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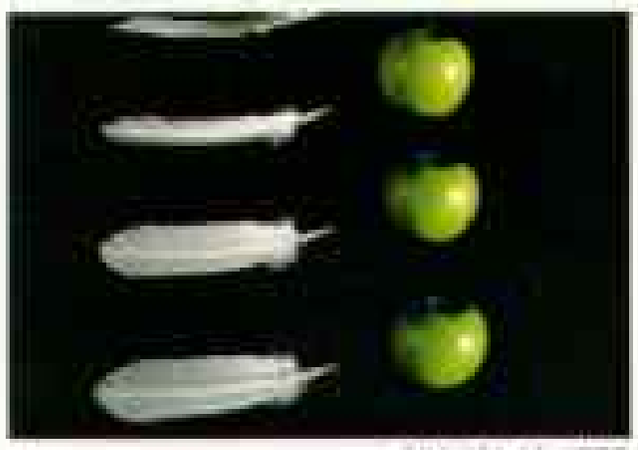
UNIQUE TEPUI PLANTS

Venezuela's Islands in Time 526

Like fortresses in the clouds, lofty mesas called tepuis tower above forests edging the Amazon Basin. Author-photographer Uwe George visits the region that inspired Sir Arthur Conan Doyle's Lost World, *where unique plants and animals have remained all but unknown.*



GRAVITY AT WORK

Searching for the Secrets of Gravity 563

The force that keeps our planet circling the sun and our feet on the ground is not as simple as Newton thought. Another force may be at work as well, reports John Boslough. Photos by James A. Sugar.

SAILING THE FAR NORTH

Braving the Northwest Passage 584

For centuries European seamen tried to reach the Far East through the icy waters of northern Canada. Not until the early 1900s was the voyage made, and not until last August was it made under sail and muscle power alone. Jeff MacInnis and photographer Mike Beedell describe their 2,300-mile journey aboard an 18-foot catamaran.

BALTIC ENCOUNTER

The Baltic: Arena of Power 602

The rules have changed in this traditional East-West buffer zone, with glasnost and perestroika replacing hostility and suspicion. Priit J. Vesilind and photographer Cotton Coulson find the seven Baltic nations cooperating to save the sea they share.

SWISS AVALANCHE BARRIER

Are the Swiss Forests in Peril? 637

For centuries forests have sheltered Swiss valleys from avalanches. Today many trees, weakened by air pollution, insects, and former forestry practices, show alarming damage. Christian Mehr tells of efforts to save the forests. Photos by the author and Sam Abell.

WHAT DOES THIS BOX HOLD?

U. S. History in a Box 652

On April 30 National Geographic EXPLORER will televise the opening of a Long Island family's time capsule, sealed a century ago. Space-age technology previews the contents, mementos of President Benjamin Harrison's inaugural in 1889 and possibly of George Washington's in 1789. Text by Benjamin P. Field V, heir to the box, and Senior Associate Editor Joseph Judge; photos by Sisse Brimberg.

COVER: *In a dreamlike swirl, members of Leningrad's Kirov Ballet perform* Giselle. *The Soviet Union, dancing to the tune of glasnost, holds the full attention of its Baltic Sea neighbors. Photograph by Cotton Coulson.*

Venezuela's

ARTICLE AND PHOTOGRAPHS BY UWE GEORGE

Islands in Time

Lonely outposts of life, 9,094-foot-high Mount Roraima and related sandstone mesas—known as tepuis—lift harshly beautiful worlds above the mists.

The flight of Angel Falls, the world's highest, ends more than 3,000 feet down the face of Auyan-tepui. More than a hundred

tepuis—a Pemón Indian word for mountains—rise mainly in southeastern Venezuela; fewer than half have been explored.

A delicate arrangement of some of the world's toughest plants takes hold on an oasis of mosses and lichens atop Roraima's

nearly soilless plateau. All are unique to the tepui region; perhaps half of Roraima's species live only on that summit.

Blackened and sculptured by algae and fungi, the sandstone labyrinth atop Cuquenan swallows Venezuelan scientist Fabian

Michelangeli. Plants were first collected here in 1963. Algae and fungi, along with water, are the chief agents of tepui erosion.

South America is a place I love, and I think, if you take it right through from Darien to Fuego, it's the grandest, richest, most wonderful bit of earth upon this planet. . . . Why shouldn't somethin' new and wonderful lie in such a country? And why shouldn't we be the men to find it out?

—SIR ARTHUR CONAN DOYLE
The Lost World, 1912

THE PATH through thick vegetation grows steeper, leading directly into the clouds. Rain begins to fall. Here and there the way is so steep and slippery that I can only advance on all fours. Everything smells of decay—sweetish, heavy, pungent.

I am in a remote corner of southeastern Venezuela near the border with Brazil and Guyana (map, page 541). The cliff I am trying to scale is the face of Mount Roraima, an enormous sandstone mesa, or *tepui*. At 9,094 feet (2,772 meters) it soars above the surrounding savanna and tropical forest like some vast, impregnable fortress.

There are more than a hundred such tepuis—a Pemón Indian word for mountains—scattered over an area of some 200,000 square miles (500,000 square kilometers). All the tepuis are remote; while most have been visited, fewer than half have been extensively explored. Many of them are hidden by dense cloud cover, like the surface of Venus, for days at a time. In some respects we know more about that distant planet than we do about the vast and mysterious tepuis of Venezuela.

As a German writer and explorer I had long been fascinated by these extraordinary geologic formations. The tepuis, in effect, are the remains of mighty sandstone plateaus that at one time stretched across the entire area. In the course of time the plateaus were largely worn down by erosion, leaving only the tepuis as giant monuments to their existence.

As a result of isolation over millions of years, much of the plant and animal life atop the tepuis is unique. The first expedition to the top of Roraima in 1884 brought back plant samples that were significantly different from species then known to botanists.

Roraima, I quickly learn, not only has strange life-forms but all-too-familiar ones as well. As I reach for a handhold among the vines above me, one of my four Indian companions shouts a warning: *"Veinticuatros!"* I snatch my hand back from a huge black ant nearly an inch long perched atop one of the vines. The creature's name means "24-hour ant," and it is more feared by the local

Into the heart of Auyan-tepui, a bush pilot known as El Tigre pulls while author-photographer Uwe George pushes a dugout through an 800-foot-deep canyon at the mountain's base. When a rainstorm raised the creek 20 feet in two minutes, they paddled. Waterfalls blocked their passage after little more than a mile.

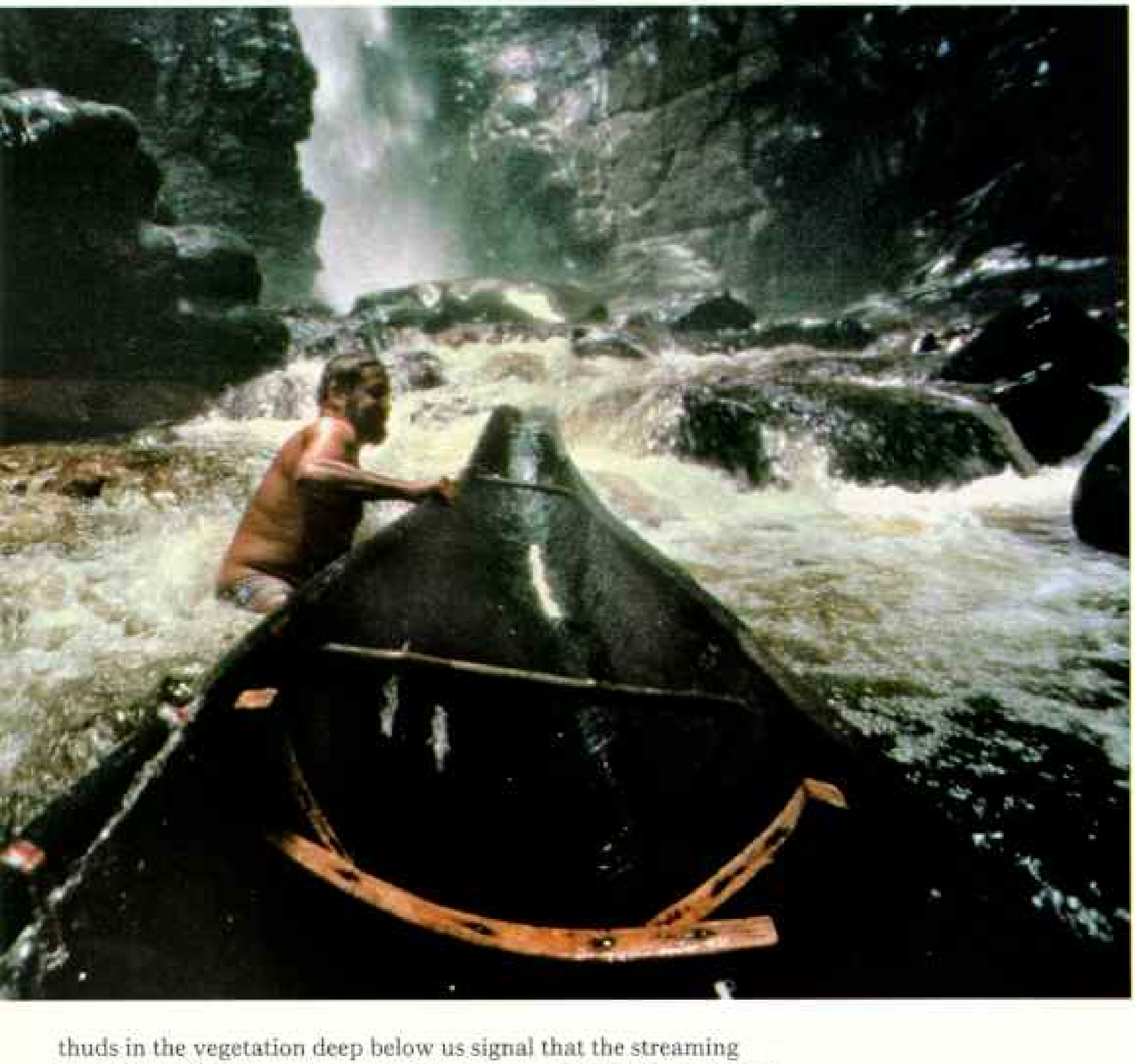
Cloud buildup over tepuis —some lofty enough to create their own weather—releases as much as 150 inches of rain a year. The violent run-off feeds headwaters of the Orinoco River.

UWE GEORGE is explorations writer-editor for the German magazine *Geo*. His assignments have taken him to Africa, the Arctic, the United States, and South America.

Indians than scorpions. The ant's sting causes brutal pain and a dangerous one-day fever that can be fatal to those with a severe allergic reaction.

"Careful, Uwe," cautions my Venezuelan explorer friend, José Miguel Pérez, with a grim smile. "You're too big for us to carry back down."

We continue to move upward, climbing higher and higher across overgrown ledges along the wall. From cracks and holes in the wall water gushes out under high pressure as if from a huge burst water pipe. Even from the top, from the edge of the plateau hidden in the clouds, the water pours down on us. Again and again muffled



thuds in the vegetation deep below us signal that the streaming water is tearing away the rock. Far above us on the plateau distant thunderstorms rumble. The big rains of summer have not yet come to an end.

Sometime in late afternoon the heavy, somber cloud cover opens briefly one more time. The light of the sun, already far down the horizon, makes the rock wall sparkle for a moment like pure gold. Old myths and legends awake. . . .

IN EUROPE not long after Columbus reached the New World, the news spread of a country where humans lived without heads and where women went to war with strange poisoned arrows that were blown from pipes. This country was supposed to be so rich in gold that the natives powdered themselves with gold dust.

Sir Walter Raleigh, better known for his attempt to found the Virginia Colony, explored Guyana in 1595 and wrote of that fabled

land: "The common soldier. . . . shal find there more rich and bewtifull cities, more temples adorned with golden Images . . . then either *Cortez* found in *Mexico*, or *Pizzaro* in *Peru*. . . . *Guiana* is a Countrey that hath yet her Maydenhead, neuer sackt, turned, nor wrought, the face of the earth hath not beene torne. . . ."

Raleigh went on to tell of a crystal mountain covered with diamonds and other precious stones where waters gush down. The mountain, Raleigh wrote, gave the impression of a "white Church towre. . . . There falleth ouer it a mightie riuer which toucheth no parte of the side of the mountaine, but . . . falleth to the grounde with a terrible noyse and clamor, as if 1000 great belles were knockt one against another. . . . but what it hath I knowe not, neyther durst he or any of his men ascende to the toppe of the saide mountaine, those people adioyning beeing his enemies (as they were) and the way to it so impassible."

Raleigh obviously had seen a tepui, and his description is regarded as the earliest written reference to one.

MY THOUGHTS are interrupted by José Miguel calling me from above: "Uwe, hurry up, we really have to reach the plateau before nightfall." How right he is. Darkness quickly creeps up the rock wall. We cannot spend the night on the rain-soaked cliff. Just in the very last shimmer of the day, as distant sheet lightning becomes brighter than the daylight, we reach the surface of the plateau at about 8,500 feet.

What I can distinguish of the landscape in the last daylight seems to have come out of a nightmare. Boulders and pinnacles in every size and form are piled one on top of the other. Stormy winds whip ice-cold rain into our faces. In the light of our lamps we stumble a few hundred yards farther. There is no thought of putting up a tent. There is not one square yard of flat surface. What is not naked, slippery rock is bottomless morass.

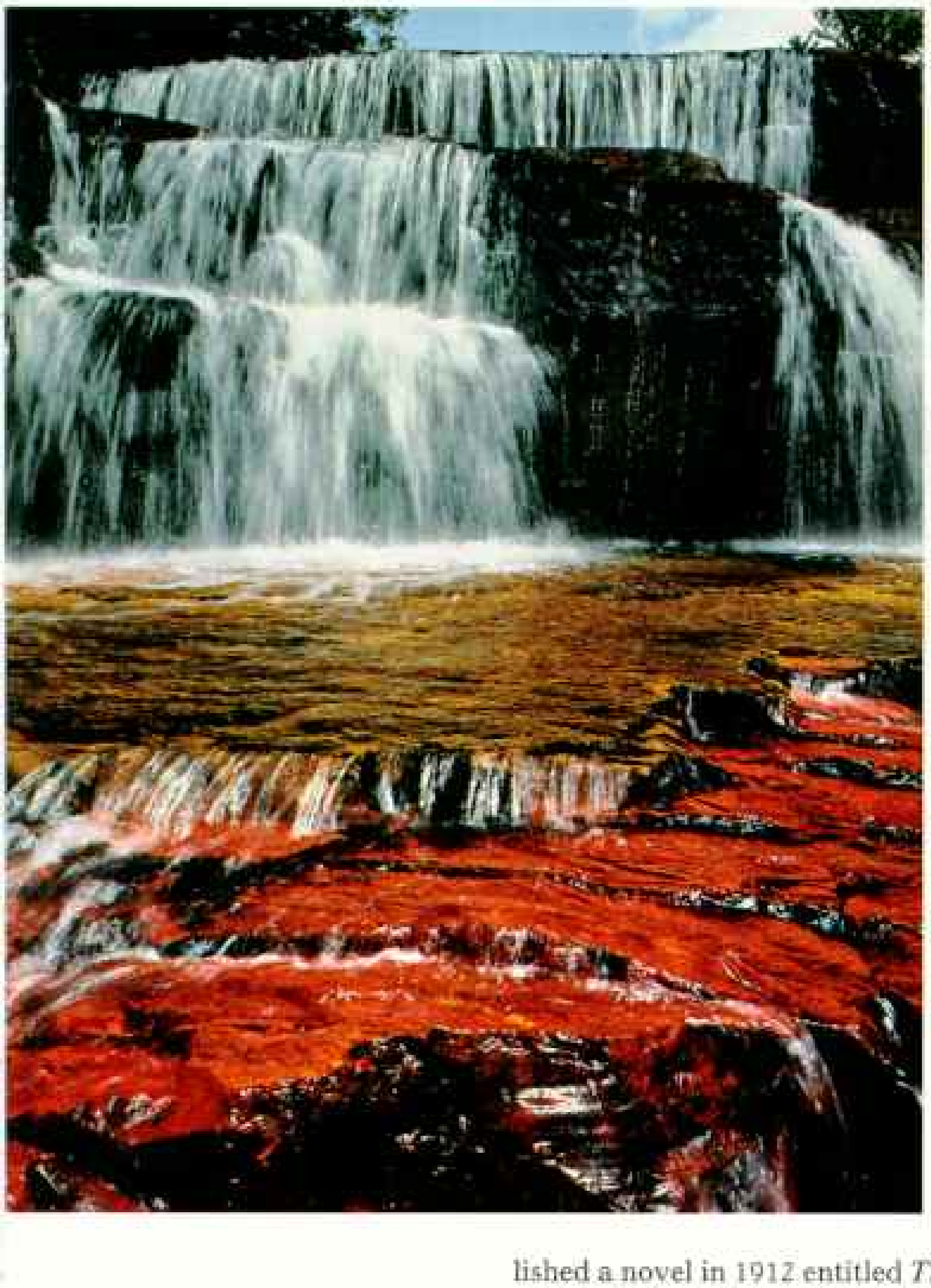
Like wet dogs José Miguel and I crawl under the stony roof of a mushroom-shaped rock ledge and get into our sleeping bags. The Indians go off to another shelter. A thunderstorm of primeval power breaks over us. The rolls of thunder last over a full minute each. Lightning follows lightning, crashing into the rocks, accompanied

"All their festive songs have Roraima for subject matter," ***German botanist Richard Schomburgk wrote of the Pemón Indians, who in 1842 helped him climb the tepui whose name means "singing of waterfalls." It towers at far right in this view from his savanna camp (left), a perspective confirmed by the author (top left). Schomburgk and his brother Robert—who first saw the tepui in 1838—failed to reach the summit, but they excited Europe with specimens from a "botanical El Dorado," such as one from a tree in the tepui's base forest (above).***

BY CHARLES BENTLEY, FROM FIELD SKETCHES BY RICHARD SCHOMBURGK (LEFT); *WEINMANNIA BALBISIANUS* VAR. *RORAIMENSIS*, BY J. URPE, COURTESY BOTANISCHES MUSEUM, BERLIN (ABOVE)

by a torrential downpour. Secure in our sleeping bags, though uncertain of whether we share our shelter with scorpions or other poisonous creatures, we stare out onto a scene that could easily have been the set for a production of Wagner's *Götterdämmerung—Twilight of the Gods*.

Depending on where the lightning strikes, new sets emerge one after another. It is easy to imagine the pinnacles and towers of rock around us as the ruins of temples from some strange, long-ago cultures. My mind conjures up colossal Egyptian statues, Greek deities, Siamese pagodas, Roman gods, dwarf elephants, and giant camels—all grown stiff for eternity.



With a deafening crash lightning strikes the ledge directly above us. I feel it tremble and fear it will break off and bury us alive. But we have no choice; we must stay where we are.

THE THUNDERSTORM lasts through the night. We cannot think of sleep, but I am happy: I am finally on Roraima.

From boyhood I read the works of the German-born explorer and scientist, Robert Schomburgk, who was probably the first European to see Roraima. Schomburgk explored the tepui region for Britain's Royal Geographical Society in 1838. Although he himself never reached the top of Roraima, his writings inspired others to continue exploring the remote area, among them a British botanist named Everard Im Thurn, who finally reached the top of Mount Roraima on December 18, 1884.

