of an ancient crater in Herjólfur's Valley, near the spot where Iceland's move toward independence from Denmark has been celebrated since 1874. The annual festival brings townsfolk to rows of trim white tents for three nights of merrymaking. Among them is Hallgrímur Thórhásson, who shows me to a trestle table in his tent on the first night. He watches my expression intently as I unwrap a foil bundle containing dinner.

"Good, yes?"

Reluctantly, I have to agree. The dark meat is delicious, a little like venison, with a subtle smokiness.

"Puffin tastes best after it's been hung over a sheep-dung fire," says his son, Thórháður, grinning as he hands me a vodka. From the amount of silver foil being unwrapped tonight, it's clear that dining on puffin is as much a part of life to a Westmann Islander as breakfasting on oatcakes is to a Scot.

Two days later I meet Hallgrímur and Thórháður again, at a hut on Vstiklettur, a craggy promontory high above Vestmannaeyjar Harbor. Hallgrímur has been hunting puffins in these parts for more than half a century. He pays the town an annual fee (about a hundred dollars) for the right to do so. We clamber downslope, and Hallgrímur and I go into hiding behind a ridge. Thórháður continues down to another spot at the very edge of the colony.

Puffins flying toward us are visible for only a split second as they cross the ridge, so Hallgrímur has to choose his target quickly. He swishes a long-handled net, or *lundaháfur*, into the



path of the bird and with a deft flick makes the hit. He then quickly wrings its neck with a double twist and a pull. After catching several birds, he spikes some of the corpses with thin metal rods and props them up as decoys.

No one can say exactly how many puffins are hunted in Iceland during open season from July until mid-August, but 200,000 seems a reasonable estimate. (Since last year each hunter must have a license, which will aid record keeping.) Despite this reduction the Westmann puffinry is healthy and stable—in part, perhaps, because of an unwritten code by which hunters catch only immature and nonbreeding birds and avoid puffins carrying fish to their chicks.

Westmann Islanders resent criticism from animal-welfare advocates who oppose the hunt. As Jón Kristinn Jónsson, a young hunter, says, “They seem to think that because puffins look so cute, we shouldn’t hunt them. Yet many of those people eat chickens whose lives in captivity are much worse than the lives of our free-flying puffins. These people are not trying to understand the society here. This is a tradition.”

UNCONTROLLED HUNTING in the late 19th century to provide feathers for hats, pillows, and mattresses left the eastern seaboard of North America severely depleted of puffins. The only colony that survived in the United States, on Matinicus Rock in the Gulf of Maine, now has about 150 pairs.

Puffin recovery in the U. S. took a dramatic step forward on July 4, 1981, I learn from Evie Weinstein, who is guiding a National Audubon Society cruise around Eastern Egg Rock some

Facing the unknown together, well-wishers in Iceland bid bon voyage to a six-week-old chick found the night before on the streets of nearby Vestmannaeyjar. On August nights, as fledglings set out from the local nesting colony toward the beckoning sea, thousands are lured off course by the town’s noise and glare. Rescued by children, the birds get something nature rarely offers: a second chance.

25 miles west of Matinicus. "I was doing chores at the north end of the island, when out of the fog came a really beautiful sight—a puffin flying in with its beak crammed full of fish. The only time puffins carry fish is when they're feeding young, so that one bird was a sure sign of the first puffin breeding activity on Egg Rock in almost a hundred years."

The puffin comeback began in the summer of 1974, when Evie's husband, Audubon ornithologist Steve Kress, and David Nettleship of the Canadian Wildlife Service transplanted 54 two-week-old puffin chicks from Great Island in Newfoundland to Eastern Egg Rock. (For the parents of these healthy youngsters, this benign kidnap would have been no more than a brief setback in their long breeding life.)

All the birds survived and, banded for identification, left for their winter sojourn at sea. Over the next several summers more chicks were brought in from Newfoundland.

Would any of these puffins come back to breed? To make Egg Rock more enticing, Steve, director of Project Puffin, and his helpers placed puffin decoys at likely nesting sites. They set up mirrored boxes to trick the birds into believing that they were moving into the most desirable neighborhood, thick with puffins. It took seven years of waiting before Evie saw the puffin with the fish in its beak.

One bright summer afternoon I join Steve to watch for birds from a tower blind on Seal Island National Wildlife Refuge, also in the Gulf of Maine. A 65-acre strip of rock, sand, and scrubby vegetation—heavy with the scent of wild strawberries—Seal Island was once home to the largest colony of Atlantic puffins in the U. S. In 1984 Steve and his "puffineers" began bringing Newfoundland chicks here too. The nesting sales pitch was strengthened by tapes of puffin calls, a noise like the buzz of chain saws, broadcast from loudspeakers.

As we wait, hoping to see puffins flying home with fish, the raucous din of nesting terns makes conversation difficult. "That's the sound of a lively, healthy place," Steve says happily. "It's one of the best feelings in the world—to look out on all these seabirds breeding here."

Our afternoon on Seal Island produced few sightings, but this



Doing a double take, a puffin eyes a carved impostor in Seal Island National Wildlife Refuge off the Maine coast. Wiped out by hunters by the late 1880s, the colony has been revived in recent years with chicks brought from Canada. Decoys entice full-grown birds back to the island to breed.

With more than ten million adult Atlantic puffins estimated rangewide, the



DRAWN BY HENRY

species for now appears in fine fettle. But oil spills pose a constant threat, and overfishing of herring and other puffin prey remains a problem. Yet merely glimpsing this irrepressible bird renews hope. Says one smitten watcher, "The sight of a puffin never fails to lift my spirits."

of the Aquarium and Museum of Natural History, tells me one evening as we watch a boy scooping a tiny puffin from the gutter outside a gas station. "That's maybe 800 children, who help several thousand pufflings—*lundapysjurnar* we call them—every year." Carrying flashlights and cardboard boxes, the older kids scour the streets in small groups, competing to see who can find the most birds. The younger children look from their parents' cars for stranded puffins.

Early the next morning on a black-sand beach below Stórhöfði Peninsula, I watch the Valgeirsson family, visiting from Reykjavík, and a young friend from Heimaey walk slowly toward the water. They lay down a box, and Mr. Valgeirsson, with help from Jóhanna, his four-year-old daughter, places a puffin on the sand.

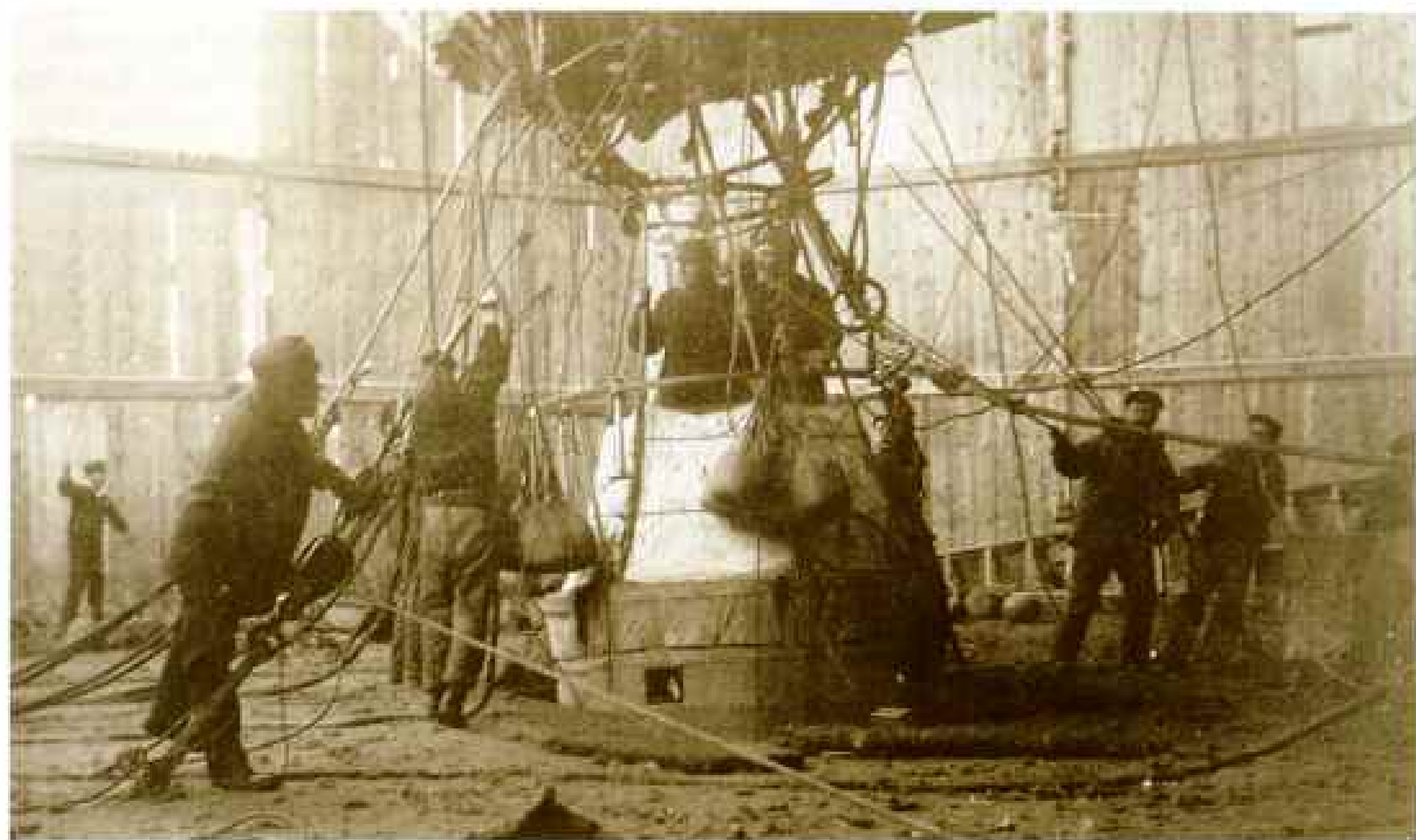
A wave sets the little bird afloat and washes it out to deeper water. The puffin dives, surfaces still farther out, and paddles confidently past a small boat into the wide embrace of the sea. Saved from almost certain death in Vestmannaeyjar, this puffin is entering a natural realm where predators threaten, food may be scarce, and hazards such as oil spills may await. For it and for us, I think, the challenge has just begun. □

colony, along with Egg Rock, now has more than 80 breeding adults and a number of unattached birds. "Every year we watch the numbers go up," says Steve. "I feel more confident that these colonies are here for good."

IF IT IS IMPRESSIVE that one scientist and a handful of volunteers are restoring lost puffinries, it is no less remarkable that puffins themselves can mobilize an entire town. This is what happens every August in Iceland, when thousands of young puffins leave colonies on Heimaey and become disoriented. They make their first flight at night, avoiding natural predators, but, inexplicably, instead of heading out to sea, many aim for the bright lights and noise of Vestmannaeyjar, where they face danger in the form of vehicles, cats, and dogs. Everyone in town, it seems, even the puffin hunters, comes to the rescue.

"All children from about six up to the early teens help," Kristján Egilsson, director

FLASHBACK



JAMES HOWARD GORE (BQIM)

■ FROM THE GEOGRAPHIC ARCHIVES

The Doomed Balloon

Preparing for the first aerial Arctic expedition in July 1897, Swedish explorer Salomon Andrée and his two-man crew (above, in basket) help check their balloon for leaks (top). Minutes after its launch from Spitsbergen archipelago the craft lost its dragropes—and drifted into oblivion. Despite searches, the men's fate was unknown until 1930, when their bodies were found on an island 300 miles away. Andrée's diary, found near him, describes three months on the ice after the balloon's demise. "Raw bear with salt tastes like oysters," he wrote. These photographs were never published by the GEOGRAPHIC.



Hooker's Sea Lion (*Phocarctos hookeri*) Size: Length of male, 250-350 cm; female, 200 cm Weight: Male, 300-450 kg; female, 160 kg Habitat: Sandy beaches and cliffsides on New Zealand's subantarctic islands Surviving number: Estimated at 10,000-15,000

Photographed by Tui De Roy



WILDLIFE AS CANON SEES IT

A mother Hooker's sea lion and her pup enjoy a quiet moment amidst their bustling beach colony on Enderby Island. While the mothers are out at sea feeding, the playful pups chase about through the rata forest of the lower slopes and the tussock grass of the higher bluffs. When the mothers return, they call to their young with a mooring sound. Each pup can identify its mother's call, and responds

with an equally recognizable bleating. With only a few small windswept islands as its sole refuge, the non-migratory Hooker's sea lion is especially vulnerable to changes or disturbance in its environment. As a global corporation committed to social and environmental concerns, we join in worldwide efforts to promote greater awareness of endangered species for the benefit of future generations.

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In pursuit of non-pollutant energy sources, Canon continues to develop solar-cell technology and aims to shortly introduce on the market steel-based, amorphous-silicon solar-cell integrated roof panels for home and industrial use.



Watch "NATURE" on PBS. The program is funded in part by Canon U.S.A., Inc.