Back in Europe Im Thurn lectured on his expedition. One of his performances in England was attended by novelist Arthur Conan Doyle of Sherlock Holmes fame. Doyle was so fascinated by Im Thurn's account that he published a novel in 1912 entitled *The Lost World*, describing the ascent of a South American plateau where prehistoric plants and dinosaurs had lived isolated and unchanged for millions of years.

In fact, scientists both then and now have been fascinated by what happens to species of plants and animals when they are isolated at some place on earth, perhaps for millions of years. Have some ancient species survived the times in remote corners of the earth such as Mount Roraima?

AT SOME POINT in the early morning I must have fallen asleep, for I am awakened by the clatter of cups as José Miguel makes tea.

"How many different species of dinosaurs did you meet in your dreams?" he asks.

"They were all struck by lightning," I reply.

The morning air is clear and cold. In the midst of an endless ocean of thick clouds far below us, we stand on a stony raft whose wild surface surpasses anything I have ever seen. In the distance other tepuis rise like "islands in time," in the words of Charles Brewer-Carias, a Venezuelan writer who knows the region well. The nearest tepui, only a few miles away, is Cuquenan. From it waterfalls plunge down into the clouds. One of our Indian guides gestures toward it. "Many men have climbed up, but no one has ever come down again," he says grimly. In fact, some have. But, behind it are tepuis where no human may ever have set foot.

According to the Indians, there is a possible campsite some six miles to the north on Roraima. It is an all-day hike because of the difficult terrain, and we set off immediately.

We make our way painfully over a rocky landscape that I come to think of as "rain desert." Most of the mineral nutrients that are essential to plant growth have been washed away by incessant rainfall. Yet beautiful miniature oases bloom here, combinations of many species of plants that seem to survive on water and air alone.

Until recently no one knew Roraima's age. Then, a few years ago, geologists discovered sites where molten rock had thrust its way between layers of sandstone after the ancient plateaus were formed. The geologists conducted chronological-dating tests on the igneous diabase and other rocks and came up with an astonishing result: The sandstone here is at least 1.8 billion years old.

Thus, Roraima dates back to a period before even the most primitive life-forms existed in the oceans. It would be another 1.2 billion years before plants and animals emerged from those oceans to live on land.

Such vast expanses of time are incomprehensible to most of us, and we try to reduce those periods to measurable human terms. The best example I know is offered by writer John McPhee in his book *Basin and Range*. "With your arms spread wide . . . to represent all time on earth," McPhee wrote, "look at one hand with its line of life. . . . All of the Cenozoic is in a fingerprint, and in a single stroke with a medium-grained nail file you could eradicate human history."

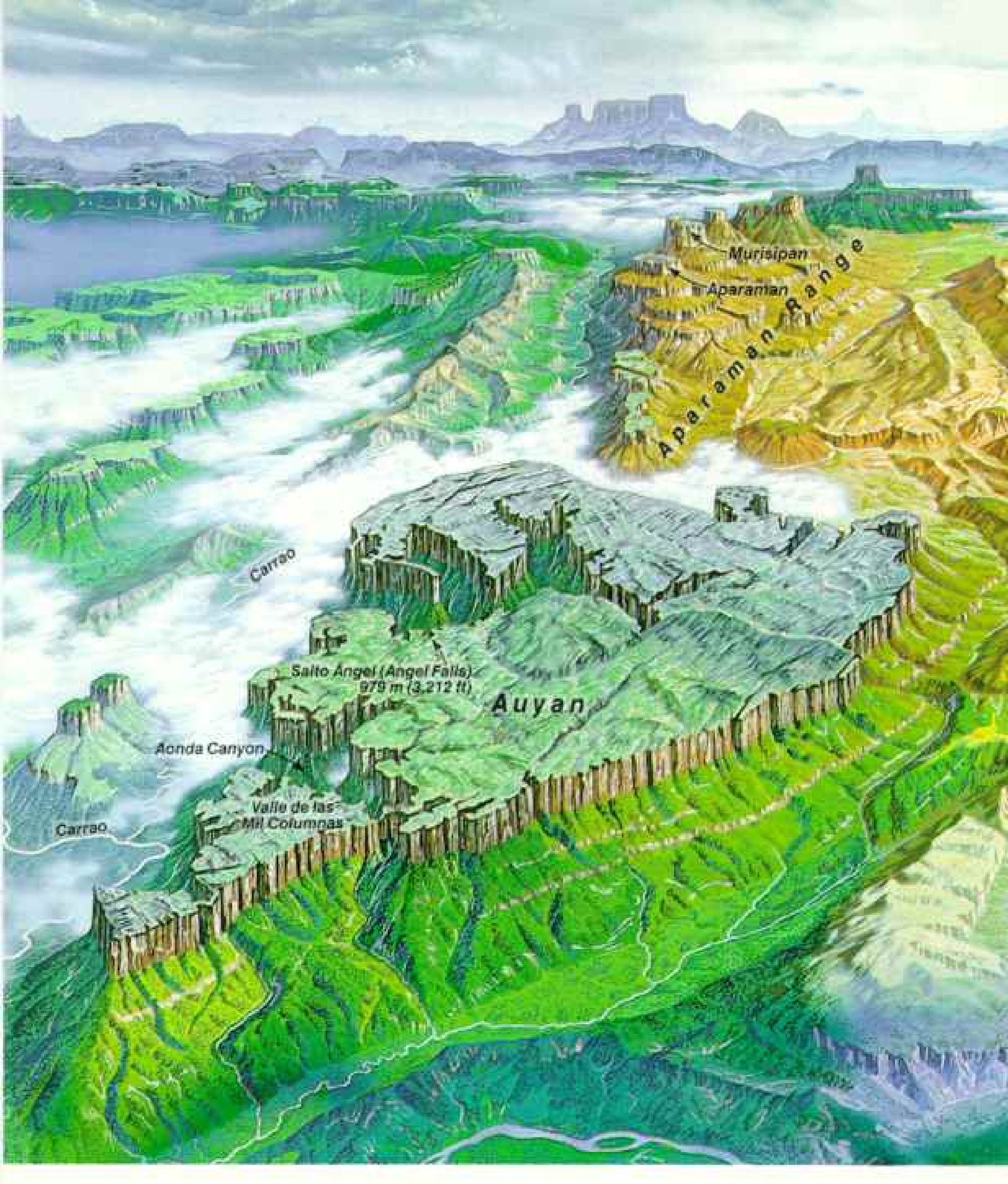
Roraima's sedimentary rock was already age-old when South America and Africa were joined together in the prehistoric continent now called Gondwana. Gondwana began to break up some 135 million years ago, yet evidence of the original junction still exists: Cliffs and mesa-like mountains in the western Sahara consist of sandstone similar to that of Mount Roraima.

It was Im Thurn who first brought back hitherto unknown plant species from Roraima. Like Charles Darwin, who had discovered and described species of the Galápagos Islands half a century earlier, he had found new examples of life-forms that had been isolated over eons of time.

None of us who followed Im Thurn to Roraima have found primordial creatures or their fossil remains there, but the terrain is so

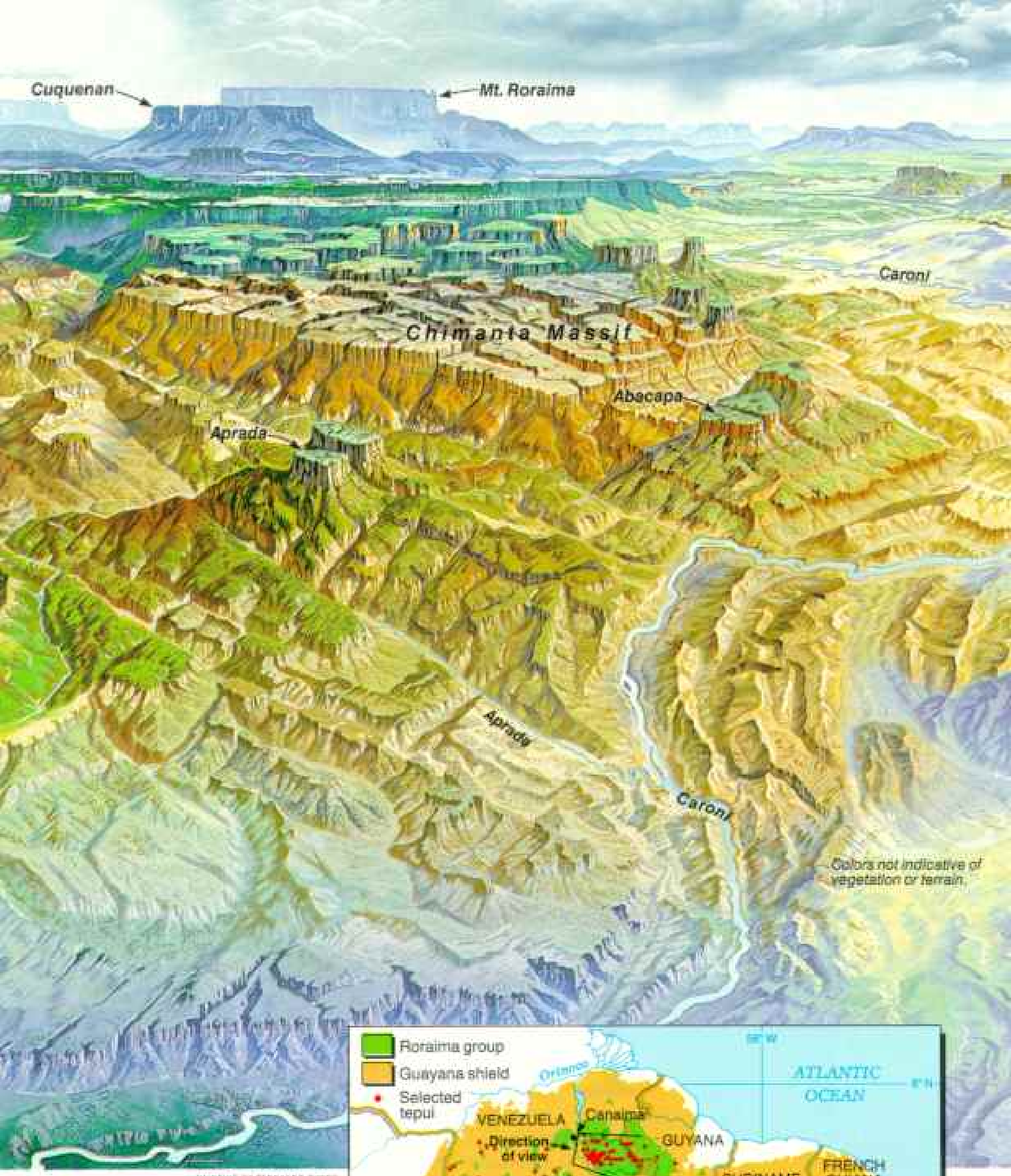
Inflamed by the presence of jasper, tumbling cascades 30 miles southwest of Roraima expose rock sandwiched within the sandstone from which the tepuis are formed. Some of the world's oldest sandstone, these deposits were laid down at least 1.8 billion years ago atop the Guayana shield, the oldest rock in South America.

FABIAN MICHELANGELI



Isolated Worlds of the Tepuis

Remnants of vast sandstone plateaus called the Roraima group, tepuis are natural laboratories for studying the adaptation of species to severe environments. Isolated from human horticultural tampering, they hold clues to natural plant succession and dispersal in habitats ranging from rocky outcrops to riverine forests. At least half the estimated 10,000 plant species here are unique to the tepuis and surrounding



PAINTING BY FERNANDO RUSSO

lowlands. New species are still being discovered.

Able to penetrate cloud cover and vegetation, satellite radar images provided information for this illustration, encompassing 13,000 square miles.

difficult that only a fraction of the tepui's 44 square miles has so far been explored.

As we hike toward the campsite, the boulder-strewn terrain becomes increasingly savage; I feel as though I am walking through the ruins of a bombed-out city. Then suddenly we enter a canyon so spectacularly beautiful it seems to have been drawn from a fairy tale. Here and there the ground beneath our feet consists entirely of sparkling white and pink crystals. Dr. Brewer-Carias, who discovered the canyon in 1976, named it Valle de los Cristales—"valley of the crystals."

The canyon ends abruptly on the east side of Roraima, and here a waterfall pours over an outcropping of crystal. The light reflects from it as if from a mirror broken into a thousand pieces. The legend of Raleigh's crystal mountain becomes reality.

Beyond the canyon we find the campsite and set up for the night at the edge of a huge unexplored area known as the "great labyrinth of the north." It is a three-square-mile region of jumbled rock towers and chasms as deep as 150 feet. The Indians tell us that there are diamonds to be found in the labyrinth, but they stoutly refuse to set foot there. José Miguel and I agree to explore a bit of it the next morning and then bed down for the night.

During the night I hear a weird scream that seems to come from far away in the labyrinth. The sound calls to mind again Arthur Conan Doyle's novel *The Lost World*, in which the narrator, E. D. Malone, hears similar screams one night while his group is camped.

"We were all sleeping round our dying fire," says Malone, "when we were aroused—or, rather, I should say, shot out of our slumbers—by a succession of the most frightful cries and screams to which I have ever listened. I know no sound to which I could compare this amazing tumult, which seemed to come from some spot within a few hundred yards of our camp."

Malone described the screams at length and later attributed them to a dinosaur. Once again I hear the ghastly sound that seems to emanate from the labyrinth, and for a moment I consider waking the snoring José Miguel. Then quiet descends, and after a time I drift off as well.

Like other tepui observers, geologists are just beginning to understand the nature of tepuis. The artwork on the opposite page reflects a widely held theory, which stresses erosion while acknowledging the importance of uplift. Another view believes that uplift played an equal, if not greater, role in shaping the landforms.

THE NEXT MORNING José Miguel and I enter the labyrinth. It is a roofless Hades clothed in ghostly swaths of fog, and soon a steady rain begins to fall. Moving is torture; our boots cling to the wet morass at the bottom of the chasms that quickly obliterates our footsteps. To move only 200 or 300 yards takes us several hours.

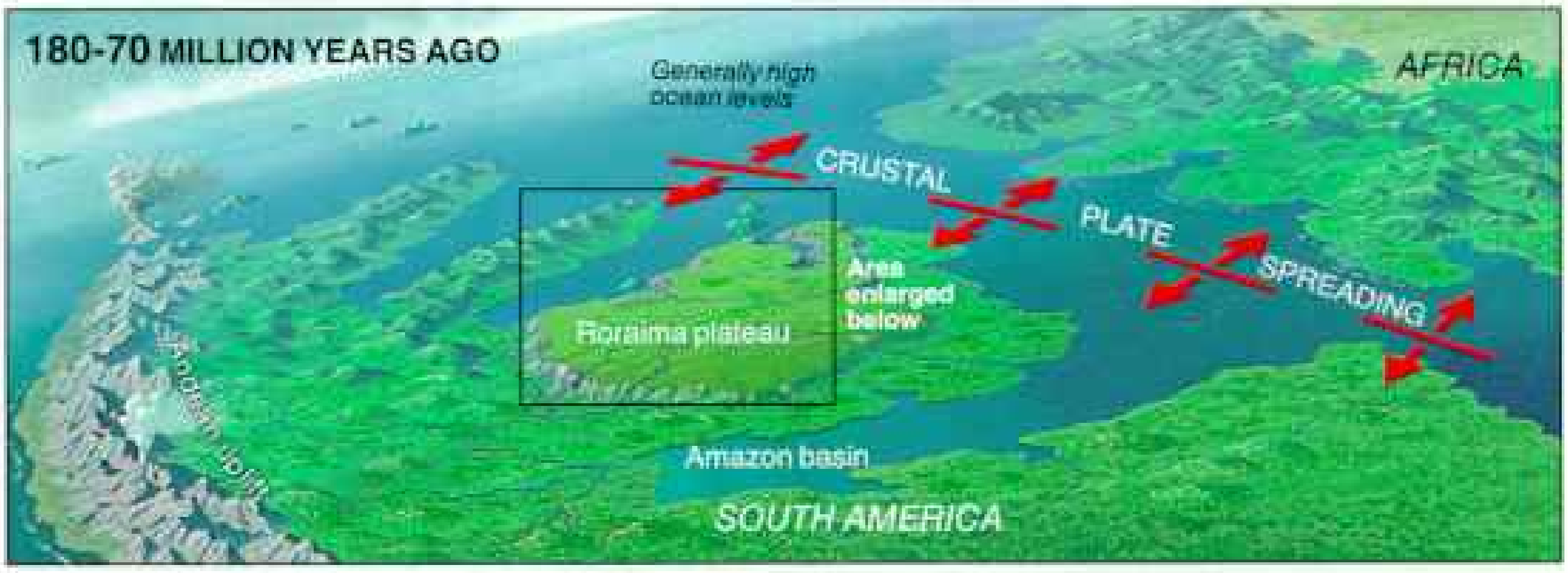
José Miguel and I become separated. I call to him and he calls to me, but the calls come back from every direction as strangely mixed echoes. As I penetrate farther into the labyrinth, I recall the weird screams of the previous night. At each turn I expect to meet the source of the screams in the form of some monstrous creature. And then I do encounter a very strange creature indeed.

It is a monster but only in miniature—a toad less than an inch long with enormous eyes and a skin completely covered with warts.

This is not the source of the screams, but it is a fascinating creature nonetheless. I recognize the toad as the species *Oreophrynella quelchii*, a relative of which was recorded earlier on a group of tepuis known as Neblina. I had been told by a herpetologist on the

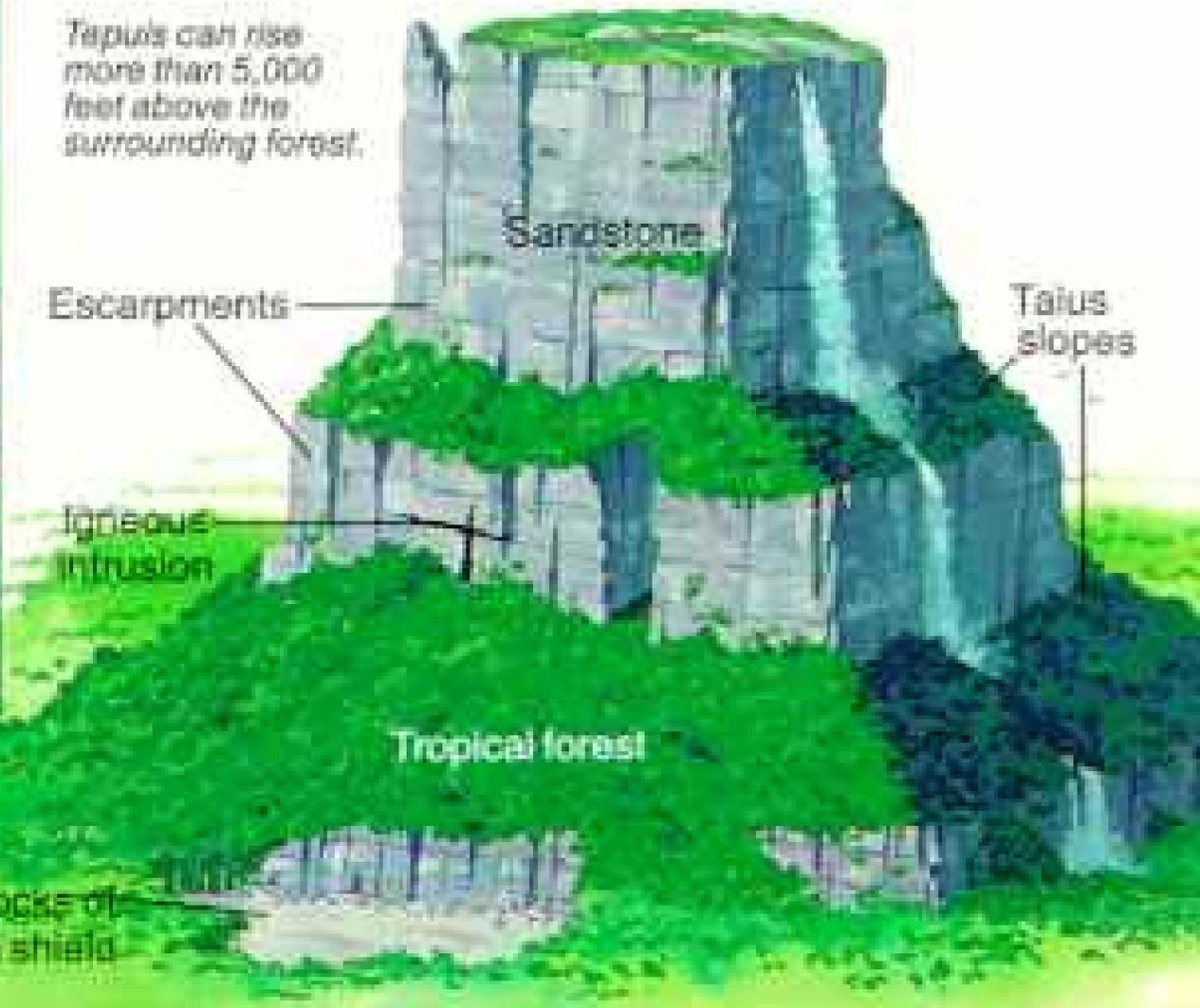
The Roraima group was already ancient when South America and Africa were linked as part of the supercontinent Gondwana.

Datable intrusions of igneous diabase in Mount Roraima—forced through fissures in the sandstone as molten rock—indicate that sand from eroding mountain ranges, right, had been spread by water and wind over the Guayana shield by 1.8 billion years ago.



The inner-earth forces that set South America adrift helped define the future shapes of the tepuis. Warping of the continental plate created fissures and fractures in the Roraima sandstone plateaus. Patterns of erosion followed these weak spots and enlarged them.

Tectonic forces within the earth also uplifted blocks of the plateaus, helping further separate tepuis and vary their heights.



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Fairly well established in their present-day appearance three to four million years ago, tepuis today represent a fraction of the original sandstone deposits; the bulk washed to sea. This composite tepui, right, displays the typical tiering caused by varying degrees of erosion along ancient fractures, the result of changing climate and geologic conditions that determined the hardness of the sandstone.

FROM JUNE 1912 STRAND MAGAZINE

"Not a bird, my dear Roxton . . . a dinosaur. Nothing else could have left such a track." Gamboling iguanodons (left) and swooping pterodactyls met the heroes of Arthur Conan Doyle's Lost World, *set on a tepui. Inspired by the lectures of Everard Im Thurn, who scaled Roraima in 1884, Doyle embraced the erroneous notion that tepui life was frozen in time. His imagination seems cast in stone as shapes reminiscent of the Mesozoic loom in the mists of Murisipan-tepui (right). The toad* Oreophrynella quelchii*—a species discovered on Roraima in 1894 (below)—retains primitive traits not because of isolation but because the environment has not forced it to change. Barely an inch long, it cannot hop or swim.*

expedition that relatives of some of the species of amphibians found on Neblina may be native to Africa. Thus, ancestors of my miniature monster may well date back to that distant age when South America and Africa were one and the same continent.

Soon afterward José Miguel and I join up again and make our way back to camp. The Indians seem surprised to see us, as if we had escaped from the labyrinth by some magic charm. The next morning we make our descent from Roraima. To this day I do not know the source of the terrible screams that night in the labyrinth. Perhaps an owl. Perhaps something else. . . .

DURING MY TIME on Roraima I developed a severe case of "tepui fever"—a longing to visit other tepuis and explore some of the mysteries they have guarded for eons. In 1986, a year after José Miguel and I climbed Roraima, I joined an expedition organized by Terramar, or "landsea," a group of Venezuelan scientists and amateur naturalists devoted to exploring remote areas of their country.

The president of Terramar is a prominent Venezuelan lawyer, Dr. Armando Michelangeli. Other leading members include Armando's brother, Fabian, who is a biochemist, Dr. Armando Subero, a neurosurgeon, and Dr. Klaus Jaffe, a professor of biology at Venezuela's Simón Bolivar University in the capital city of Caracas. The goal of our expedition was a large tepui known as Auyan, located to the northwest of Roraima. We were fortunate to be accompanied by another member of Terramar, Volkmar Vareschi, a German-born Venezuelan now in his 80s who is a superb artist and the country's grand old man of tropical ecology.

A cargo plane flew our team of eight scientists and tons of supplies from Caracas to the small southeastern settlement of Canaima. There we loaded our supplies aboard a fleet of dugout canoes and set off up the Carrao River to Auyan-tepui.

For most of the way the Carrao is bordered by dense tropical forest. Often as we rounded a bend in the river, troops of monkeys and clouds of big, bluish red macaws fled shrieking into the jungle on either side. Repeatedly a sort of blue lightning flashed before our

canoes. It was unreal, like the light of a blue laser. I discovered that it came from huge, iridescent blue morpho butterflies whose millions of tiny scales flashed in the tropical sunlight. A day's journey from Canaima we stopped to visit Alexander Laime, a 75-year-old man who has lived alone for many years on a small island in the Carrao and who made an expedition to Auyan-tepui in 1955.

Alexander has cleared an area of jungle on his island for a garden featuring bananas, manioc, potatoes, pumpkins, and mangoes. He lives in a palm-thatched wooden hut that he built himself. Beside the door hangs a plumb bob on a string by which Alexander keeps track of the damage from termites that continually devour his hut. At the time of our visit the plumb bob indicated an alarming tilt to the hut, suggesting it was time once again for Alexander to rebuild.

Alexander is a keen student of wildlife on the tepuis, and he insists that on his 1955 expedition to Auyan he encountered three dinosaur-like lizards. Over tea in a corner of his garden he told us he had come upon them while searching for diamonds in one of the rivers on top of Auyan-tepui.

Gripped by "tepui fever," the author joined six expeditions to the region between 1984 and 1988. On the first, guide José Miguel Pérez (left, far right) and Pemón Indian assistants wait out a lightning storm on Roraima. Reached in an all-day climb, it can be scaled without mountaineering gear.

Speeding tepui research, helicopters serviced this camp on Cuquenan (below). One foggy day George walked a minute from his tent and was lost in the rocky chaos for hours.

"They were sunbathing on a rocky ledge above the river," he said. "At first I thought they were seals, but when I sneaked closer, I saw they were creatures with enormously long necks and ageless reptilian faces. Each had four scale-covered fins instead of legs."

For proof Alexander rummaged through a pile of papers and came up with some drawings of the creatures that he had made at the time. To me they resembled plesiosaurs, marine reptiles that became extinct 65 million years ago.

Alexander had drawn the creatures to scale, indicating a length of slightly less than three feet. "The length is important," he explained, "for if any of these prehistoric reptiles have survived, they

would have to be small ones that could adapt ecologically, rather than giant dinosaurs that everyone still hopes to come across."

Some scientists think Alexander saw a large species of tropical otter that has a long neck. But Armando points out that rivers on Auyan-tepui are not known to contain fish—the otter's principal food—and thus it is unlikely that otters would exist there.

Leaving Alexander, we reached the base of Auyan-tepui the next day and camped beneath sheer rock walls that disappeared above

us in a canopy of cloud and fog. Nearby a gossamer waterfall descended softly from the heights. I was lulled to sleep by the sound of the nearby river.

THE NEXT MORNING the waterfall shimmered silver against the rose quartz of the rock wall, but its source still lay hidden in clouds far above. This was the great Salto Ángel, or Angel Falls, the world's highest falls, which plummets in two leaps 3,212 feet down the escarpment of Auyan-tepui.

Angel Falls is named not after some heavenly being but after Jimmy Angel, a U. S. bush pilot who came across the falls by accident in 1935 while searching for a gold-rich river he had once visited with a mining engineer. In his book about the tepui region, *Devil Mountain*, L. R. Dennison quotes Jimmy Angel on the experience. "I was in Panama. . . . broke, as usual," Angel says, "and wondered just what I was going to do next. While I was sitting in the hotel lobby . . . an old fellow came up to me and asked if I would fly him to Venezuela. . . . I flew this old fellow to a mountain nine thousand feet high in the Gran Sabana country of Venezuela. . . . That mountain is a hell of a place to land a plane. . . . but I landed right where the engineer told me to, by a little stream, and in three days we took seventy-five pounds of gold out of the gravel. We could have taken more, but I was afraid to put too much extra weight in the plane."

In the years afterward Angel sought many times to find the mountain and the stream again. He never did, but he is immortalized by the mighty cataract that today bears his name.

That morning beside Angel Falls a helicopter arrived from Caracas to shuttle our team and supplies up to the plateau of Auyan-tepui. Volkmar Vareschi and I were assigned to the first flight, and we buckled in behind the pilot, Raúl Serrano. As we climbed in a tight spiral beside the falls, the forest below became an immense mosaic in varying shades of green.

At first glance Auyan-tepui seemed far more hospitable than the bleak and jagged surface of Roraima. The area where we landed was mostly moor and swamp, with scattered "islands" of bushes and small trees here and there. We quickly unloaded the helicopter,

The glistening leaves of Drosera roraimae *lure, trap, then digest small insects and spiders. Dead leaves skirt this six-inch-tall specimen on Auyan-tepui. Commonly known as sundews, about a hundred drosera species inhabit nutrient-poor soils around the world. Seven are endemic to the tepui region.*

FABIAN MICHELANGELI

National Geographic, May 1989

"A rain desert," author George called this bleak corner of Auyan-tepui. The rapid runoff of torrential storms sweeps soil from this sea of rock, where an island of lichens and mosses (below) anchors a colony of Brocchinia reducta. *These bromeliads endure both intense solar radiation and cool, humid conditions. Deprived of nutrients from soil, they catch their own, digesting insects that fall into the water in their throats. Bromeliads are a wide-ranging tropical family, but only on tepuis have they displayed this carnivorous behavior.*

Unique to the tepui region, five species of carnivorous sun pitchers thrive in more sheltered, boggy stretches of the mesas. On Aracamuni, about 375 miles southwest of Auyan-tepui, Heliamphora tatei *(bottom left) attracts insects with its red nectar gland. Walking into the pitcher on downward pointing hairs, victims slip and drown in the funnel. But this beetle (left) was observed to visit with impunity and even appeared to be scavenging insect bodies from the pitcher.*

and Raúl returned for another load. After pitching our team's four small tents, Volkmar and I set off to explore our new surroundings.

Along the way Volkmar gave me a short course in how to survive on a tepui in case of emergency. "Of course there is always water, thanks to the rainstorms," he said, smiling. "And food is just as plentiful if you know where to look."

He pointed to a fan-shaped plant growing at the edge of a swamp. "Its Latin name is *Stegolepis;* it's a member of the Rapateaceae family. The leaves can be pulled off and sucked just like the leaves of an artichoke. They're delicious, and Indians say they're so nutritious that you could survive for weeks on them alone. As for

CAMPONOTUS SP., 0.8 IN. (18 MM.). CHARLES BREWER-CARIAS

fire, here there's the 'tinder bush,' *Chimantaea cinerea.* It's well named, for it's so rich in resin that you can light a fire from it with a single match in a driving rain."

Not every tepui, of course, has the same types of vegetation, and there is little chance of a natural exchange among them. "Over millions of years of isolation," Volkmar explained, "each species of plant has adapted to its particular environment, not only in terms of climate but in altitude and nutrition as well. Few plants that live at this altitude and temperature could survive a natural transfer to a distant tepui through the tropical heat and climate of the lowland savanna."

After a time we returned to camp to welcome our colleagues as Raúl delivered them along with our supplies and equipment. I noted that Raúl never switched off the helicopter engine; if it should fail to start again, we would all be prisoners atop Auyan-tepui.

Raúl left us before sunset, agreeing to return each day if possible, to fly us to inaccessible parts of the great plateau. By evening we had our camp well organized, and that night the usual violent thunderstorm welcomed us to Auyan-tepui.

A DAY OR TWO after our arrival I went on an orchid hunt with Armando Subero and Gustavo Santana, both orchid enthusiasts who have discovered new species that may one day bear their names.

"Don't bother with the flashy hothouse varieties up here," Santana advised me. "You'll find orchids on Auyan with blossoms hardly bigger than a pinhead."

Fifteen years ago Volkmar Vareschi, a specialist in orchids, discovered 61 different species—some of them new to science—in an area of barely five acres on a flank of Auyan-tepui. The soil was so infertile that most vegetation could hardly survive, but the area was an orchid paradise.

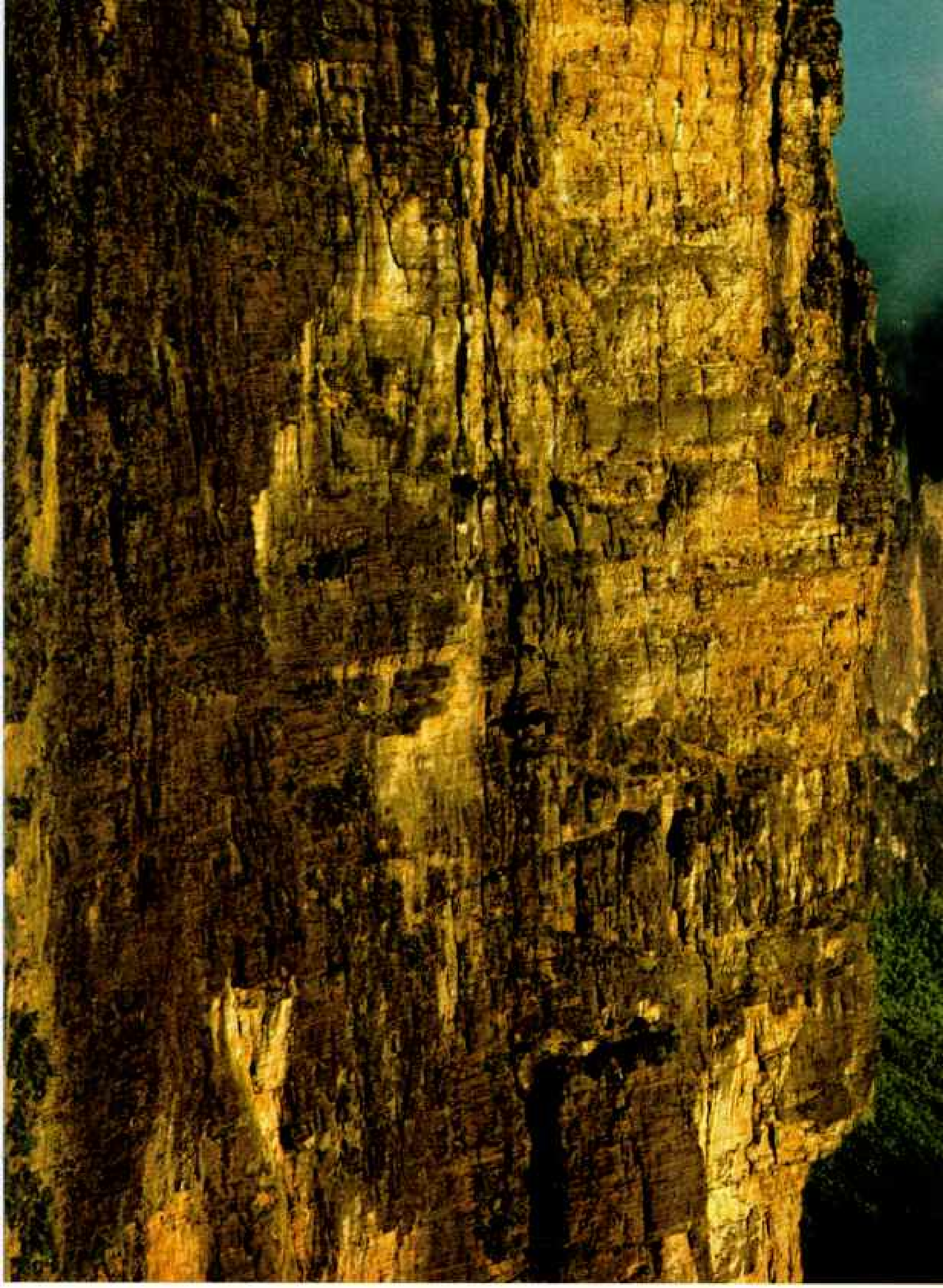
I soon learned to look for the tiny magnificence of orchids among other, far larger plants and bushes. Each orchid occupies a specific environmental niche in which it survives. This may be simply an accumulation of humus on the branch of a tree, a tuft of moss in the crevice of a rock, or some small area lit by the sun through a window in the dark crown of the forest.

Other plants on the tepuis find essential nutrients in more dramatic ways. During a walk with Fabian Michelangeli he singled out a small plant known as *Heliamphora*, or sun pitcher. The "pitcher" is a green cup with a bright red extension that attracts a variety of insects. The cup catches and holds rainwater. Insects light on the edge of the cup, enter on downward-pointing hairs, then lose their grip and fall into the water and drown. As their bodies decay, they release nitrogen and phosphorus, essential nutrients for the plant, which absorbs and digests them through special cells in the wall of the cup. Thus the cup is not only the sun pitcher's trap but also its stomach.

For all their exotic life-forms the tepuis have familiar ones as well. One morning as I walked along the edge of a swamp, something sparkled between my boots like a fiery red ruby. It was a drosera, a sundew, similar to ones I knew from childhood walks across the moors near my house in the suburbs of Hamburg. I had always been fascinated by the way the sundew attracts insects with its bright color and false promise of nectar. Once the insect touches down, the sundew's sticky tentacles slowly close around it, and the plant digests its victim. Volkmar later told me that as far as we know, seven species of sundew are endemic to this region.

One magical day I flew with Raúl and Ramón Blanco, a professional violin and guitar maker and an excellent climber, over a spectacular region in the northern portion of Auyan-tepui. The area is known as El Valle de las Mil Columnas—"the valley of a thousand columns"—but that is an understatement: There must be tens of thousands of rock towers and pinnacles there, some of them a

Only the ghost remains of an ant killed by a macabre fungus in the tepui lowlands. Preying on ants in the tropics, the fungus Cordyceps lloydii *begins its attack as a microscopic spore that penetrates the insect. Multiplying in the blood like yeast, within days the fungus digests all but the ant's exoskeleton. Transforming into cottony white filaments, the fungus fills and encases the body. Umbrella-like fruiting bodies later sprout and release spores, starting the cycle over again.*



"The setting sun once more poured over the red rocky walls of Roraima . . . a magic fire." This daily bewitchment restored the

Schomburgk brothers in 1842, struggling to dry plants in "meteorological conditions . . . far from meeting with our approval."