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NATIONAL GEOGRAPHIC

JANUARY 1996



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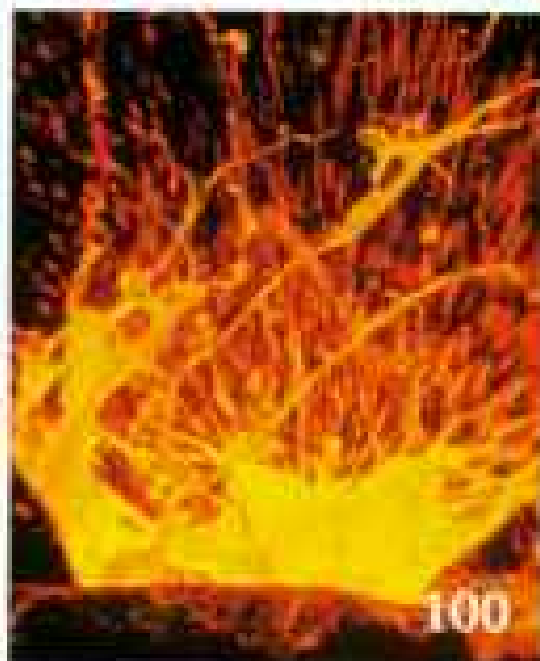
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- 2 Neandertals** *Archaeology proves these ancient humans to be intelligent hunters and compassionate beings.*
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- 36 The Edmund Fitzgerald** *High-tech dives in Lake Superior retrieve a ship's bell—and memories of a lost crew.*
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Geoguide

The Cover

Skull of a Neandertal woman, found in Krapina Cave in the Balkans, has survived for 130,000 years. Photograph by Kenneth Garrett

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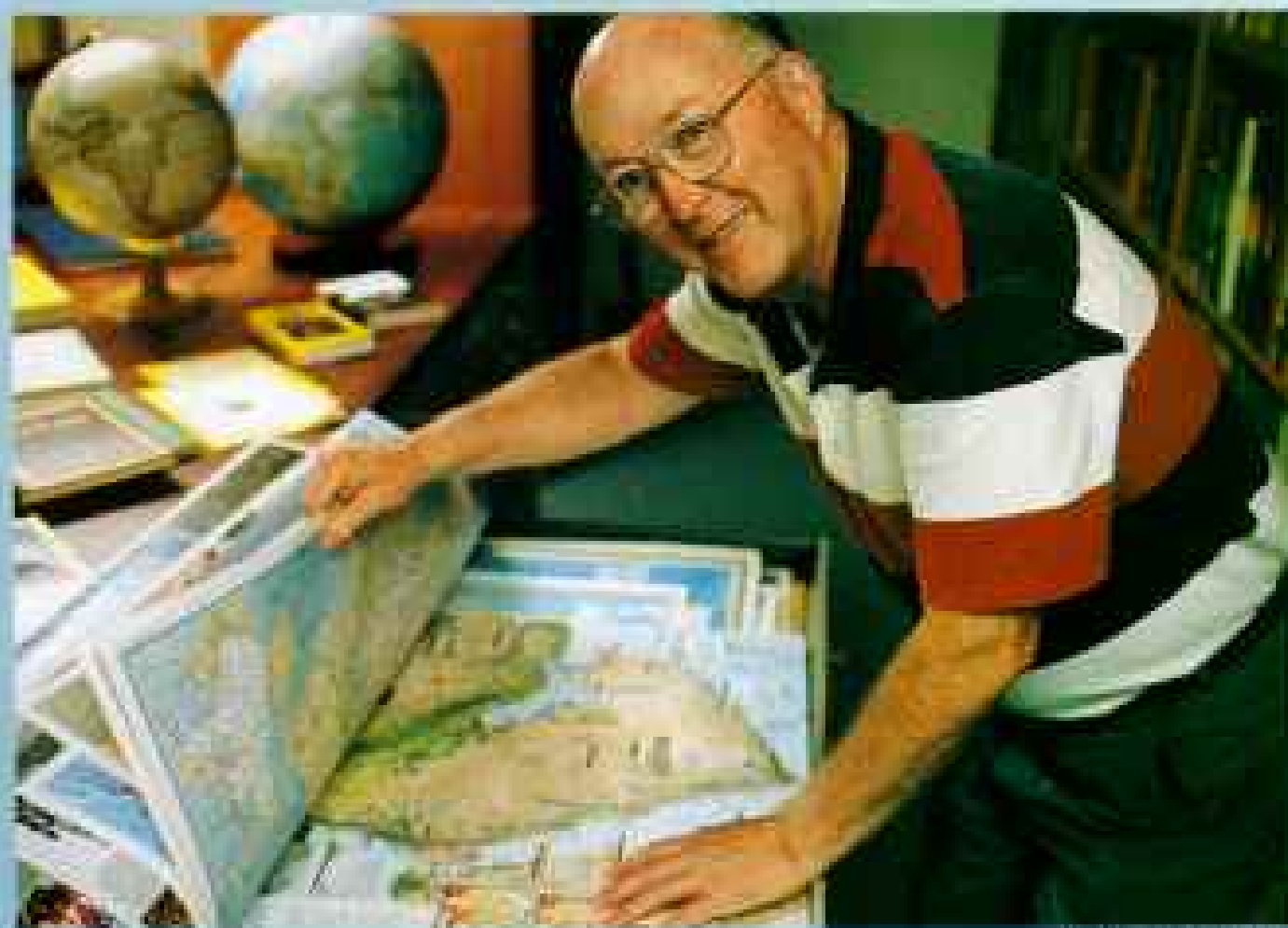
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Behind the Scenes

From the Collection of Roger Nathan

WHEN Great-aunt Rena nominated Roger Nathan for Society membership in 1958, she started something big. He now owns 1,202 of the 1,237 issues of NATIONAL GEOGRAPHIC published since 1888. "I started collecting because the old magazines were the best places to find articles about World War II," explains Roger, who frequented book sales and flea markets—and the Society itself—to build his cache. "I kept it up because it was fun." But magazines, including the *School Bulletin*, its successor *WORLD*, and *TRAVELER*, are not all he keeps in his Woodstown, New Jersey, home. He has cataloged and arranged thousands of Society books, maps, records, and brochures on custom shelves in a basement room, along with countless rarely seen Geogewgaws from paper clips to tote bags to golf



DAVID GRIFIN, AGE

shirts. Roger even wrote a book, *Collectibles of the National Geographic Society*, as a guide for others bitten by the yellow-border bug.

"Before we moved to this new house a few years ago, his collection was all over the place," says Roger's wife, Barbara. "Now that everything is downstairs," she admits, "I kind of miss it."

A Boy and His Sled Dog

COMPUTER-SAVVY KIDS all over the world followed explorer Will Steger's trek across the frozen Arctic Ocean (page 78) on the Internet last spring. Expedition members typed daily

bulletins to waiting classrooms; students sent back e-mail to the Arctic with questions about the expedition. In July the Society invited participating students to headquarters to meet Steger and members of his team—human and canine. Tom Hyndman, 11, of Levittown, Pennsyl-

vania, was especially eager to meet Steger's husky Rex (left). At Walter Miller Elementary School, Tom had followed the progress of the dogs—but never thought he'd get a kiss from one.



MARK THIESSEN

An Arresting Development

WHILE SHOOTING in Cameroon for a Geographic book on rain forests, photographer George Steinmetz was detained by local authorities—for spying.