Flashing head feathers crown the hummingbird Lophornis pavonina—part of a genus commonly called coquettes—found in abundance on Aracamuni when the tepui was first explored in 1987. Ornithologist Miguel Lentino (below) also discovered two subspecies of flycatchers.

Orchids and the butterflies that feed on them occupy Gustavo Santana on Auyan-tepui (right). Perhaps the world's most adaptable plants, orchids compose nearly a tenth of the area's flora; some 900 species are known here.

thousand feet tall. As Raúl skillfully guided us among them, I felt as if I were flying through Manhattan at rooftop level.

As a special treat Raúl let Ramón and me off on a tower to walk around. Hovering just inches above the surface, he gestured for us to jump down, then shouted, "Only 15 minutes!" and was gone.

Our tower proved to be a roof garden in the sky, containing dozens of different species of exotic plants. A cluster of beautiful yellow orchids at the very edge of the tower caught Ramón's eye, and he insisted on collecting a specimen. There was no use arguing, so I held his ankles as he lay on the rock surface and inched his way out over the edge. He managed to get his sample, though I don't remember now what species it was. I only hope it was new to science.

Soon afterward Raúl picked us up, and we flew to an area known as Aonda Canyon. Here a mighty waterfall bursts from an opening halfway up a sheer cliff. To see where the water came from, Raúl flew to the top of the plateau. There, not far from the edge, we saw an enormous hole in the rock surface, as if it had been drilled by a giant auger.

The hole was roughly 250 feet in diameter, and Raúl decided to fly down into it. To lighten the helicopter as much as possible, he dropped Ramón and me at the rim of the hole, then started down in tight spirals. The helicopter slowly dwindled until it was no bigger than a dragonfly, and then it vanished in the darkness.

An eternity later the helicopter reappeared, and Raúl landed and picked us up.

"I went down about 600 feet in the hole," he said, "and there is a dark, dense forest at the bottom. A second waterfall pours out of the side of the hole and disappears into the forest. My guess is that that second waterfall feeds the one outside on the face of the cliff by a system of tunnels through the rock."

"Did you see any prehistoric lizards down there?" I asked, half joking. Raúl shook his head.

"No, but I wouldn't have been surprised to see them—it felt like a very primitive place."

I made one last flight on Auyan-tepui with Raúl a few days later. He took Volkmar and Volkmar's son Peter and me to a lovely green

valley threaded by a river in the eastern part of the plateau. We landed on a huge flat rock beside the river, and for once Raúl switched off the helicopter engine.

It was a marvelous, beaming day. The air was clear, fresh, and stimulating. I was intoxicated by the beauty of the valley. A violin bird was singing in a nearby forest that was thick with orchids. Hummingbirds, sparkling like precious stones, buzzed in front of my face to inspect this intruder on their world. The only other sound was the gurgle and ripple of the river over the rocks.

Cracks and crevices in the rock were filled with gold nuggets of all sizes. I reached into the cool, clear water and brought out a handful. Suddenly the treasure in my hand changed into translucent, shimmering quartz. The mahogany color of the water, produced by decayed plants, had converted the quartz to gold.

A nearby pool in the river beckoned irresistibly. I took off my sweat-stained clothes, dived in, and had the most memorable bath of my life.

Lying on the warm rock to dry in the wind and sun, I conjured up visions from the shapes of clouds overhead as I used to do in the cornfields at home. Only now instead of cloud horses and cows, I saw cloud tyrannosaurs and stegosaurs. And in place of cloud storks and cranes there were winged pterodactyls. That day I christened the valley Shangri-la.

We left Auyan-tepui soon afterward, and by way of a finale Armando Michelangeli, Raúl, and I made an aerial tour of a neighboring group of tepuis known as the Aparaman Range. These tepuis are largely unexplored because they are almost always draped in cloud cover. Six months earlier a group of scientists and explorers had landed here, but they stayed only a few days before the weather forced them to leave.

Tinted by decayed leaves, a creek on Auyan-tepui lures Ramón Blanco to search for aquatic specimens. A new genus of aquatic cricket was discovered here in 1984. Acidic and nutrient-poor, tepui streams support little more than algae, mosses, and insects. A violin and guitar maker, Blanco lends his other talents as a collector and mountain climber to the Terramar Foundation, a Venezuelan association promoting tepui conservation and research.

WE WERE LUCKY, for it was December, in the dry season, and we were able to see a good bit of the range, including the billowing plumes of a dozen waterfalls plunging nearly half a mile down a sheer rock wall into an olive-hued forest. As I looked out at the spectacular view from the seat beside Armando, my tepui fever shot up another ten degrees.

In fact it was only four months later that Armando and I set foot

on Aparaman-tepui. He had organized another Terramar expedition with several of the same people from the Auyan-tepui project, including the incomparable Volkmar Vareschi.

Raúl Serrano was not among us for that trip. And to the great sorrow of us all, he was killed only months later in a helicopter crash near Auyan-tepui. The loss was especially tragic, for Raúl was not piloting the helicopter at the time. Had he been, I feel somehow he would still be alive.

Altogether we spent eight days on the Aparaman Range, exploring and gathering samples of plant and animal life. As usual we found many new species of plant life, and Volkmar spent long

hours sketching them in his journal. From these he would later draw the precise and beautiful profiles of plant communities for which he is known throughout the botanical world.

"The tepuis give us an entirely new perspective on ourselves," he told me one day, as I watched him sketching a group of orchids. "For example, out of approximately 2,100 species of plants in the British Isles, some 1,500 species are native. The other 600 species, or 30 percent, were introduced deliberately or by accident.

"By contrast, the tepuis' summits are among those rare places left on earth where 100 percent of the plant species are native. We humans, who increasingly dominate the earth, need standards by which to judge what we are doing to our environment. The tepuis offer priceless insights into that process."

ON OUR WAY back from Aparaman we stopped at Auyantepui to visit the valley I had called Shangri-la. Here I would have my most memorable adventure in the bizarre world of the tepuis. It occurred while Armando and I were exploring the river there. In places it disappeared among boulders as large as houses and into which it had carved sizable caves. Now, in the dry season, most of the caves were above river level. While Armando explored outside, I entered one of the caves to see what I could find.

Though I had no flashlight, I could see well enough by light coming through gaps in the rock overhead. The floor of the cave was covered with white sand that had been washed in by the river. As I made my way along, I noticed a peculiar, pungent odor coming from somewhere in the cave. At length the light began to fade, and I turned back to the entrance. As I neared it, I noticed a number of large paw prints in the sand and some smaller ones too. I was sure they hadn't been there when I entered the cave.

As I emerged from the cave, Armando was shouting and waving. "I thought you'd had it," he said. "Just a moment ago a mountain lion and two cubs came out of the cave. They saw me and ran off, but I was sure you'd met up with them inside and were in trouble."

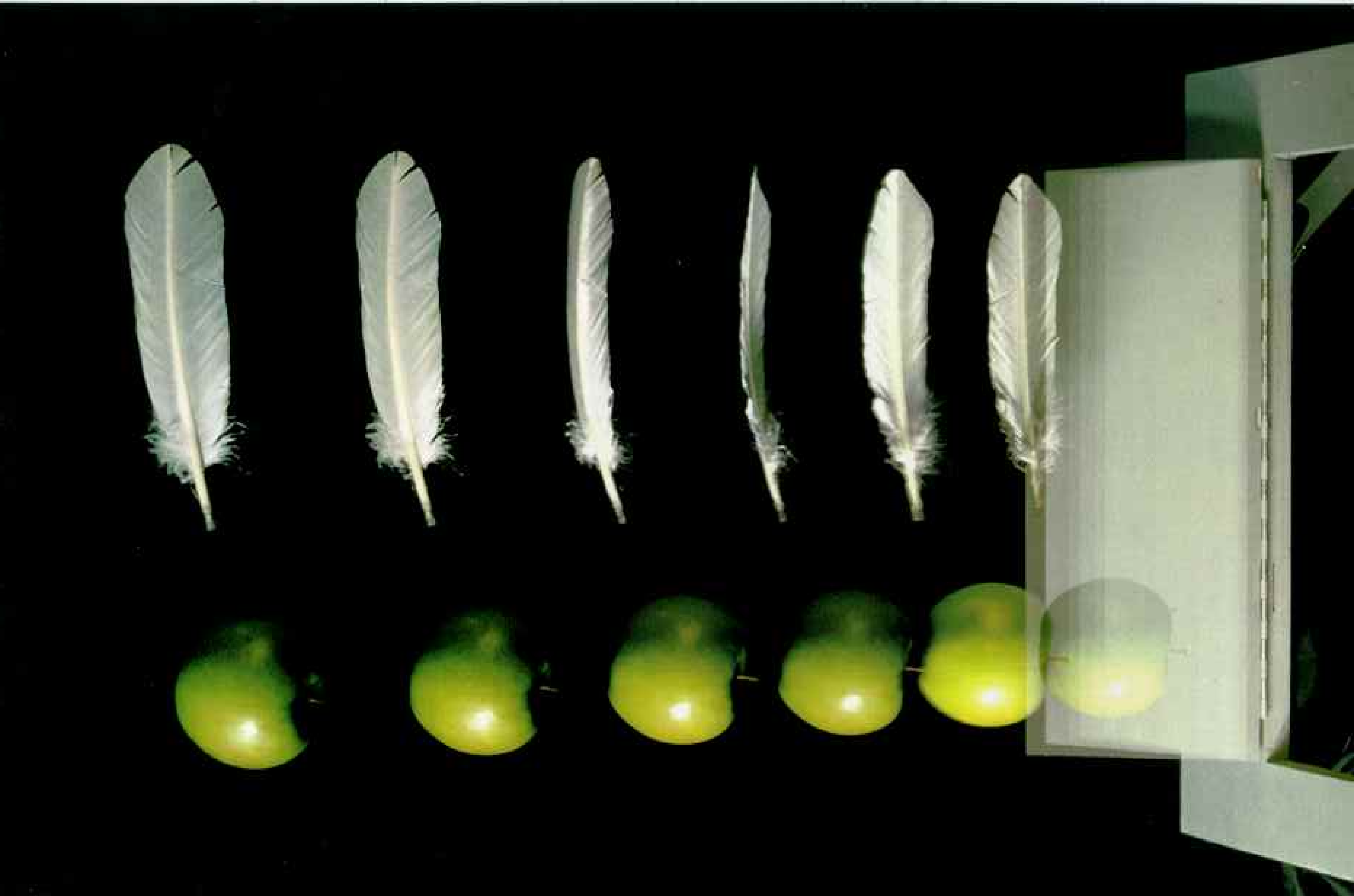
Looking back on it, I realize I must have passed the three lions in their lair in a side chamber or corridor off the main tunnel. If I had seen them at that moment, the lioness would doubtless have taken it as a threat, and indeed I would have been in trouble.

What fascinated Armando and me was the existence on Auyantepui of mountain lions, which had never been seen there before. The classic prey of the mountain lion is the lowland tapir, which also has never been seen on a tepui and which, unlike the mountain lion, could never climb up or down the steep inclines. But a few months later several Terramar scientists came across some three-toed footprints in a dried mudbank of Shangri-la valley. The footprints strongly resembled those of the lowland tapir, whose actual discovery on top of a tepui would be noteworthy, but not as much of a scientific sensation as the existence there of a prehistoric lizard.

Only a well-organized and long-term expedition could make such a discovery. If anyone could do it, it would be Armando and Terramar. I can feel my tepui fever rising again. □

Scars of waterfalls past score 7,000-foot-high Aparaman-tepui during the dry season (above). In 1987 author George became the first to stand on its summit. Exploring the crevices of its jumbled surface (left), Bruce Holst of the Missouri Botanical Garden discovered a new bromeliad.

Collection and analysis of tepui flora and fauna is an ongoing odyssey. Notes tepui entomologist Paul Spangler: "Many of the experts who will study and classify these materials are not yet born."



Searching for the Secrets of GRAVITY

By JOHN BOSLOUGH
Photographs by JAMES A. SUGAR BLACK STAR

EPHRAIM FISCHBACH's problem was snakewood. It was late 1985, and Fischbach was on to something. If right, it would be one of the biggest discoveries in science since Isaac Newton saw an apple fall, then explained why.

Fischbach, a theoretical physicist at Indiana's Purdue University, believed he had found a natural force counteracting gravity. He knew it was preposterous—only fantasy or science fiction. But if it existed, it could force us to reevaluate our view of the universe.

To help prove his discovery, Fischbach had to know how gravity affected snakewood. But he had no idea what it was or where to find it.

Fischbach was treading dangerously. Gravity, in a sense discovered by Newton three centuries ago, is a cornerstone of modern science. Newton's *Principia*, often called the greatest scientific book of all time, laid out the mechanics of gravity and, consequently, of the entire known universe.

As the force that attracts conglomerates of matter to one another, gravity has a limitless pull. It keeps the moon orbiting the earth, the earth in place around the sun, and our solar system within the galaxy, orchestrating the universe in a cosmic life-and-death dance.

Of the four known natural forces, gravity was the first seen but is the least understood. The others are electromagnetism, which we know as electricity, magnetism, and light; the strong force binding atomic nuclei; and the weak force causing radioactive decay.

ADAM WOOLFITT

Though gravity rules the universe, the other forces are trillions of times stronger. Take any kitchen magnet, for instance. Its electromagnetic field is stronger—over a space of a few inches—than the earth's entire gravitational field. Earth's gravity field is so weak that when you pick up a rock, your muscles are easily overcoming the pull of the planet's entire 6,000,000,000,000,000,000,000,000 kilograms (6.6 sextillion tons).

THOUGH FAMILIAR as a falling apple, gravity remains the least understood force in nature. Dropping through a vacuum, a feather and an apple fulfill Galileo's bold prediction of 1638: All objects fall at the same rate of acceleration. Or do they? Purdue University physicist Ephraim Fischbach (above) and others suggest that a previously unknown force may counteract gravity, making objects fall at different rates.

JAMES A. SUGAR, WITH KEVIN SCHUMACHER AND LARRY D. KINNEY, NGS STAFF (LEFT)

How gravity works

Bricks fall. Tides surge in. Planets circle the sun. Why? Because objects attract each other—a revolutionary idea proposed in 1687 by Sir Isaac Newton, who defined that attraction with precise, orderly equations. Newton, however, failed to explain all the effects of gravity on a cosmic scale. When Albert Einstein extended our knowledge in 1916 with his general theory of relativity, the universe took on a bizarre and unsettling look. But his approach—which certifies Newton's as a good approximation in most cases—proved so complex that it is seldom used. Thus Newton still gets us both to the refrigerator and to the moon.

1

In Einstein's theory, gravity is not a force that acts between objects but a property of space itself, which includes the fourth dimension, time. Matter warps—or curves—"space-time," causing what we experience as gravity. Mind boggling? Yes, even to most physicists. One way to visualize gravity's effect is to squeeze space-time into a two-dimensional rubber sheet. Heavy objects—matter—make dimples in the sheet.

2

The curvature of space-time produces its greatest effects around objects with the most mass, such as the sun or other stars.

Roll a billiard ball along the sheet in the general direction of a dimple, and it will dip toward the dimple and roll away at a different angle. In the same way, the path of any form of matter or energy—including light—will bend as it passes through the gravitational field of a massive object.

Just as a ball circles endlessly within a dimple on the frictionless sheet, a planet or satellite orbits a massive object.

When a star runs out of nuclear fuel, it can collapse under its own weight. As if stretching the sheet to infinity, gravity intensifies unimaginably, crushing atoms and trapping any matter or energy that enters. From such a black hole, not even light can escape.

3

At the heart of general relativity lies a profound insight. The effects of gravity and acceleration are equivalent. In empty space (A) the lack of any gravitational field means that you feel weightless if your spaceship is coasting at a constant speed (B), but you experience a sensation exactly like gravity if your ship suddenly accelerates (C).

A

D

Exploding stars and other violent cosmic events are thought to flood the universe with gravity waves. Rippling through space-time at the speed of light, they briefly disturb everything in their path. Too weak to detect so far, these waves create distortions smaller than the diameter of a single particle inside an atomic nucleus.

B

E

4

Within earth's gravitational field (D) you feel the effect of gravity by just standing still on a fixed surface (F). To experience weightlessness, you would have to free fall like a skydiver, who feels only air resistance (E).

With this equivalence principle and his generalized theory, Einstein transformed our understanding of the universe and its origins. Yet his theory has not been integrated with quantum mechanics, the mathematical language for theories of the other fundamental forces of nature, and Einstein died searching for a still elusive unified theory.

C

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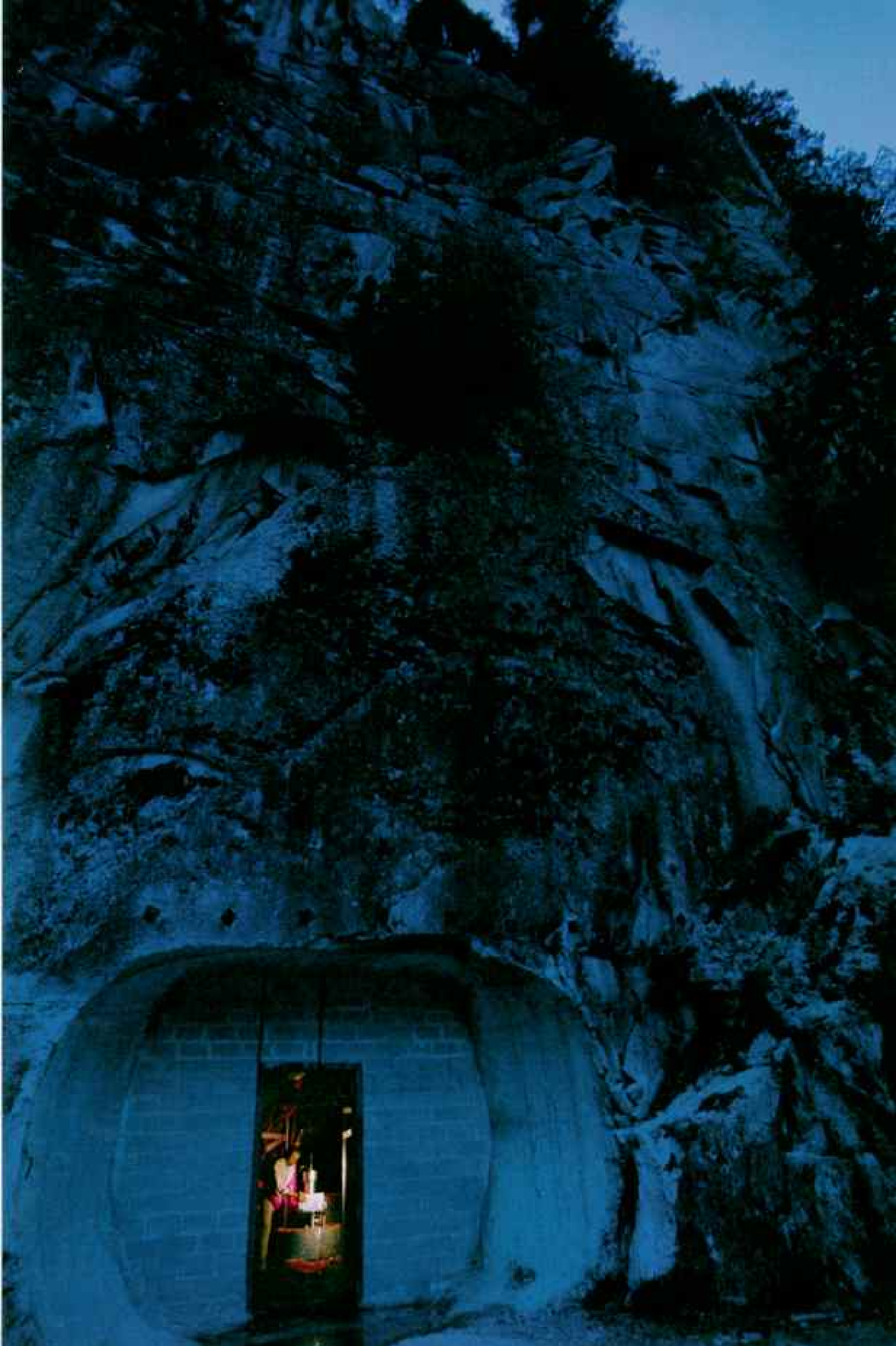
F



Gravity, too, is the only force man cannot control. We can increase, decrease, and sometimes even reverse the others. But not gravity. It cannot be reflected, stopped, or slowed. It always attracts, never repels.