"I had told them when I arrived that I was from National Geographic. They figured that anything 'national' must mean from a foreign government," he remembers. George spent five days under house arrest in a remote village.

Why was he finally released? "A sense of humor is always valuable out on assignment; I told a lot of jokes that week. I showed them I was no threat. Plus," he says, "I ate so much, they were glad to get rid of me."

**Brilliant ideas often start
from a simple question.**



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Amado Ortiz, Logistic Executive Manager, Physical Distribution,
Mexico City, Mexico



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PHILIPS



CAROL FARNETH FOSTER

Off to a Flying Start

DEEP IN the jungle heart of Belize's Maya Mountains, members of the British Army Training Support Unit Belize and the Army Air Corps' 25 Flight perform a special mission: helping preserve that country's ancient heritage.

For years archaeologist Peter Dunham, a Society grantee, has documented Maya ruins in

the rugged uplands. Now, to support the government's preservation efforts, army helicopters ferry supplies to Dunham's team, transport artifacts such as this thousand-year-old pot (above) to Belizean agencies, and make routine patrols of archaeological sites.

"We found five ruins in three months," says Peter. "We couldn't have done it without the help from the British."

He Only Has Eyes for Ewe

"THE STRANGEST THING I ever ate on assignment was a sheep's eye, in Reykjavik, Iceland," reports writer Noel Grove of his 25-year career with NATIONAL GEOGRAPHIC. "The eye is saved for honored guests—when you bite down on it, it pops like a grape. And while I was eating it, all I could think of was 'Here's looking at you.'"

QUOTE TO NOTE

If I couldn't read GEOGRAPHIC, what would I do?

—101-YEAR-OLD MEMBER CLARENCE CARLSON, WHOSE CATARACT SURGERY RESTORED HIS SIGHT

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(Continued from page 10) ... ago, although the exact date of the deposit is uncertain. He calls them pre-Neanderthals, because their faces differ from classic Neanderthals but show the set of features we now associate with the group. They may be the Neanderthals' immediate ancestors.

We join several of Arsuaga's young colleagues, ~~and students~~, who sit or lie on the scaffolding, picking out tiny pieces of bone from the dirt below them. A few lightbulbs illuminate the walls of the misty chamber. Someone had painted "Chris 1958" on one wall. On my descent I had seen the names of other adventurers, dating back to the 16th century. In 1985, for instance, "Ferdinand" had carved his name into one limestone wall—not far from claw marks engraved many thousands of years earlier by a bear ~~as early as that~~.

"It was a local tradition for young men to come down here as an act of bravery," explains Pepe Cervera, a team member. "They collected fossil teeth of cave bears to present to their girlfriends. Over time the cave became famous among speleologists. Then in the 1970s a local archaeologist recognized a 'bear tooth' from the cave as human."

That discovery sparked the interest of other ~~archaeologists~~, and in 1984 the laborious excavation finally began. A few years ago the team's hard work began to pay off. They had pieced together enough bone fragments to see that the middle of these people's faces projected out like a Neanderthal's. The backs of the skulls also had a light ridge evocative of the one seen in classic Neanderthals.

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16 *Two did these*

National Geographic, January 1996

Getting It Right

A CALL CAME IN, the story goes, to a Smithsonian zoologist. "Somebody wants to know how high an elephant's eye is," said his assistant, "to confirm that Oklahoma corn grows that high." Said the scientist, "Oh, no! Not the GEOGRAPHIC again!"

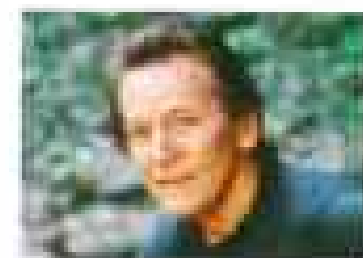
To maintain our reputation for accuracy, every

fact—every word—published must pass our research staff's scrutiny. Researchers scour written sources and review the text with experts, noting appropriate corrections. (This issue's "Neanderthals" gets the treatment, above.) Quotes, style, and spelling are also double-checked. Only then is an article ready for the printer—and our members.

—MAGGIE ZACKOWITZ

THE LEGEND LIVES ON S.S. EDMUND FITZGERALD

*Later that night when the ship's bell rang,
Could it be the north wind they'd been feelin'?*
*...The church bell chimed 'til it rang 29 times,
For each man on the Edmund Fitzgerald,*



from *Wreck of The Edmund Fitzgerald*

Gordon Lightfoot

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Passage In Moonlight



Every Man Knew

David Conklin, award winning artist, has painted the fated ore carrier in maritime environments both serene and hostile. The original works, commissioned by the Sault Ste. Marie Tribe of Chippewa Indians for the Great Lakes Shipwreck Historical Society, will be on exhibit in the Shipwreck Museum at Whitefish Point just 17 miles from the *Edmund Fitzgerald's* wrecksite.

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Forum

Hawaii's Vanishing Species

With the national debate raging over reauthorization of the 1973 Endangered Species Act, the September 1995 article on "Hawaii's Vanishing Species" could not have been better timed. The opening foldout of our botanists dramatizes the slender thread by which paradise hangs in the balance. Our botanical garden has, since 1989, germinated 210 of the 421 rare and endangered species—making the garden a veritable Noah's ark for preservation of the Hawaiian flora. Since 1990, 27 species thought to be extinct have been rediscovered and 21 new species discovered, including one genus new to science.

But growing plants in gardens and test tubes is at best a stopgap. We must save the habitats where these species grow naturally.

WILLIAM MCK. KLEIN, JR., *President*
National Tropical Botanical Garden
Lawai, Hawaii

The Peregrine Fund and cooperating groups have initiated an aggressive effort to recover endangered Hawaiian forest birds. We have hatched several native species never before hatched in captivity and have released two species. Construction is under way on a permanent facility, the Keahou Bird Conservation Center on the Big Island.

AL LIEBERMAN
CYNDI KUEHLER
The Peregrine Fund
Boise, Idaho

Your cover story was insightful and timely, particularly the reference to the endangered *wēkiu* bug on Mauna Kea. While observatories on Mauna Kea have expanded our knowledge of the universe, they have also inadvertently become the greatest threat to the *wēkiu* and at least 11 other unique insect species. Desiring further expansion, the University of Hawaii's Institute for Astronomy recently convinced state agencies to relieve it of an earlier promise to protect these insects as well as Hawaiian cultural and religious sites.

NELSON HO, *Chair*
Statewide Conservation Committee
Sierra Club
Honolulu, Hawaii

I am disgusted that feral pigs are being killed by people who call themselves conservationists. Nature changes all the time. Why is it that when seabirds accidentally carry seeds to offshore islands, we call this natural. But when people do it, we call it artificial?

ANTON DOLINSKY
Jersey City, New Jersey

Hawaii is yet another example of how feral animals in a delicate ecosystem can upset a balance that took thousands of years to perfect. A professor of mine once compared the environment to an airplane and the species to the rivets holding it together, posing the question, "How many species can become extinct before that plane crashes?"