At least until Ephraim Fischbach.

The idea of antigravity first crept—maddeningly—into Fischbach's mind in 1979. He and another physicist, Samuel Aronson, were studying findings from an atomic accelerator—or atom smasher—when they came upon a set of results they could not explain.

In seeming defiance of gravity, particles called kaons were behaving strangely in the accelerator. Says Fischbach: "We thought of every possible explanation. Nothing worked. Finally on Halloween night we decided it could only be a new force—a fifth force."

If true, it was a Nobel Prize finding. Yet they were so cautious that they put the fifth force on hold for six years. Meanwhile they reexamined gravity experiments of the past.

GRAVITY has always occupied the best minds, including Galileo Galilei, the extraordinary 17th-century Italian who was the first modern scientist. Before Galileo, it had been assumed—largely from a dictate of Aristotle—that gravity causes a heavy object to fall faster than a light one. Aristotle had confused the effects of gravity's pull with the distance something could be propelled: You can throw a small rock farther than a big one, so the big one must fall faster. Galileo decided to see what actually happens. In Pisa, where he was born, I climbed the worn steps of the tower that has been leaning southward almost from the day it was built in the 13th century. Nicolò Beverini, a University of Pisa physicist whose specialty is gravity, climbed with me.

"Galileo probably never dropped cannon balls or anything else from this tower," said Beverini, standing uneasily on one of the precarious, slanting balconies. "He may have thought about it, but he didn't write about it."

Instead, he rolled balls of different weights down and up inclined planes. "These ramps slowed them, making gravity's effect directly observable," said Beverini.

Galileo found that all objects, no matter what they're made of, fall at the same ever increasing rate. Thus, if air resistance is ignored, a cannonball and a wooden ball dropped simultaneously will strike the ground at the same time.

This conclusion seemed to be reinforced by experiments conducted early this century by Baron Roland von Eötvös, a Hungarian who measured the effect of gravity on various test materials and found virtually no differences.

UP IN THE AIR over gravity, U. S. Air Force researchers measure variations in its strength as they climb a 600-meter (2,000-foot) TV tower near Raleigh, North Carolina (right). Their results hint at the existence of a subtle force acting, oddly enough, to boost gravity, a finding that may improve the accuracy of long-range missiles.

University of Washington's Paul Boynton measures how different materials respond to the attraction of the granite mountain behind him. So far, no one can explain the anomalies unearthed.

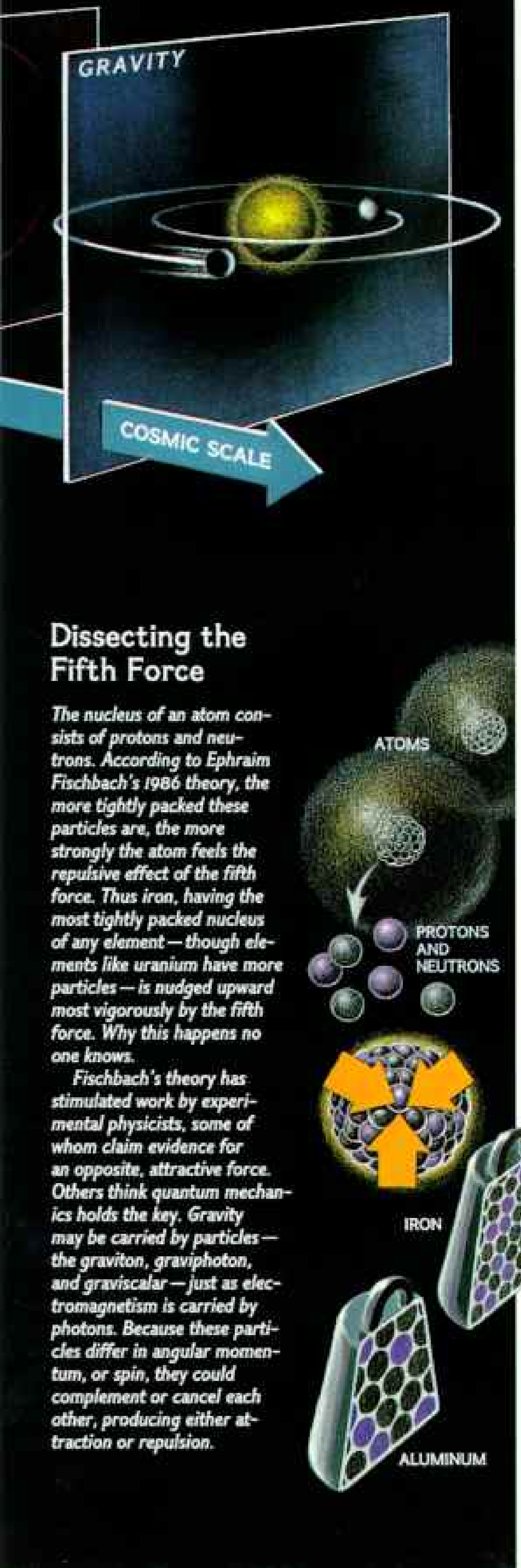
Glimpsing a possible fifth force

Until recently scientists thought that all events in nature could be explained by four basic forces: the strong force, which binds together atomic nuclei; the weak force, which causes radioactive decay; electromagnetism, which gives us light, heat, and microwave ovens; and gravity. The first two operate only on the subatomic scale, the latter two along the entire range from protons to galaxies.

Some physicists, however, now report occurrences in which gravity appears to act differently than Newtonian formulas predict, leading them to speculate upon the existence of a fifth force. Two weights in a vacuum are supposed to fall at the same rate, no matter what their composition. But these scientists say that a subtle new force makes an iron weight fall more slowly—to an extremely small degree—than an aluminum one, because iron's atomic nuclei are more tightly bound.

This theory, which seems to flout our common sense, has met with skepticism from other physicists, who argue that anomalies reported so far can be explained either by other, known factors or by limitations of measuring devices. Even proponents acknowledge many uncertainties. The force they seek to measure is thought to operate between objects only over a range of about ten meters to a few hundred kilometers (30 feet to, say, 200 miles) and to be one-hundredth the strength of gravity, itself trillions of times weaker than nature's other fundamental forces.

PAINTING BY WILLIAM H. BOND



Dissecting the Fifth Force

The nucleus of an atom consists of protons and neutrons. According to Ephraim Fischbach's 1986 theory, the more tightly packed these particles are, the more strongly the atom feels the repulsive effect of the fifth force. Thus iron, having the most tightly packed nucleus of any element—though elements like uranium have more particles—is nudged upward most vigorously by the fifth force. Why this happens no one knows.

Fischbach's theory has stimulated work by experimental physicists, some of whom claim evidence for an opposite, attractive force. Others think quantum mechanics holds the key. Gravity may be carried by particles—the graviton, graviphoton, and graviscalar—just as electromagnetism is carried by photons. Because these particles differ in angular momentum, or spin, they could complement or cancel each other, producing either attraction or repulsion.

Three-quarters of a century later Ephraim Fischbach and Samuel Aronson took another look at the baron's findings.

What they saw was startling. Said Fischbach: "The Eötvös tests actually showed that objects fall at slightly different rates according to their atomic makeup—the more tightly packed the atomic nucleus, the slower the fall. Eötvös's colleagues published the results after he died. They ignored the differences as statistically insignificant."

Fischbach's group analyzed the test materials of the original Eötvös experiments—asbestos, tallow, copper, water, and platinum. But they could not find one material: snakewood.

"We needed complete results," said Fischbach, a personable Brooklyn native. "But what was snakewood? We knew it was a dense, tropical wood—nothing more."

Fischbach sent inquiries to chemists and lumberyards, to South America and to Hungary. No luck. One day he read that 19th-century violin makers used snakewood for bows. He started contacting musicians.

At last in Seattle he found his man: Alexander Illitch Eppler, a balalaika player of Russian descent. By luck, Eppler had a supply of aged snakewood for making his instruments.

"He even had a piece he could trace to Budapest in the 1890s," said Fischbach. "We analyzed its composition. It fit just right."

ABOUT THE SAME TIME, data from an Australian mine was adding credence to the notion of a fifth force. Geophysicist Frank Stacey and colleagues at the University of Queensland had used a sensitive meter to measure gravity at different depths.

The deeper Stacey went, the stronger the pull of gravity became, simply because they were getting nearer to the earth's center of mass. Stacey expected this. But he detected something else: a force opposing gravity, with about one percent of its strength and a range of a few hundred meters.

Other measurements in boreholes and mines elsewhere have substantiated the

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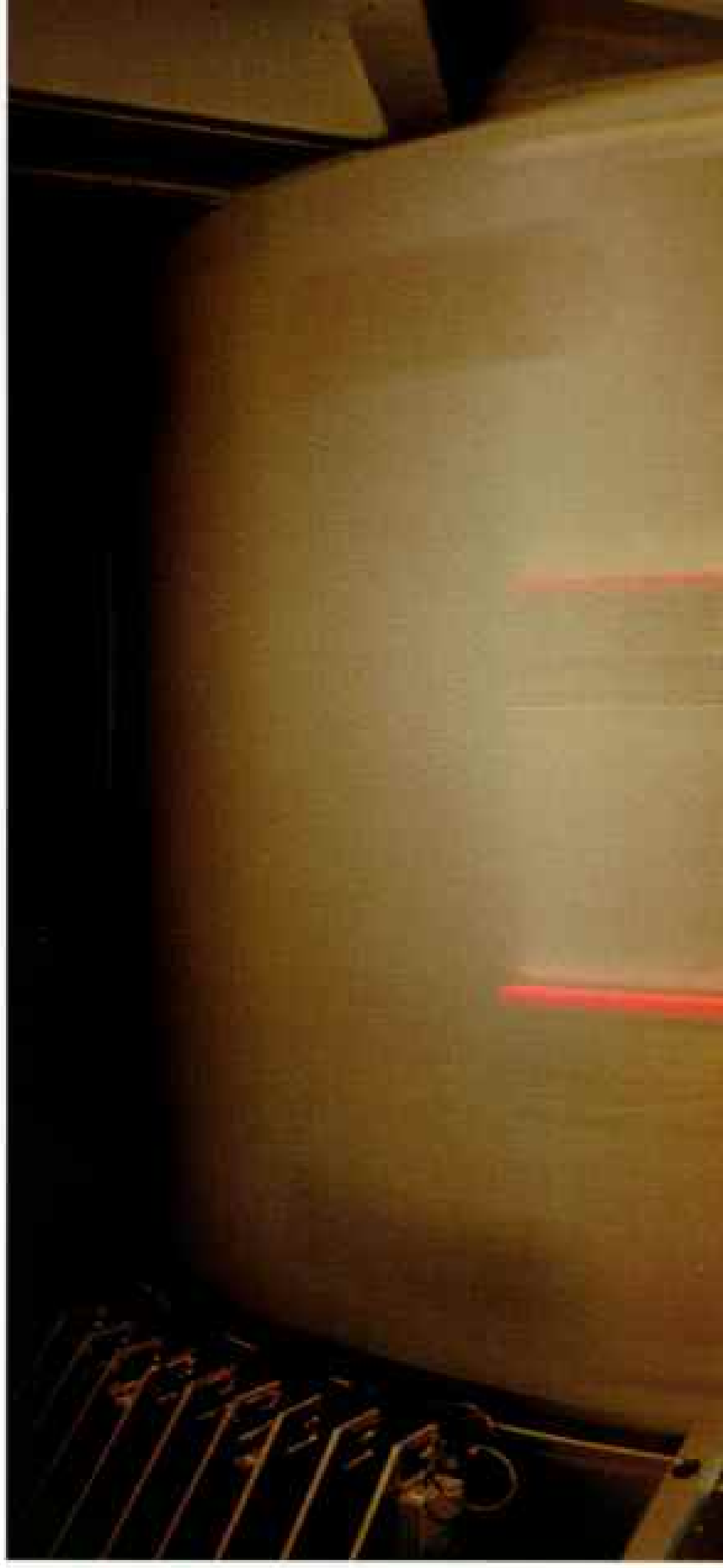
Science writer JOHN BOSLOUGH guided GEOGRAPHIC readers through the arcane realm of particle physics in the May 1985 article "Worlds Within the Atom." He is author of the book *Stephen Hawking's Universe*. Veteran photographer JAMES A. SUGAR has photographed 17 articles for the magazine, three of which he authored.



OUT FOR A SPIN, a blindfolded subject buckles up in the rotation room at Brandeis University near Boston (right). The NASA-sponsored research suggests that astronauts may avoid motion sickness by gradually increasing revolutions per minute over time. At the University of California at San Diego a researcher hangs upside down to test lung function, expanding knowledge of earthly diseases as well as of space hazards.

Queensland result. "This has to be taken seriously," says Stacey, who has emerged from his mine shaft as something of a fifth-force guru.

Some physicists are calling the new discovery the "hypercharge force." Hypercharge is the number of protons and neutrons in a nucleus—different for each element. An attraction called binding energy, or the strong force, holds these subatomic particles together. And in the topsy-turvy world of the atom, binding energy can have mass of its own.

Binding energy could be the key to the antigravity force. A ball of iron, with high binding energy, could receive a strong antigravity lift and fall slightly slower than a snakewood ball of equal weight. According to Fischbach, Galileo may have been dead wrong.

Naturally this heresy has generated monumental controversy within physics circles, inspiring hundreds of researchers around the world to try to trap the elusive force.

Still, an answer may not come easily. Says Princeton's Robert Dicke, an eminent physicist: "Few experiments are simpler in principle, harder to put into practice, and so far-reaching in implication."

One way to test the theory is simply to repeat the Eötvös experiments with modern equipment. The first such experiment was carried out by Peter Thieberger, who floated a copper sphere in a tank of water to search for the fifth force. Paul Boynton, a University of Washington physicist, fashioned weights of beryllium and aluminum and suspended them next to an immense granite wall in the Cascade Range.

JAMES A. SUGAR, WITH GEORGE VON KANTOR, NGS STAFF

"The idea is to see if the cliff's mass pulls differently on the two bodies," he said.

Boynton and his colleagues detected variations but are still working to see if the fifth force is the cause.

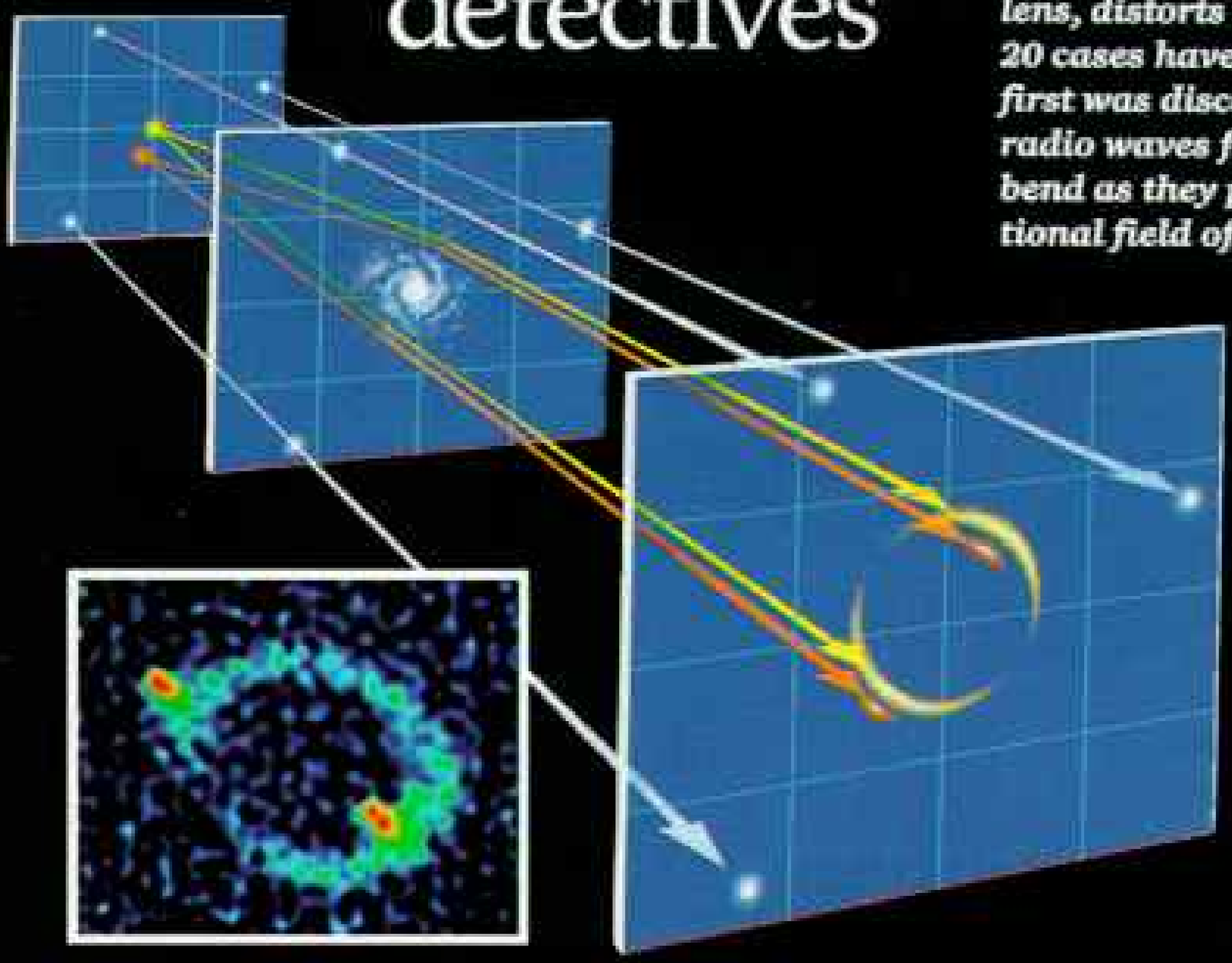
British geophysicists Keith Runcorn and Bob Edge ran an experiment at a reservoir in Wales aimed at pinning down the fifth force by measuring the gravitational pull of the water as the reservoir emptied and filled.