JOE TULPINSKI
Valinda, California

As a child growing up in Hilo, on the Big Island, I took for granted the beauty, biological diversity, and uniqueness of the islands. Your article reminded me of how lucky I was.

BLAKE BARRETT
Phoenix, Arizona

Hawaii Map

The statement "Captain James Cook was received as a god" is conventional wisdom, but there is no evidence for it. None of Cook's men believed this; according to their journals Cook was received as an important chief. *Lono* was a chiefly title as well as a god's name. The idea that Cook was a Hawaiian god was a myth developed in England after his death, as part of the romantic promotion given to his image. An anthropologist at Princeton has scrutinized the evidence and corroborates my conclusions (Gananath Obeyesekere, *The Apotheosis of Captain Cook*, 1992).

HERB KAWAINUI KANE
Captain Cook, Hawaii

Huautla Cave

In the article "Cave Quest" the death of a team member was indeed a tragedy. But the statement that the author was afraid he "made the wrong choice" by sending a diabetic into the cave is upsetting. The wrong choice was the diabetic's decision to go without checking his blood glucose often and making sure his blood-sugar level was high enough. Diabetics can do everything nondiabetics can do. We have to be more careful when we participate in strenuous activities, but there should be nothing that prevents us from attempting them.

LYNN DAWSON
Halethorpe, Maryland

I'm glad there is a magazine in which I can read about places like Huautla Cave. Otherwise, since I lack the bravery and equipment for exploration, I wouldn't know what they look like.

SHANNON D. SNELL
Clinton, Ontario

Dawn of Humans

At this time when evolution is under serious attack, your magazine is to be commended for this excellent article. As a professor of anthropology, I know how such features are sorely needed to enlighten the public. Readers worldwide, especially teachers and students, will benefit greatly from this compelling presentation of the growing fossil evidence for hominid evolution in central East Africa. Having done research at Koobi Fora, I wonder what

Charles Darwin himself would think about the ongoing controversy over his scientific theory and these remarkable discoveries that clearly support human evolution.

H. JAMES BIRX
Canisius College
Buffalo, New York

Please thank Meave Leakey for allowing the possibility that man's earliest ancestors could have arisen somewhere other than Africa. It has always bothered me that recent fossil finds are accepted as proof of African genesis, because few people are looking anywhere else. Other locations, like Siberia or under the slums of Calcutta, are largely ignored because of the difficulty of working in such places and the unlikelihood that any fossils would be preserved.

GARY D. JENSEN
Lake Jackson, Texas

El Salvador

Your profile leaves the impression that the population is sharply split between the idle rich (unflatteringly pictured gorging themselves with alcohol) and the mistreated poor (pictured without limbs, in dirty clothes, and eating from the dump). The presence of a middle class ought to be identified and examined. History, as well as socioeconomic theory, tells us that as the welfare of the middle class changes, so goes the rest of the country. In my travels I met dozens of such families in El Salvador who both work hard and live comfortably. These citizens, who form the foundation of a lasting peace, are nowhere mentioned or pictured.

BRIAN J. LeCLAIR
Washington, D. C.

I know some of my countrymen and countrywomen will find your article insulting, but sometimes the truth is unpleasant.

GERARDO LARDÉ
San Salvador, El Salvador

The guerrillas sound almost like saints. They also committed a long list of atrocities, including planting mines that maimed many children and destroyed a lot of infrastructure.

CARLOS NORVIK
San Salvador, El Salvador

The author gives the impression that in the 1994 elections the Salvadoran people rejected the FMLN and embraced the ARENA Party. Many observers, including myself, concluded that the election was contrived to minimize the participation of those who might vote for the FMLN or other opposition party candidates. This included a difficult voter registration process, "lost" registrations, discrepancies between registration lists and voter lists, confusing polling places, and the intimidating presence of ARENA operatives at the polls. If there is going to be lasting peace in El Salvador, the international community must press for the inclusion of all citizens in the political process.

KENNETH E. VAN DYKE
Grand Rapids, Michigan

Readers should know that numerous citizens groups are working to improve the quality of Salvadoran life in very practical ways. One group, CESTA, is providing new bicycles at affordable prices to thousands of needy Salvadorans. In appreciation of CESTA's work, the Salvadoran Poste has issued a stamp featuring the bicycle as a healthful, nonpolluting means of transportation.

JOHN DOWLIN, Editor
Bicycle Network News
Philadelphia, Pennsylvania

Giant Cuttlefish

This article presented fascinating insights into the behavior and diversity of this unusual cephalopod. It brought back memories of finding cuttlebones of varying sizes and shapes washed up on the desolate storm-swept beaches of the southern Mornington Peninsula in Victoria, Australia. I have also seen living specimens in aquariums, and the sight of a huge cuttlefish suspended motionless in the water—with its side fins undulating—is mesmerizing.

JOHN FRITH
Paddington, New South Wales
Australia

Provence

Your article was like drinking a cool white wine of the Lubéron while listening to music at Silvacane under the stars. Had I not already been living here for the past 40 years, I would certainly have decided to come. Unhappily, behind the glamorous pictures lies everyday reality. A bridge on the Rhône at Salins de Giraud has been announced. The water of the Rhône is so polluted as to be dangerous, especially in the Camargue. Bird life, indeed the whole life of the Camargue, is menaced.

CATHERINE ALDINGTON
Stés-Maries-de-la-Mer, France

Your far too short article almost made me long for my nemesis, Le Mistral, and brought back cherished memories of blooming lavender fields, rugged countryside, and fiercely independent people. I am a proud daughter of Provence who emigrated 20 years ago. I am now homesick.

FRANCOISE B. EVERHART
Lexington, North Carolina

I think the author was wrong to try truffles in an expensive restaurant. The best way to appreciate truffles is in an ordinary omelette, which mustn't be overcooked but rather *bien bavouse* (quite runny). My late father, who was crazy about that dish, used to say, "*J'en mangerais sur la tête d'un mort*—I would eat it over a dead man's head."

EDMOND VOLPI
Lubéron, France

Letters for FORUM should be sent to National Geographic Magazine, Box 37448, Washington, D. C. 20013-7448, or by fax to 202-828-5460, or via the Internet to ngsforum@nationalgeographic.com. Include name, address, and daytime telephone. Letters may be edited for clarity and space.

Geographica



PATRICK SHORT

Canoe Fleet Revives a Polynesian Tradition

HERALDED BY beating drums and trumpeting conch shells, Easter Islanders pilot a reed raft toward the island of Raiatea, near Tahiti, during a rendezvous of Polynesian canoes last spring. Traditional oceangoing vessels from Hawaii, Tahiti, New Zealand, and the Cook Islands gathered to reestablish an alliance that once brought priests and warriors from all over Polynesia to the holy stone temple of Raiatea for religious rites and diplomatic sessions. A taboo banning such meetings—imposed around 1350 when one chief killed a fellow ruler—ended last year.