"We were definitely surprised," said Edge, an expert in measurement of tidal changes. "Early results showed that the water's gravitational attraction deviated about 5 percent from the expected. Like everybody, we're worried we've missed something."

Donald H. Eckhardt, a geophysicist at the U. S. Air Force Geophysics Laboratory in Bedford, Massachusetts, is more sure of his results. He and his colleagues went up a North Carolina television tower nearly 600 meters high, measuring the pull of gravity.

His group found a "significant departure" from normal gravity, said Eckhardt at a recent meeting of physicists in Perth, Western Australia. The scientists had gathered from around the globe to try to sort out the fifth force and other gravity-related problems.

Cosmic detectives



Astronomers today look for chance alignments of objects in which the closer one, acting as a gravitational lens, distorts the other's image. Some 20 cases have been reported since the first was discovered in 1979. Light and radio waves from a distant quasar bend as they pass through the gravitational field of a galaxy (diagram, left). Near alignment (orange) may produce multiple images; perfect alignment (yellow), an "Einstein ring." One such ring, named MG1131+0456 (inset), was found in 1987. More than optical illusions, these lenses may help focus our picture of the universe.

Mark Ander of the Los Alamos National Laboratory in New Mexico and Mark Zumberge of the Scripps Institution of Oceanography in La Jolla, California, led a team that braved sub-zero temperatures and blizzards in Greenland. There they lowered a sensitive gravity-measuring device down a 2,000-meter hole bored through ice at a site dubbed Dye 3.

The results stunned the Perth group. The Greenland team found a "very large anomaly," suggesting something other than ordinary Newtonian gravity. Further, the "force" was dead opposite to that found by other experimenters: it actually *increased* gravity's strength. Several months later the two Marks announced that their results needed more thinking—that anomalies in the earth's crust may have affected the measurements.

Other seekers of the fifth force have encountered disappointing results. University of Washington physicist Eric Adelberger did an experiment similar to Paul Boynton's. He found absolutely nothing at all. James Faller at the Joint Institute for Laboratory Astrophysics in Boulder, Colorado, compared the falling rate of masses of unlike composition, à la Galileo. Faller also came up empty.

Indeed, there seem to be as many detractors as experimenters. I first met one, theoretical physicist Alvaro De Rújula, a blue-eyed Spaniard, at the European Laboratory for Particle Physics (CERN) in Geneva, in 1986. "In a few years, this fifth-force rubbish will be gone," he predicted.

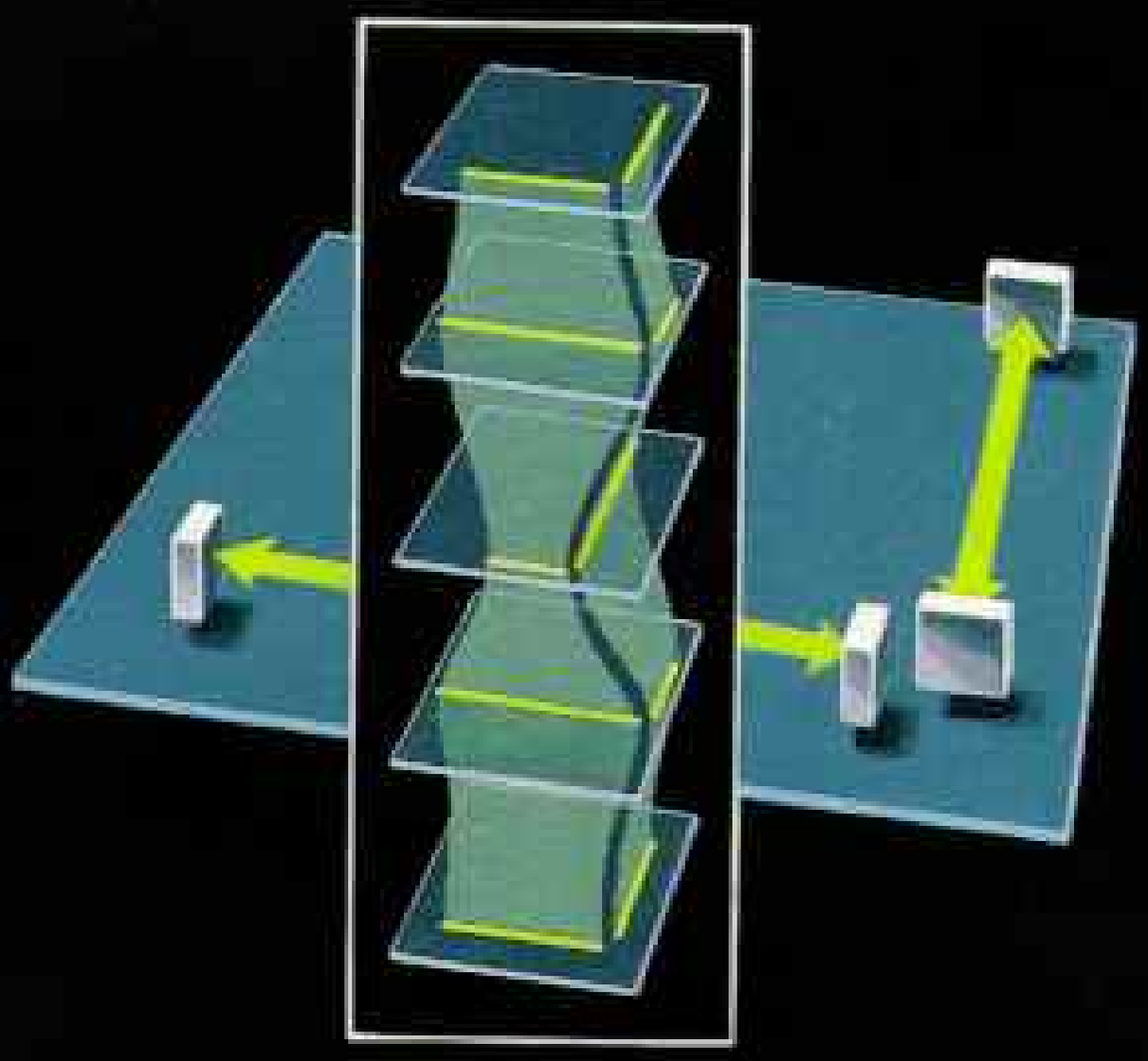
Two years later his criticism was more subdued. "In the absence of any two experiments with the same results, we can't really say anything scientific about it yet," he said. Princeton's John Wheeler, a leading theorist, was more adamant. "I think the fifth force will prove to be a flash in the pan," he told me.

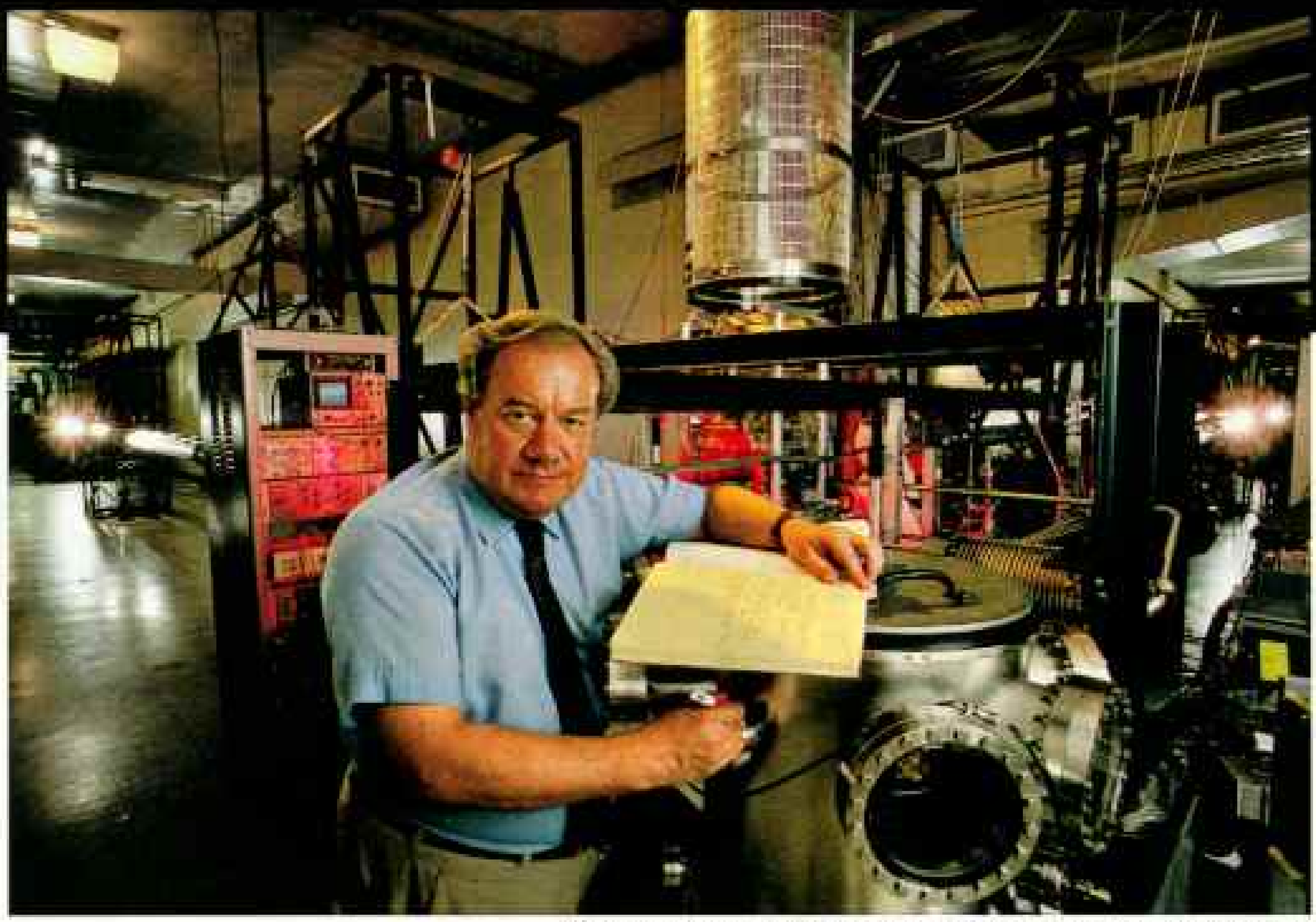
EVEN EXPERIMENTERS with positive findings still recoil from tampering with the work of Isaac Newton, one of the greatest thinkers in history by anybody's account.

Born in 1642, the year Galileo died, Newton was a man of almost terrifying powers of concentration. While still an undergraduate at Cambridge University, he invented the mathematical system of calculus—later to prove essential to understanding gravity.

Years later the German mathematician

Do exploding stars create gravity waves, as Einstein predicted, causing objects on earth to jiggle imperceptibly? Yes, most scientists would say, but no one has yet found proof. Armed with the world's largest wave detector, Ronald Drever of Caltech (below) remains confident. This prototype (diagram, right), which can measure movements one-millionth the diameter of an atom, bounces laser light (arrows) between weights suspended within pipes 40 meters long. A wave passing over the instruments, as in this time sequence, foreground, would move the weights slightly, lengthening and shortening the paths of light.





JACQUELINE HEWITT, MIT HAYSTACK OBSERVATORY (FAR LEFT); DIAGRAMS BY WILLIAM H. BOND

Gottfried Wilhelm Leibniz developed a similar system, and Leibniz's supporters claimed his was better. Swiss mathematician Johann Bernoulli set out to resolve the dispute by publishing two problems requiring calculus.

After several months Leibniz had solved but one. When Newton received the problems, he solved both within 24 hours, submitting the results anonymously. Bernoulli then declared: "The lion is known by his claw."

At the time, it was generally accepted that the planets and moons were carried around their orbits by vortices in an invisible "ether," a favorite theory of the French philosopher Descartes. Newton wondered about this.

During an 18-month stretch before he was 24, he worked out the laws of motion and universal gravitation, showing that the force pulling the apple down and the force keeping the moon in orbit were one.

Newton's law of gravitation, universally accepted by scientists even in the face of a fifth force, showed that any two objects attract each other at a rate directly proportional to

WITH AN UNFETTERED MIND in a body shackled by Lou Gehrig's disease, Cambridge University's Stephen Hawking (right) leads the search for the holy grail of physics: a unified theory of the universe. Looking on from his death mask, Sir Isaac Newton (below) would surely approve. His 1687 Principia, which defined the laws of gravity, launched scientists on the quest.

their masses and inversely proportional to the square of their distance apart. An object ten times closer feels a pull not ten times but a hundred times greater.

And his mathematical invention, calculus, explained why the apple falls straight down—instead of, say, sideways toward a nearby mountain or building: All the gravitational mass of the earth pulls toward a single point at the planet's center, overwhelming the minuscule pull of other objects.

Newton's *Principia*, written with abstruse mathematics to keep away "little smatterers," was published only by chance. Nearly 20 years after Newton first explained gravity, England's astronomer royal, Edmund Halley, visited him for help calculating planetary orbits. Newton had already done the work but had lost the calculations. He did them again on the spot. Realizing the value of the research stuffed in Newton's desk, Halley himself paid to have the material published in 1687.

"I really believe he did see the apple fall," said Professor Rupert Hall of London's Imperial College, a leading Newton scholar. "He confirmed it at least twice."

History's second most famous fruit tree—or at least what may be a graft on the stump of the original, which blew down in 1820—stands at Woolsthorpe Manor, Newton's birthplace, a short drive from London. And it still produces a small, foul-tasting apple.

For Newton gravity was a sort of cosmic cat's cradle—a combination of forces from every star and planet tugging and pulling at every other celestial object across the chasms of space. This concept may, surprisingly, remain intact even with a fifth force.

"Since the fifth force is so weak and its range limited to a few hundred kilometers,

our planetary calculations will still follow Newton," says Fischbach.

EVEN IF THE FIFTH FORCE outflanks Isaac Newton on the wings of the superprecise technology of today, it will still have to contend with Albert Einstein, another of history's great thinkers.

In 1916 Einstein modified Newton's *Principia* with general relativity. While Newton's universe was clocklike and stately, Einstein's was strange and unsettling. Gravity was not a simple pull, but the very architecture of the universe itself. His universe was a single vast bed of gravity, not a hodgepodge of billions of attractive forces.

According to Einstein, in a perfectly uniform universe—one containing no matter—there would exist only time and a vast sheet of space, representing the possibility of gravity. Gravity would not yet exist. But if you put matter, say a star, into this universe, you would distort the sheet of space-time, like setting a cannonball on a taut sheet of canvas. This dimpling effect is gravity.

"From the point of Einstein's general relativity, it is easy to say that gravity is not a force at all," says Roger Blandford, an astrophysicist at Caltech. "It's simply the normal behavior of matter in space-time."

In terms of general relativity, then, gravity is simply a curvature caused by material objects in space-time. The universe itself, a machine fueled by gravity, is a consortium of the curvatures caused by all celestial objects pushing against the canvas of space and time.

It's a difficult mental image, admits Blandford: "The metaphor of the cannonball on canvas leaves out the dimension of time so crucial to Einstein."

THE GLORY of general relativity, one of the most powerful scientific statements of all time, is that it made predictions that Newton did not. According to Einstein, gravity, when strong, slows time and bends space. In 1919 astronomers found that the tremendous mass of the sun curves space just enough to slow light traveling through it, thus accounting for the apparent displacement of a star on the far side of the sun—as an oar seems to bend in water.

Physicists today think gravity played a major role in shaping the universe during its infancy, when matter, drawn to other matter by gravity, coalesced into stars and galaxies. Some physicists think gravity ultimately could cause the end of the universe, too, if its current expansion eventually reverses itself in a massive gravitational contraction.

Gravity is responsible for the strangest beast in the cosmic menagerie. "A black hole is a creation of gravity," said Stephen W. Hawking, a general relativist who holds Newton's old chair at Cambridge University.

"Newton first posited the idea of escape velocity," Hawking told me in his office in a back-street building that seemed ancient enough for Newton himself to have occupied. "And a black hole is an object so dense that the speed required to escape its gravity is greater than that of light."

According to Einstein, during a cataclysmic event in space like the birth pangs of a black hole, waves of gravity should swarm back and forth across the field of space-time—as an earthquake sends shock waves through the earth. Elaborate gravity-wave detectors have been placed around the globe to pick up these ghostly signals from space, though none have yet recorded an unambiguous signal.

Because of Newton and Einstein, scientists today can measure gravity's effect with precision. Still, nobody knows exactly what drives gravity—what makes it happen.

Quantum mechanics, a mathematical system developed in the 1920s and '30s, describes in great detail how nature's other three forces work. Unfortunately, this leads to a paradox. General relativity says that any large object—a star, a planet, a football—acts in an entirely predictable manner. In general, quantum mechanics merely makes statistical predictions for the behavior of subatomic matter. This means that there are different rules for these two realms.

Einstein could not abide the randomness of quantum mechanics. God does not play dice with the world, he declared. He spent his last 30 years trying to find a single theoretical statement that would explain the behavior of both subatomic particles and the curved geometry of gravity.

The secret of this "theory of everything," as physicists only half-jokingly call it, may lie at the beginning of the universe. When it was just a point of infinite heat, density, and pure energy, all four forces may have existed as one in a state of "symmetry."