"This is part of a rejuvenation of Polynesian culture," says archaeologist Mark Eddowes of the Polynesian Center of Human Sciences in Tahiti. It began when a 1976 voyage by *Hokule'a*, a 62-foot double-hulled Hawaiian canoe, proved the accuracy of ancient Pacific navigation (GEOGRAPHIC, October 1976). *Hokule'a* attended this event.

Tortoise Village, a Sanctuary in France

ONLY SIX INCHES LONG when fully grown, Hermann's tortoises seem miscast as stars of the turtle world. Yet, thanks to fans, the last native French land turtles have a bright future.

The ranks of Hermann's tortoises had dwindled as homes, vineyards, and roads shrank their habitat in Provence. In 1988 writer and filmmaker Bernard Devaux created Tortoise Village in the mountains west of St.-Tropez. The preserve

acquires turtles, often from pet owners, treats the ailing or injured, and releases about 500 a year into the wild. "One of our aims is to make people understand that tortoises are not domestic pets," says Devaux.

A highway bisects prime turtle habitat, so Tortoise Village lobbied successfully for turtle tunnels. It also convinced Michelin to relocate a proposed tire-testing track, a victory hailed at a 1995 conservation conference held at the refuge. All told, some 90,000 turtles now roam the countryside.



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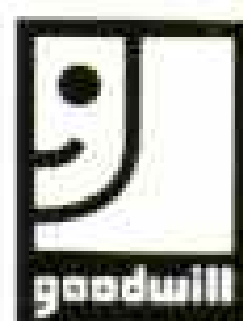
Rhonda's parents are home with her tonight after a hard day's work.

Gerald's mom helps with homework because she learned how to read.

One person really can make a difference.

You did.

Thanks for working with us.



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BETRYCE HALLAY

Shelter From a Storm: Instant Snow House

ABRAHAM NIAQU, an Inuk in far northern Quebec, puts the final touches on a temporary snow house while on a hunting trip on Lake Povungnituk.

Hunters caught away from home, and unwilling to trust tents in winter storms, still build shelters called *illuvigait*. Igloo is the English name for a more permanent snow home, no longer used in the Canadian north.

An experienced hunter like Niaqu builds a snow house in 30 to 40 minutes with windswept, hard-packed snow. Wielding a machete-like snow knife or even

an ordinary wood saw, the hunter carves out blocks of snow two to three feet long and four to six inches thick. He fits them together from the ground up into a snug dome six to ten feet in diameter and caulks the cracks with more snow. Says Craig d'Entremont of the Science Institute of the Northwest Territories: "I've slept in such shelters at minus 40°F with caribou skins above and below me and been very comfortable."

After a Century, a Burst of Blooms

FOR 100 YEARS this century plant, *Agave ferox*, a native of dry, sunny hillsides in Mexico and Central America, lived quietly in England at the University of Oxford Botanic Garden.

"We planted it in our succulent house in 1894," says Timothy Walker, head of the garden. It grew to six feet in diameter but never bloomed. "In the wild it flowers at 20 years—its equivalent of puberty."

In December 1994 cooling vents failed to open when the greenhouse temperature topped 68°F. A cone of leaves opened, and a stem emerged. For two weeks it shot up, until it resembled a 12-foot stalk of

asparagus, according to Walker. In May flowers appeared (left), filled with nectar that "smelled like rancid burnt sugar."

In its native habitat bats distribute the plant's pollen.

"We haven't any bats," says Walker, so a staff member collected and transferred pollen with a feather on the end of a cane to fertilize the plant and produce seeds.



TIMOTHY WALKER

Is This Phone Book Lovely as a Tree?

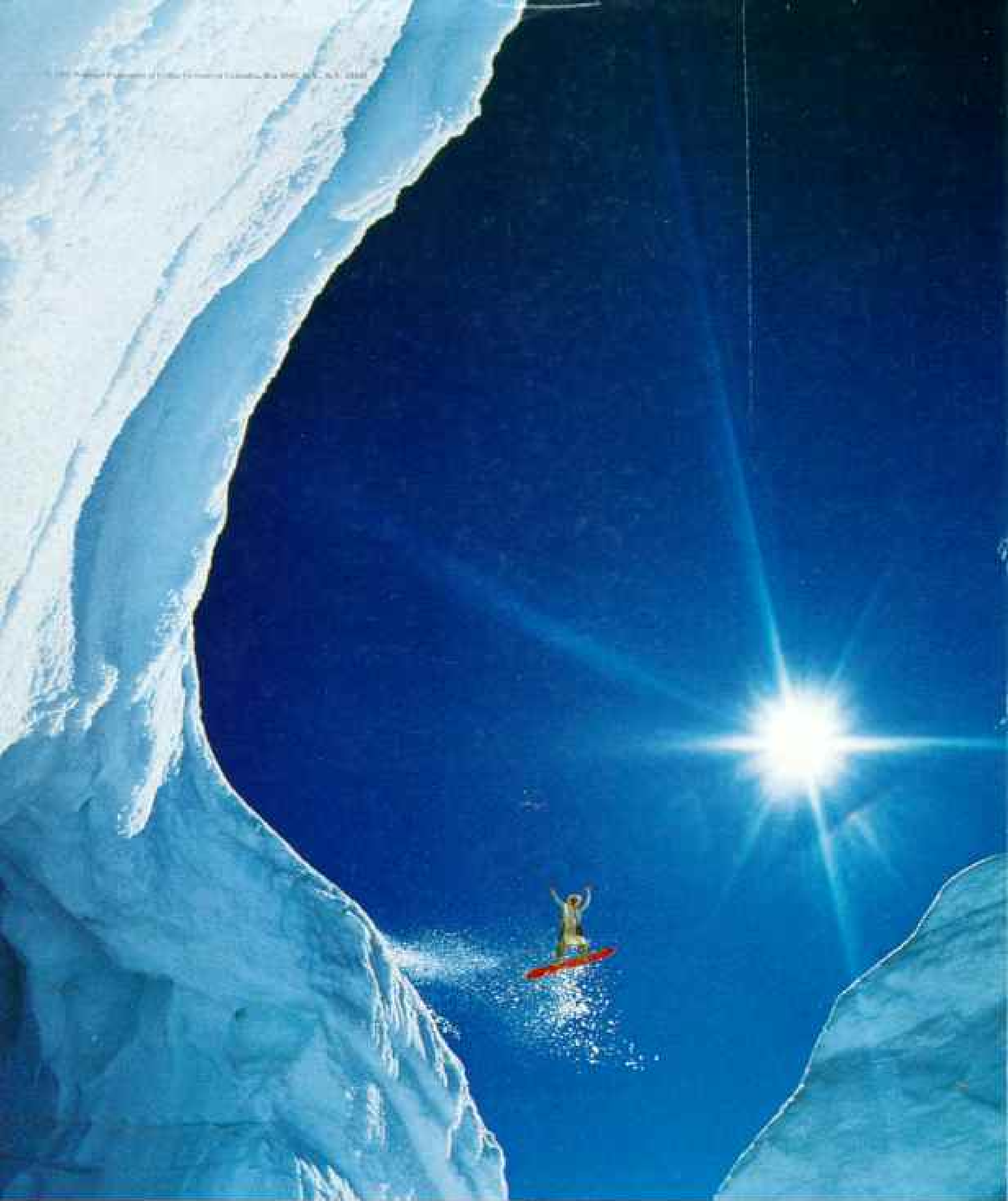
YOU'RE PLANNING A TRIP, so your fingers walk through the phone book to "Travel Agencies" and find . . . "The Road Not Taken," by poet Robert Frost.