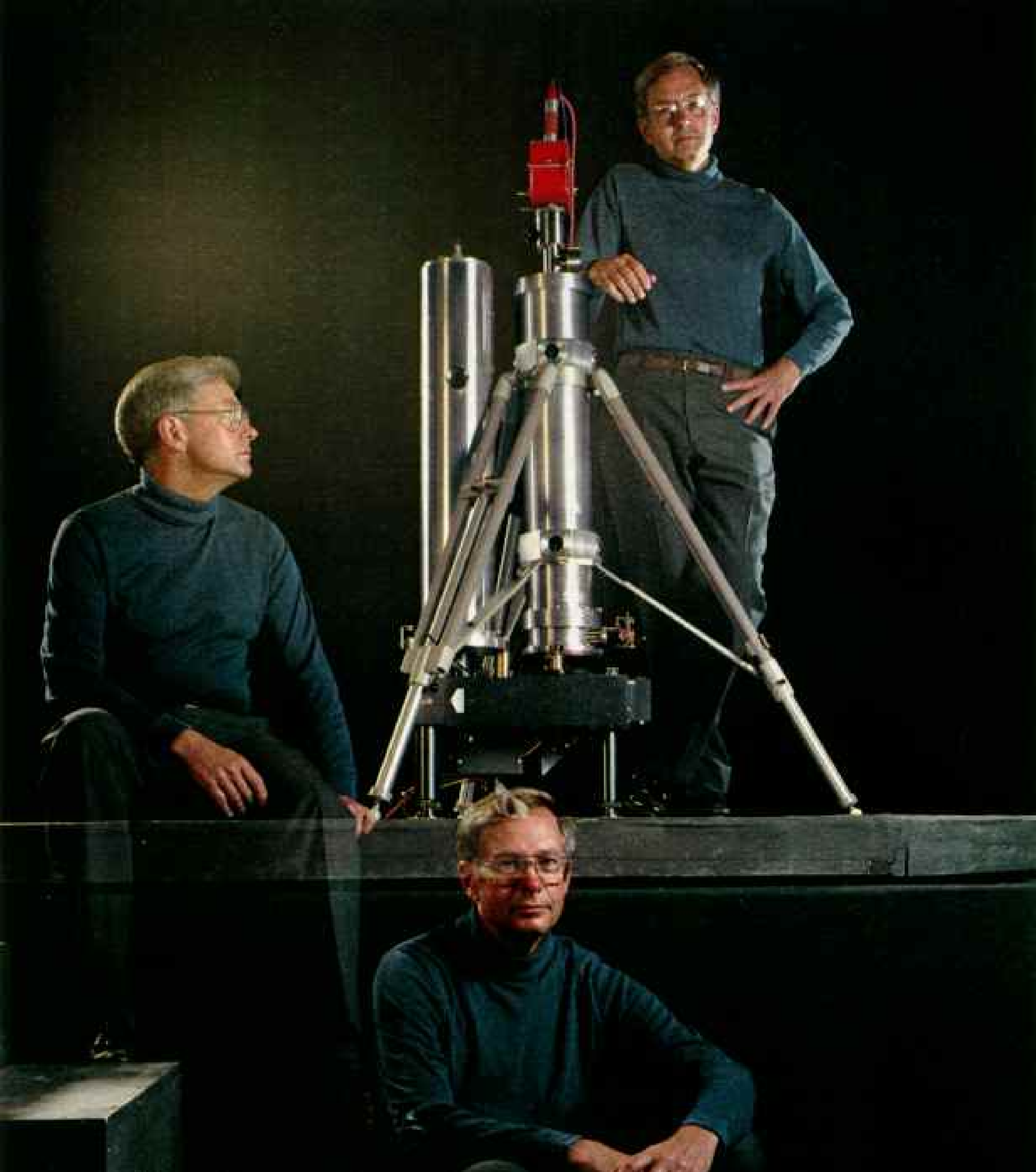
As the universe exploded outward, symmetry was broken, and the forces split off from one another. Three of the forces went to work inside atoms, employing tiny force carriers known as bosons. These short-lived subatomic particles zip back and forth between protons, neutrons, and electrons, binding them together or pushing them apart. Some physicists think particles called gravitons could do the same job for gravity. But no sign of them has yet been seen.

"General relativity and quantum mechanics are simply two different things," says Caltech's Blandford, as he tosses two books onto

MIKE CLEMMER (ABOVE); JAMES A. SUGAR, WITH KEVIN SCHUMACHER

ATTACKING the problem of geographic variations in gravity, technicians take readings beside F-16s at McIntyre Air National Guard Base in South Carolina. Local deviations are recorded to set inertial guidance systems for aircraft.

Gravity meters may someday be used by security agents to detect intruders. The world's most sensitive meter, built by Colorado physicist James Faller (right), can detect even subtle changes in his position.



his desk, one on relativity and the other on subatomic physics. "One side sees geometry. The other sees gravity as just another kind of quantum force."

THEORETICAL PHYSICISTS have tried to get around this split by using multidimensional geometry. Oxford University's Roger Penrose, a mathematician with a supple, geometric mind that inspired several of Dutch artist M.C. Escher's marvelous visual illusions, envisions a subatomic world constructed of eight-dimensional objects called "twistors," from which all four forces are generated.

Another contender for the "theory of everything" title is equally bizarre—the superstring theory. A creation of physicists John Schwarz of Caltech and Michael Green of the University of London, it supposes basic building blocks made up of tiny strings of vibrating energy.

These strings, open-ended or looped, are incredibly small: One string is to the size of an atom as an atom is to our solar system. Always moving, strings engage one another in a free-for-all dance—swaying, bumping, sliding into one another in a process that could create every type of subatomic particle, including the elusive graviton. This theory combines the geometry of general relativity with the randomness of quantum mechanics.

"There has always been a problem fitting gravity into the scheme," says Schwarz. "But with strings, we find that not only does gravity fit, it becomes necessary." He acknowledges that superstrings are still only a mathematical abstraction.

Some theorizers think a new force such as Ephraim Fischbach's will be just the thing to unify gravity and the three quantum forces into physics' so-called holy grail.

Little wonder that the possibility of a mystical fifth force is driving on seekers everywhere. "A force counteracting gravity? It's enough to get anybody's heart pumping," says Paul Boynton.

Think of the possibilities. If we could harness such a force, might we someday have craneless construction, cableless elevators, or spaceships zipping between planets on "hyperdrive" that engages the fifth force locked within subatomic particles? As you might expect, none of this has escaped the notice of the U. S. government, especially the Pentagon.

Exotic and expensive research aimed at pinning down the new force is already in the works. Physicists from the Los Alamos National Laboratory have joined with Italian physicists to find out if a fifth force would have an effect on antimatter. (Antimatter is material identical in mass but opposite in electrical charge from ordinary matter. Upon meeting, the two annihilate themselves in a violent burst of energy).

Scientists at the European Space Agency are planning an experiment in space aimed at precisely measuring the extent of fifth-force influence on objects floating free of earth's gravitational pull. Japanese scientists working at the Tsukuba National Laboratory will spin a large rotor to see what effect a fifth force might have on various metals. And Italian scientists at CERN in Geneva are undertaking a similar experiment to help establish the range of the hypothetical new force.

Professor Romano Bizzarri of the University of Rome explained what seemed to me to be an especially keen Italian interest in the fifth force. "We Italians do love our Galileo Galilei and gravity."

GRAVITY INFLUENCES virtually everything. Almost all mechanical devices on earth, from clocks to hydroelectric dams, rely on gravity for their operation. So does all life. Gravity governs our height and shape and keeps us from falling off the surface of a ball spinning a thousand miles an hour at its Equator.

"We are children of gravity," says Dr. Ralph Pelligra, director of medical research at the National Aeronautics and Space Administration's Ames Research Facility in California. "As we age, we reach a point when we begin to yield to it. Sagging skin and organs, varicose veins, arthritis, failing hearts—these all come from the lost battle against gravity.

"We can't touch it or see it. But it has guided the evolutionary destiny of every plant and animal species and has dictated the size and shape of our organs and limbs."

The human spine is a cantilever and our arms are levers, designed to overcome gravity. Says Pelligra: "Every bone and muscle is aligned to maximize mobility in one g. If you don't think so, look at the shapes of creatures that have evolved where gravity is not very significant—in the water."

I like to envision a species of humanoids

JAMES A. SUGAR, WITH GEORGE VON KANTOR

PRIVY COUNCIL to the world's toilet makers, Thomas Konen and assistants test models at Stevens Institute of Technology in New Jersey. His work has promoted commodes that use compressed air as well as gravity to build pressure, thus conserving water.

that, having evolved on the moon with one-sixth earth's gravity, are double our height but too spindly to play basketball. On Jupiter, which has 318 times earth's mass, they might look like pancakes with short legs.

Here on earth, gravity hardly exists for insects; in fact it presents almost no danger to any animal on the small side of a mouse, according to British geneticist J.B.S. Haldane. "You can drop a mouse down a thousand-yard mine shaft," wrote Haldane, "and, on arriving at the bottom, it gets a slight shock and walks away. A rat is killed, a man is broken, a horse splashes."

Not until we took to the zero-g environment of space did we find out how much the human body is a gravity-dependent machine. I shared in this realization high over the Gulf of Mexico in an extraordinary NASA plane used to train astronauts.

The KC-135 aircraft, a military version of a Boeing 707, with a near-empty fuselage padded like an asylum, flies in a parabolic curve that creates a sensation of weightlessness for 20 to 30 seconds. This occurs when the plane arrives at the top of a steep climb, levels off, and drops—making you feel as if you've arrived at the crest of a giant roller coaster.

As the plane reached the top of its first climb, euphoria erupted among a dozen astronauts, photographer James Sugar, and me. We whooped and yelled as we began floating free from gravity's bonds as only a handful of earthlings have ever done.

Free—but helpless. I tried to swim. No luck with nothing but air for my arms and legs to push against. Jim Sugar snapped pictures as he floated by, oblivious of being on a collision course with a row of hard steel seats. With one hand I easily pushed him to safety.

At first it was great fun. But after 33 times and a little over ten minutes of weightlessness, I was disoriented and nauseated.

MORE SERIOUS damage to the body comes from prolonged absence of gravity. We have learned much about this from the often painful experiences of Soviet cosmonauts, unrivaled for long-duration sojourns in the punishing world of zero g.

His first night aloft Oleg Atkov drifted uneasily through the space station Salyut 7. Sleep was impossible. His head, accustomed to its own weight on a pillow, felt large and light. His face was bloated with blood that, no longer held in his legs by gravity, had migrated upward. When he closed his eyes, he felt as if he were spinning, since without gravity his inner ear could not sense up and down.

Without intending, Atkov, a cosmonaut-physician, was serving as a test subject for another of Albert Einstein's contributions to science: the principle of equivalence.

It states that there is no difference between the effect of gravity and that of acceleration; they are equivalent. Thus a person falling will not feel his own weight, an idea that helped lead Einstein to his grand theory of gravity—general relativity.

An orbiting space station, like the moon, continuously falls toward earth. Only its forward motion prevents it from crashing. To Atkov the effect was the same as being inside a freely falling elevator.

Atkov's body reacted profoundly.

His muscles, which were no longer needed for supporting his body or lifting things, atrophied rapidly, despite intense exercise each day. "I could see them wither before my eyes," said the amiable cosmonaut when I visited him in Moscow.

Atkov's bones, similarly underemployed, insidiously gave up calcium and lost density. "I became lethargic and fatigued, far worse than I had expected." When he landed after eight months in space, he was so weak he had to be carried on a stretcher. He called his one trip to space "more than enough."

Medical researchers are worried about a tentatively planned trip to Mars, taking as long as three years round-trip.* Dr. Harold Sandler, a NASA aerospace physician at Ames, wonders: "Is there a point in sending

* See "Mission to Mars" by lunar astronaut Michael Collins in the November 1988 issue.

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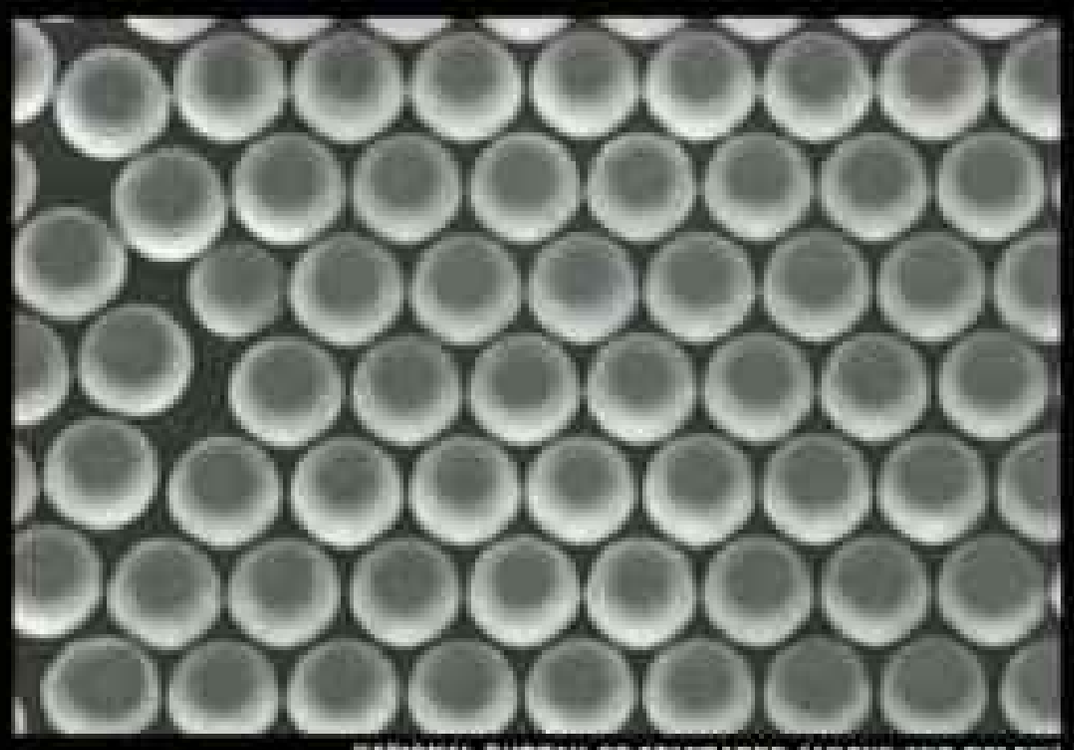
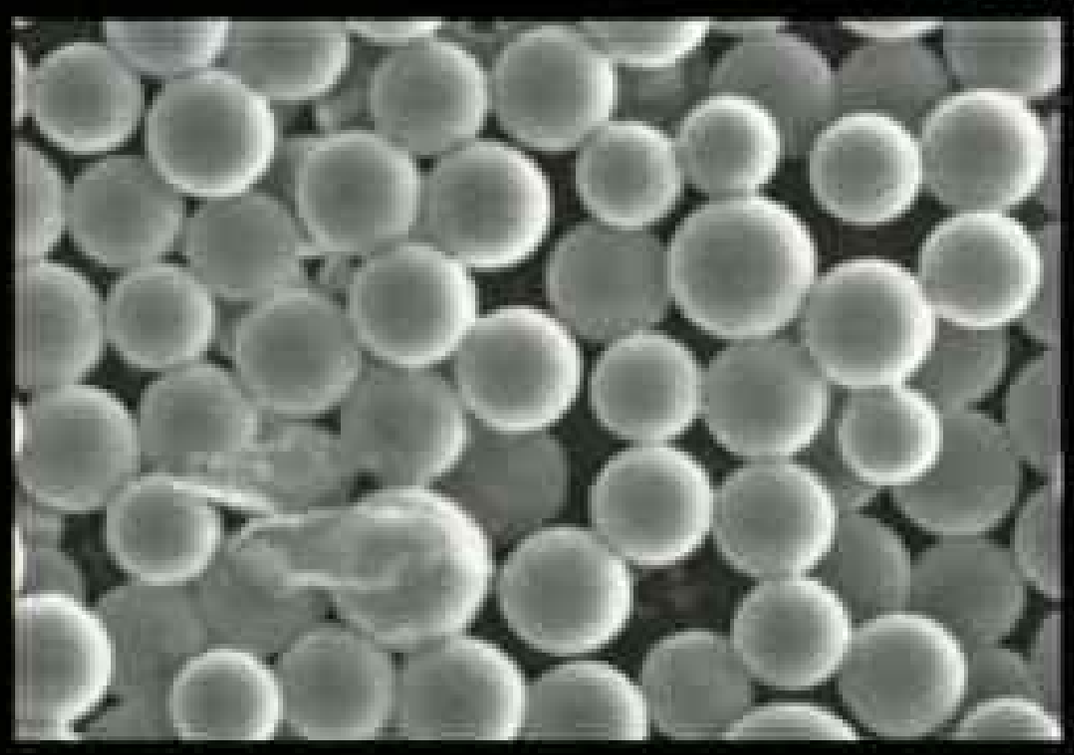


NATIONAL BUREAU OF STANDARDS (ABOVE AND BELOW)



Microscopic polystyrene spheres made aboard a space shuttle in 1982 beaded perfectly (above right), as did a drop of water on the Soviet space station Salyut 4 (above). Now used by many industries to calibrate instruments, the spheres outperform those made on earth (right).

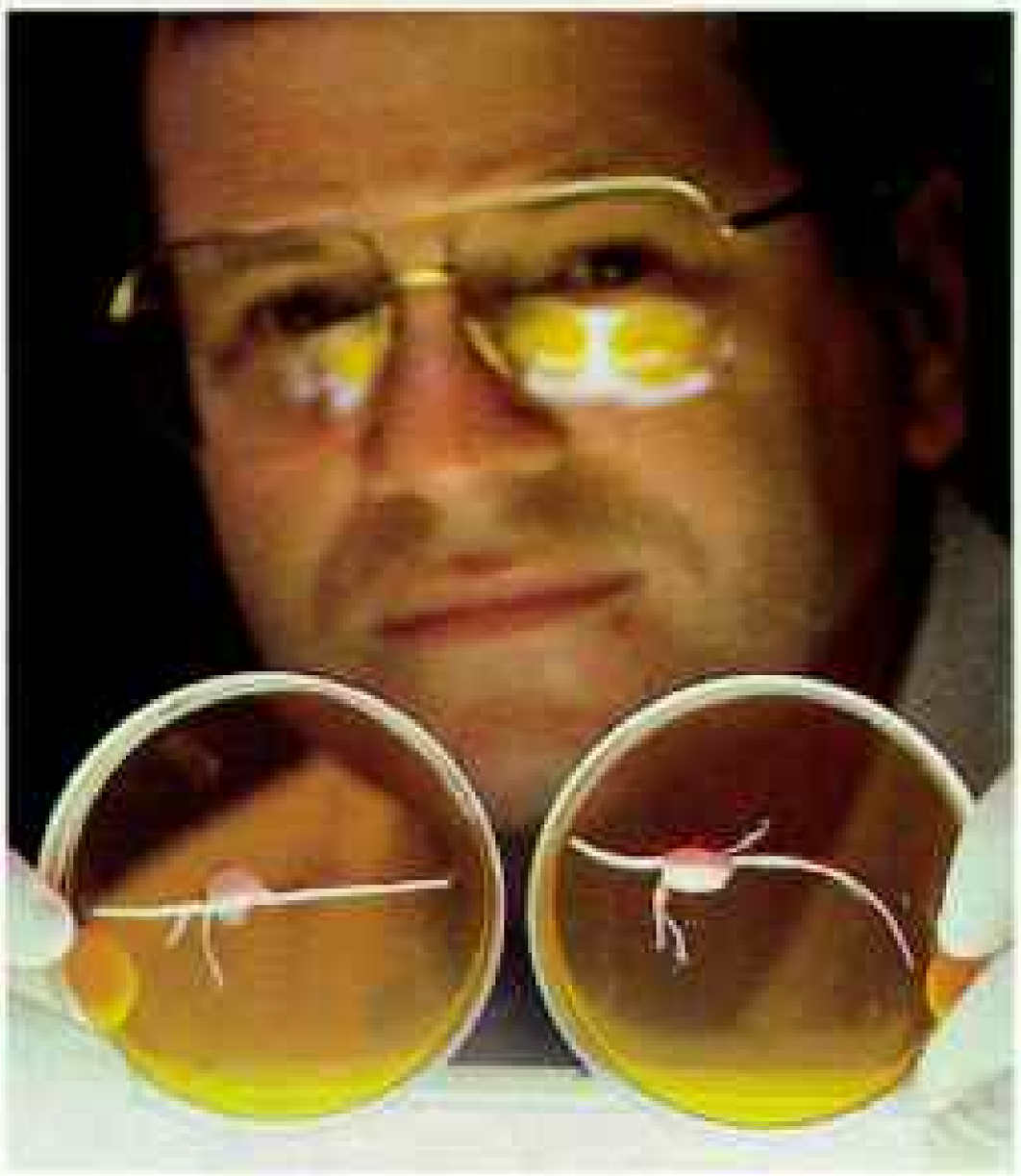
someone to Mars who won't be able to stand up when he gets there?"