Welcome to what may be the world's most literate telephone directory: the Peconic Telbook, serving 86,000 homes and businesses in eastern Long Island.

Publisher Rodney Ryan had been concerned that "we spend so much time talking about the failures of society" and was seeking positive messages. In the December 1994 GEOGRAPHIC article about Walt Whitman, he read of Andrew Carroll's American Poetry & Literacy Project, which aims to put poetry in public places. He called Carroll, who selected 82 poems by 41 poets. Ryan placed most of them randomly in the directory, but Emily Dickinson's "In the Garden" aptly turns up under "Garden and Lawn Furnishings."

—BORIS WEINTRAUB





“Grab life by the beans.”

Juan Pablo



The richest coffee in the world.



On Television

■ EXPLORER, JANUARY 7, 9 P.M. ET

Come to Dinner; We're Having Leftovers

AMONG YOUR HOSTS is the Rüppell's griffon vulture (right), whose messy feeding habits cloak it in blood at every meal. Equipped with a barbed tongue, the vulture can strip soft flesh from bones in seconds. Practicing strength in numbers, the aggressive birds, weighing as much as 20 pounds each, drive off an uninvited golden jackal from the banquet (below).

EXPLORER's "Wings Over the Serengeti" investigates a natural cleanup operation in an area where most deaths are caused by drought, disease, and infirmity. Tooth, claw, and beak are some of the tools that help keep Tanzania's 5,000-square-mile Serengeti Plain—home to abundant wildlife—from resembling a giant graveyard and waste-disposal site.

Tidying up is a dirty job, but someone has to do it. Cleaning



FRITZ POLKING, PETER ARNOLD, INC.

crews range from the noble lion—not above seizing a few morsels—to the lowly dung beetle, perhaps the key to the entire food chain.

Great recyclers, these dung beetles go after every ounce of the 4,000 tons of dung dropped each day by herds of wildebeests. Male beetles form the manure into balls with their

legs, competing in a sort of ball game to accumulate the largest manure pile and attract a female.

A suitably impressed female climbs atop her chosen's ball, and the male rolls her away. Together they hide the ball underground, where the female lays a single egg in the manure. When the rains come, the young emerges, nourished on the dung.

Using aerial and time-lapse photography, "Wings" captures the animals—from flies to big cats, from ants to porcupines—that play a part in recycling waste into new life.

■ PROGRAM GUIDE

National Geographic Specials
NBC. See local listings.

National Geographic EXPLORER
TBS. Sundays, 9 p.m. ET

National Geographic Videos and Kids Videos Call 1-800-343-6610.

Children's Programming
CBS. Saturdays, 12:30 p.m. ET
Really Wild Animals



PATRICIA D. HOEHLMAN

Earth Almanac

Chinese Medicine Targets Bears

PRISONER OF ECONOMICS, an Asiatic black bear awaits surgery to implant a drainage tube in its gallbladder so its bile can be collected and dried. Some 400 bears are kept here in Sichuan on one of China's largest "bear farms." A bear, milked for several months, annually produces about five pounds of dried bile, believed to alleviate liver disease and other maladies. Exported to South Korea, Taiwan, and Japan, it sells for as much as \$1,400 an ounce. "The Chinese claim to have 10,000 bears on these farms," says Chris Servheen of the Bear Specialist Group of the International Union for the Conservation of Nature. He has long monitored the farms, which are legal. Chinese officials say that one live bear yields a hundred times as much bile as a dead one. Even so, Servheen points out, many wild Asian bears, especially brown bears, are being poached solely for their gallbladders, as are black bears in North America. "Trade in bear parts is still legal in several U. S. states," he adds. "With wildlife parts entering the commercial market, protecting that wildlife becomes very difficult."



CHRISTOPHER SERVHEEN

Better Mousetrap Vacuums Its Victims

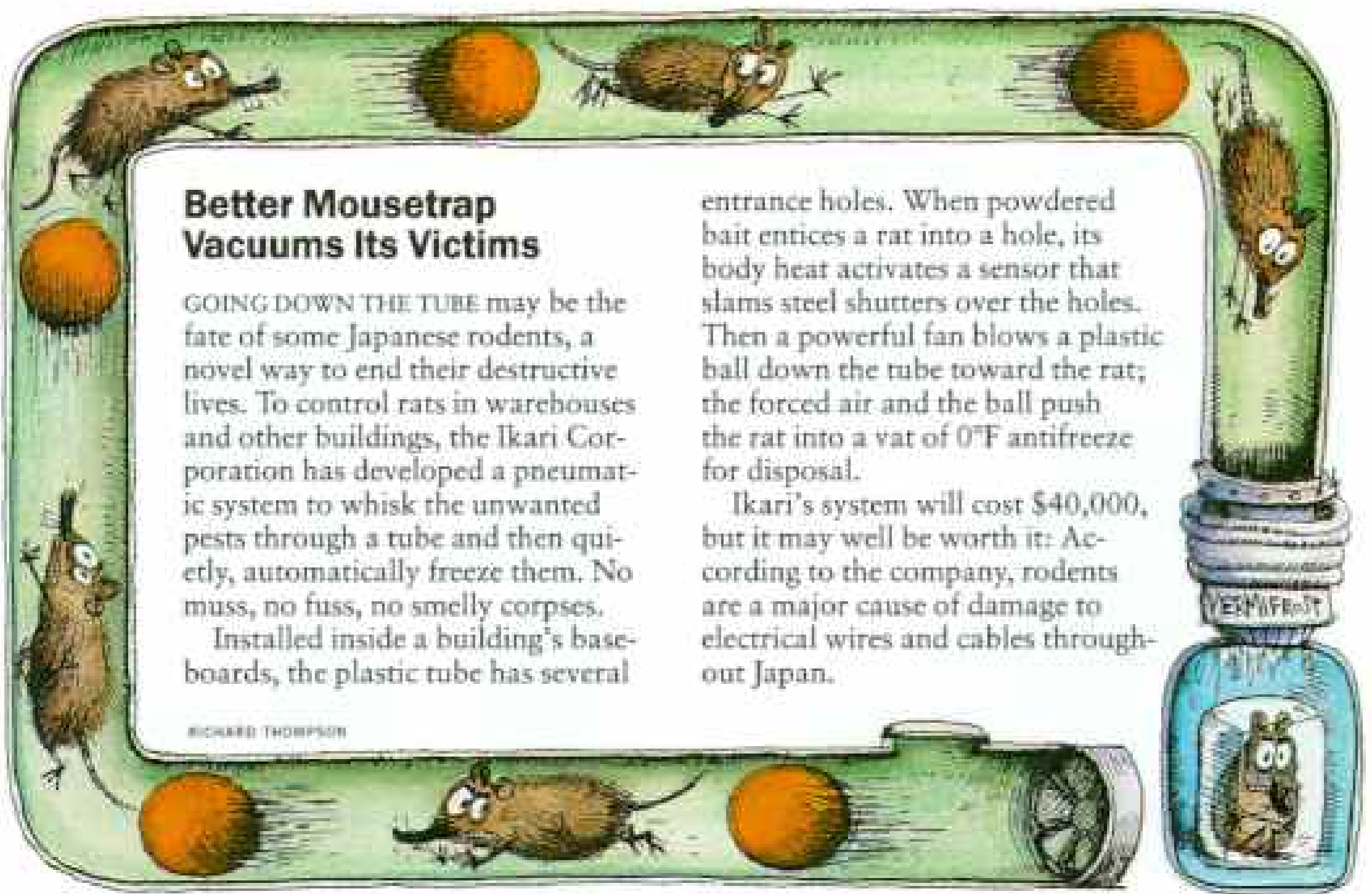
GOING DOWN THE TUBE may be the fate of some Japanese rodents, a novel way to end their destructive lives. To control rats in warehouses and other buildings, the Ikari Corporation has developed a pneumatic system to whisk the unwanted pests through a tube and then quietly, automatically freeze them. No muss, no fuss, no smelly corpses.

Installed inside a building's baseboards, the plastic tube has several

entrance holes. When powdered bait entices a rat into a hole, its body heat activates a sensor that slams steel shutters over the holes. Then a powerful fan blows a plastic ball down the tube toward the rat; the forced air and the ball push the rat into a vat of 0°F antifreeze for disposal.

Ikari's system will cost \$40,000, but it may well be worth it: According to the company, rodents are a major cause of damage to electrical wires and cables throughout Japan.

RICHARD THOMPSON





BILL LARNED, U.S. FISH AND WILDLIFE SERVICE

A Winter Spectacle of Eiders

WHERE DO SPECTACLED EIDERS spend the winter? Last February in Alaska, U.S. Fish and Wildlife Service biologists Greg Balogh and Bill Larned solved the mystery. Twenty-two of the threatened sea ducks had been fitted with tiny transmitters. Weeks after most of the batteries had died, a signal was detected from a lone female far offshore in the Bering Sea pack ice.

Incredulous, the biologists tracked the hen's signal to the eiders' winter hangout—holes in the ice like this one crammed with 5,600 birds,

just some of 155,000 they found. Only the birds' movements

and body heat keep such holes open. "When one flock flew from its pool, a cloud of steam rose—it was amazing," says Balogh.

Among many new questions: Does the eiders' winter diet include krill, small crustaceans abundant at the surface of the birds' hole?



EUMATERIA FULMERA BATES LITTLEHALDES

Gold Mine Camped on Yellowstone's Doorstep

LESS THAN THREE MILES from Yellowstone National Park, a classic confrontation pits environmentalists against a company seeking to mine gold, silver, and copper from Montana's Henderson Mountain.

Crown Butte Mines, Inc., estimates that the mine could yield more than 500 million dollars in gold. Opponents worry about 5.5 million tons of acidic tailings. The company proposes to store the waste in an impoundment

at Fisher Creek, which flows into Clarks Fork, a tributary of the Yellowstone River. An alternate site lies near Soda



Butte Creek. At either location, if the impoundment leaked or the earthen dam failed, acid and heavy metals would

pollute groundwater and streams.

Crown Butte president Joseph Baylis says the impoundment "will outlast the mountain it sits on." But park superintendent Mike Finley counters, "They say they'll treat the mine's wastewater for 40 years. We plan to be around for a lot longer. And we can get a thousand earthquakes a year." A draft environmental impact statement from Montana and the U.S. Forest Service is pending. A permit could be denied based on loss of wetlands, or Congress could buy out the venture.

—JOHN L. ELIOT

On Assignment

■ PUFFINS

Home Is Where the Hut Is

"THE WEATHER THERE was so foul!" says FRANS LANTING of the remote Scottish archipelago of St. Kilda, home of Britain's largest puffin colony. "Even though my assistant and I had tents, we finally had to retreat to these stone-and-sod huts for protection from all the wind and driving rain." The centuries-old structures, called cleits, were once used by local people to dry and store seabirds killed in summer for winter food supplies. But the last of St. Kilda's residents moved away from the archipelago in 1930. Now the cleits only dry and store . . . photographers.



FRANS LANTING



KENNETH BARRETT

■ NEANDERTALS

Please Don't Call Him a Caveman

"AFTER FINISHING the fieldwork for this story, I never wanted to see a cave again," says author RICK GORE, at left, with archaeologist Jean-Michel Geneste outside an excavation of rock dwellings used by Neandertals and their successors in France's Dordogne River Valley. "I found myself in cold caves, muddy caves, sloppy caves, wet caves. I never realized how different caves could be. I climbed, I fell, I slithered on my stomach through them. And that's not easy to do with a notebook in your hand."

As he traveled their paths, Rick gained respect for the enigmatic Neandertals. "Climbing up frightening cliffs and slopes to reach some of the caves, then crawling through them, I was amazed at what these people must have gone through to live there. And I am equally amazed at what the scientists who study them go through to work there today."

Rick has been science editor of the GEOGRAPHIC since 1992.

Geoguide

As the expedition went on, the evening tent lights of March (below) gave way to 24-hour sunlight. Toward journey's end, drifting snow and ice ridges confronted the polar team (right) off Canada's Ellesmere Island.

Across a frozen sea

■ The polar travelers were awed by the powerful sounds of shifting ice as it heaved and split. If you drop freshly frozen ice cubes into a glass of water, they will crack loudly. Imagine the sound if the ice were eight feet thick—and you were walking on it.

■ On the map on page 80, earth's northernmost point—the North Pole—is not at the top of the map. If you walk your



fingers from the map's North Pole toward the top of the page, in what compass direction will you be going?

■ Snow and ice ridges sometimes slowed the travelers to a few miles a day. What are two other obstacles found in crossing sea ice?

■ For more than two months

huskies ran with the polar team, hauling 700-pound sleds. After the dogs were flown out in mid-June, how did the team transport its gear? Why did the dogs have to leave?

■ Comparing the maps on pages 80 and 88, why do you think the four 1995 polar teams all took similar routes?



WILL STEIGER (TOP); GORDON WILKIE