Some specialists think artificial gravity will be required. It could be attained in a slowly rotating space vehicle, creating a centrifugal effect as in the film *2001: A Space Odyssey*.

A revolving spacecraft could also alleviate problems the Soviets have found in trying to grow plants in space greenhouses. In zero gravity, plants can grow with roots up and stems down, while weightless water cannot percolate through soil, which itself is floating away from roots. These are serious problems: Plants will be essential for providing food and oxygen during interplanetary flights.

Science has gleaned a lot about the most mysterious force in the universe since Newton gave us an inkling of how it works. But does the knowledge do us any good?

Right now orbiting satellites like LAGEOS and GEOSAT are taking readings of variations in the earth's gravitational field. To do this, researchers determine whether a satellite has bobbed up or down with a change in earth's gravity below. For instance, satellites drop noticeably over the "Indian Ocean anomaly" off Africa, where the earth's surface bulges and gravity's pull is particularly strong.



CONFUSED IN SPACE, plants in zero g often send their roots up, a problem on long flights requiring crops. Cosmonaut V. Kubasov checks an experiment on a 1980 Salyut mission (below). Within two hours of being turned, a corn seedling bends its root, compared with one just rotated by Ohio State University's Michael Evans.

During the Apollo 11 mission to the moon in 1969, NASA learned—suddenly—about gravity variations there too. When the lunar module *Eagle* landed on the Sea of Tranquillity, pilot Neil Armstrong was shocked to find he had missed the projected landing site by seven kilometers, a potentially fatal error.

Project scientists later determined that the spacecraft had been jolted from its planned orbit by the immense gravitation of the large lunar basins. These dark spots that create the man in the moon are filled three to eight kilometers deep with basalt, a dense mineral, something not considered before the trip.

On earth, accurate charting of variations in gravity is used everywhere—for prospecting, for predicting volcanic activity, for the inertial navigation systems of planes, ships, and missiles, and for studying the earth's interior.

"Irregularities in the density of earth's mantle directly affect the gravity measured at the surface," geophysicist Brad Hager explained in his office at Caltech. For instance, gravity is especially strong in central Africa and the Himalaya and noticeably weaker in the Hudson Bay area and the Indian Ocean. "This has helped us draw a picture of core and mantle dynamics, which ultimately explain the earth's geology."

JUMPING ROPE proves more than child's play for aspiring astronauts aboard a NASA training aircraft. Achieving 30 seconds of weightlessness by flying parabolas, the plane—known as the Vomit Comet—gives candidates a dose of life without the most basic lifeline of all—gravity.

Gravity can vary even when the surface is flat—important for mineral and oil prospectors. Using gravity meters, they look for strong local readings that can indicate dense, ore-bearing minerals or weak signals that could lead to petroleum-rich salt domes.

The meters measure the gravitational pull on a suspended mass, much like some of the fifth-force experiments. Commercial models costing about $40,000 can detect a change of as little as .00003 ounce in the weight of a person. They can even find a person behind a wall—or report the shape of a hidden underground passage.

WE HAVE BEGUN to use Newton's discovery. Might we someday control it? Probably not, since the field of warped space-time in which we dwell does not carry positive and negative charges like nature's other forces. Still, some physicists think gravity with a minus sign could exist someplace in the universe. Or that somewhere else out there could be negative mass that would have the effect of canceling out the gravity of positive mass like us.

And then there is still Ephraim Fischbach to contend with. Scientists are already contemplating uses for his fifth force. But says Fischbach: "We just don't know yet where it could take us—just as nobody knew in the 1870s that the discovery of electromagnetism eventually would lead to television."

Newton knew that gravity kept everything in the sky in its place. Today we think that it also created the universe and could one day bring it to an end in a final gravitational day of atonement, that it stokes the fusion fires of the stars, slows down the galaxies in their outward hurtle, and makes the planets round—and that our bodies need it more than we think.

How would Newton look on our achievements? Said Professor Hall during my visit to his Oxfordshire farmhouse: "He would be rather pleased, I'm sure. After all, he was after the secret of the universe, and he thought that gravity held it." □

Through a shifting seascape of Arctic ice my partner, Mike Beedell, and I haul our

Braving the

By JEFF MacINNIS

catamaran over a perilous stretch in Canada's far north islands.

Northwest Passage

Photographs by MIKE BEEDELL

THE DREAM of a Northwest Passage lured European explorers for centuries with the promise of a quick, if hazardous, Arctic sea route across the New World to the wealth of Asia. Place-names throughout the 4,000-mile-long passage read like a roster of those who challenged its icy labyrinth of more than 18,000 islands—Baffin, Hudson, Davis, Foxe, Parry, Bylot, Sverdrup. Many gave their lives in the search. Sir John Franklin's 1845 expedition was lost with two ships and 129 men, inspiring dozens of subsequent expeditions to find and rescue him, none of them successful.

Finally, in 1903, the Norwegian explorer Roald Amundsen, who was later the first to reach the South Pole, set off through the passage from east to west in his 70-foot motorized sailer, *Gjöa*. After three years Amundsen became the first to navigate the entire passage. Others have since made the voyage, including the Canadian schooner *St. Roch*, the U. S. supertanker *Manhattan*, and Arctic explorer John Bockstoce, who compieted the journey in 1980 in a motorized umiak, an Inuit walrus-hide boat.

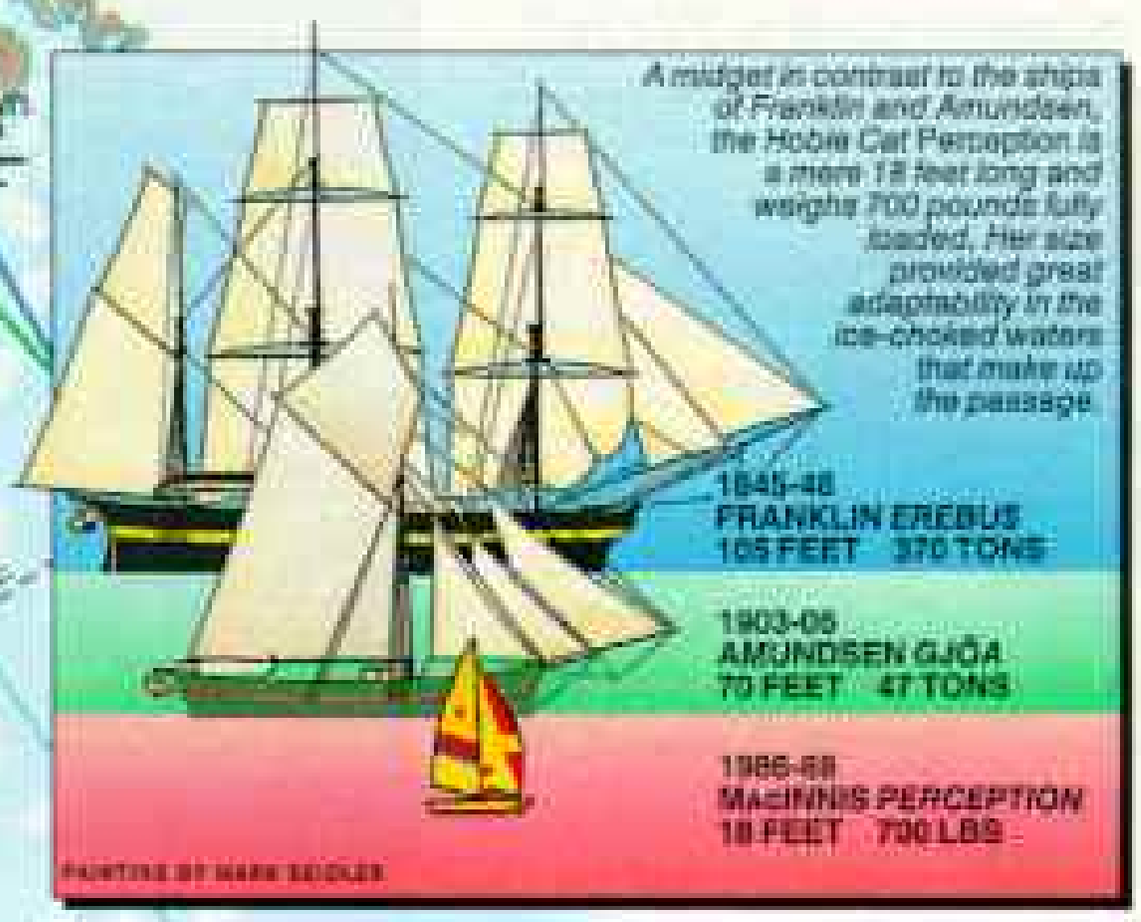
But no one had ever traversed the Northwest Passage under wind power alone. Inspired by my previous journeys to the Arctic and by journals of the early explorers, I had long hoped to sail the passage. On July 20, 1986, after two years of planning, I set out with photographer and Arctic veteran Mike Beedell in our fiberglass Hobie catamaran from the town of Inuvik, above the mouth of the Mackenzie River. It was to take us three summer seasons to sail and haul our double-hulled craft eastward through the heart of the passage's storm- and ice-racked seas to our ultimate goal, Pond Inlet by Baffin Bay.

Near the end of the voyage, in August 1988, we pass beneath the sheer 2,000-foot-high limestone cliffs at Cape Clarence (right) on the northeastern tip of Somerset Island.

A book on the voyage by Jeff MacInnis entitled *Polar Passage* will be published this month by Random House of Canada.

Through the Northwest Passage

***IN THE WAKE** of legend, Jeff MacInnis and Mike Beedell sailed their catamaran through the narrow passages sought by Sir John Franklin and others and finally conquered by Roald Amundsen. Sometimes wind driven, other times hauling their craft over ice, the team completed their voyage in three seasons.*



NGS CARTOGRAPHIC DIVISION
DESIGN: CHARLES W. BEERT; RESEARCH: SIDNEY J. RAHILL;
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BALANCED FOR A BLOW (right), I ride a portside "trapeze" on one of two outrigger-like wings that helped offset the tilt of the boat in a stiff breeze. Here in Franklin Bay during our first season we hurtle along at 20 knots, dodging ice floes littering the surface.

Throughout the voyage we wore watertight survival suits first designed for use by U. S.

JEFF MACINNIS

Navy fighter pilots. We were never tethered to the boat; there were enough lines on board as it was, and if the catamaran capsized or sank, we could be dragged under.

The agony of deep cold etches Mike's rimed face (above) during our second season, when the thermometer stood at 10°F and storm winds created a windchill of minus 30°. The storm forced us to drag our boat over razor-sharp ice that punctured the fiberglass hulls. We began taking on water and were forced to come ashore at Cape Anne on Somerset Island. There we left the boat on the open tundra and were airlifted out. We were less than 500 miles from Baffin Bay and hoped to reach it the following year.

MAKESHIFT crow's nest (below) extended our visibility by several miles. Using a foot sling, we would haul ourselves halfway up the catamaran's 28-foot mast to scout the best route through the surrounding ice. Here in Victoria Strait during our second season we were caught in the grip of impenetrable ice floes for 12 out of 40 days at sea. During that time we were carried some 80 miles in a circular path that left us farther behind than when we started.

During our flight back to the Arctic each season, we were able to appraise the ice that lay ahead of us. It usually resembled a giant jigsaw puzzle (bottom), whose pieces constantly shifted like a kaleidoscope and could come together within hours to form a solid mass. Despite the obstacles we made more than a thousand miles during our second season, when several other boats challenging the Northwest Passage made almost no headway at all. One advantage, though a painful one, was our ability to haul the catamaran considerable distances over the ice. At the end of the trip we calculated that we had hauled the boat a total of about 35 miles—more than one percent of the entire distance.

We could never pause when hauling through current-driven slush and ice for fear that the

floes would slam together and crush one or both of the hulls. At such times I came to think of the Northwest Passage as a land that devours ships.

We also tried to keep up momentum when hauling over ice that contained shallow meltwater pools, lest we fall through rotten ice and tear our thin survival suits or, far worse, break a leg. Though we carried a radio, the chance of rescue in many areas was slim, and one man could never haul the boat with the other one on board.

Here I pull at the bow (below) while Mike pushes from the stern on the ice pack south of Victoria Island. Fully loaded the catamaran weighed 700 pounds —450 for the boat and 250 for supplies and equipment, much of it stowed in the twin hulls.

Weight was a key factor, even for food. We limited ourselves to a pound and a half a day, with lightweight but high-energy items such as granola bars, powdered milk, dried fruit, cheese, and various freeze-dried dishes.

In the virtually endless light of Arctic summer we spent as many as 20 hours at a time under way, with short intervals to camp on the ice or ashore. We cooked only when we camped, using a small gas unit that served not only as our stove but also as a torch to warm the fiberglass hulls when we had to patch a leak with epoxy resin.

OASIS AT SEA, a melt pool on the surface of an ice floe provides me with a welcome drink off Victoria Island during our second season. Over long periods of time salt in sea ice leaches out, leaving fresher ice on the surface, which melts in the summer sun. With such a constant source of potable water we were able to limit the amount we carried aboard to less than two days' emergency supply. If we had had to carry enough fresh water for six weeks, we could never have made the voyage—the weight and volume of the water would have left little room for anything else, and hauling the boat would have been impossible.

I named the catamaran *Perception* because to me she was the earliest perception of how the voyage could be made. The word also symbolizes the different perceptions people have of the Northwest Passage: an untouched wilderness, an icy barricade, a crucible of history, an endless challenge. On a more mundane note, the word "Schooner" at the bow honors a Canadian beer whose maker provided generous support for the voyage.

Driven ashore by a violent storm that we barely survived, Mike and I camp (below) at Aston Bay on Somerset Island. To shield our tent from hurricane-force winds, we built a wall of snow blocks to windward, cutting the blocks with one of the catamaran's paddles. The paddles were enormously versatile, serving as radio-antenna masts, shovels, ice prods, snow knives, and potential argument settlers—whoever had one in his hand at the time would win.

In the soft glow of the midnight sun (right) *Perception* faces a 30-foot-high jumble of ice floes off the southern coast of Victoria Island. Once again Mike and I go overside to push and coax the catamaran toward a single narrow band of open water that leads in the right direction—east.

THAR SHE BLOWS! I point to a pod of beluga whales we encountered in Cunningham Inlet off Somerset Island during our third and final season. As we approached ten of the graceful creatures, blowing and lazing on the surface, they dived, and we could see their ghostly white forms in the blue-green water beneath our hulls. As we sailed deeper into the inlet, we came across several more pods, all seemingly curious but still wary.

Each summer some 1,500 belugas gather in Cunningham Inlet, drawn in part by the clean sand-and-gravel bottom in the shallows. Here the belugas rub away the yellowing outer layer of their skin and emerge a beautiful sparkling white, as displayed by the lone beluga (top right) that "spy-hopped" as we approached—rising vertically above the surface to inspect the strange, twin-bodied intruder on its home territory.

To study the beluga's behavior and migratory patterns, the Canadian government maintains a small research station at Cunningham Inlet. We were welcomed by Tom Smith, a research biologist; Tony Martin, a cetologist from Cambridge, England; and Kathy Frost, a biologist with the Alaska Department of Fish and Game.

The station consisted of two tents and a 10-by-15-foot wooden laboratory shack—luxurious accommodations by Arctic standards. Over pork chops and vegetables the scientists explained that the station had been operating for 12 years and that this year they were attaching small radio transmitters to belugas in order to track their movements by satellite link with Tony's lab in Cambridge. So far the team had managed to attach a transmitter to just one—no mean feat with a 2,000-pound animal that wanted no part of the experiment.

Mike reported that two days earlier at Cape Anne, 25 miles to the west of Cunningham Inlet, we had seen and photographed a beluga carrying a small green-and-yellow packet on its back. Tony grew excited. "That's our beluga!" he said. "Now that we have the time and the exact location, we can check the data in Cambridge to make sure our system's accurate."

The day of our arrival two belugas had accidentally become grounded in the shallows of a river delta near the station, and now that the tide had gone out,

they seemed hopelessly stuck. Such strandings are uncommon, and they offer scientists the opportunity to tag, measure, and determine the sex of the animals. In the bright Arctic afternoon we joined Tom and Tony and Kathy on a rescue mission to the whales. One was an adult that measured about 14 feet in length, its skin a pure snow-white. The animal had become so exhausted by its thrashing that Tom was able to reach inside the genital slit and determine that it was a female. Tom estimated her weight at nearly a ton, far too much for us to drag into deeper water. She would simply have to take her chances waiting for high tide, and with luck a polar bear wouldn't happen along in the meantime. With the next tide she was able to free herself.

We turned our attention to the other beluga, which was much smaller and had the gray coloring of a calf (left). It too was a female and weighed about 300 pounds. After tagging her with identification ribbons, the four of us managed to drag her into waist-deep water, where she gave a single mighty thrash and disappeared down the inlet.

A rampart of gleaming ice (overleaf) in the Beaufort Sea, a mini-berg frames *Perception* during a rare moment of calm on the long voyage.

LORDS OF THE ARCTIC, two polar bears pause at water's edge on Baffin Island's Brodeur Peninsula. The mother sensed our presence and abruptly lumbered away with her cub. Earlier another bear had happened on our tent while we were immobilized in our sleeping bags. Though we had a shotgun for emergencies, using it in such close quarters would have been risky. We lay quietly while the bear nosed around outside only two feet from our heads, then wandered away.

Giant ocean swells rolling in from Greenland marooned us here for several days, and we had an opportunity to observe the bears at close hand. They too were marooned and were deprived of their preferred diet of ringed seal. We watched them come to the beach each day to forage. Lacking meat, they resorted to devouring long strands of seaweed washed ashore by the swells.

Earlier in the voyage a curious bearded seal (top) had surfaced in Anderson Bay off Victoria Island to inspect us. Bearded, ringed, and harp seals were our frequent companions during the voyage. When winds were light, they would swim alongside, then dive and shoot out of the water behind us, agitating the surface with their flippers. On sunny days they would haul themselves up on nearby ice floes for what we called a "seal tan."

Luck ran out for a harp seal (left) caught by two polar bears in the Tasmania Islands, named for the island off southern Australia where Sir John Franklin once served as governor.

We came on the seal's carcass only moments after the polar bears had been scared off by the approach of our boat. Blood and entrails marked their line of retreat into the nearby water. With a wary eye on the water we examined the badly mauled seal. Mike reached down into the carcass and drew out a perfectly formed unborn seal pup and laid it on the ice. There was nothing to say. Wordlessly we boarded *Perception* again and set sail for Baffin Bay.

HOME ARE THE SAILORS. After three years and 2,300 punishing miles Mike and I finally reach our goal at Pond Inlet. Perversely the Arctic winds that had lashed us so unmercifully died abruptly, and we had to paddle the last few miles. Pond Inlet's low houses and brightly painted oil tanks crown the promontory ahead, beneath the backdrop of Bylot Island's glacier-capped mountains. At anchor on our left lies the settlement's annual supply ship, which later delivered *Perception* to Montreal.

With the boat safely ashore Mike and I hug each other over a bottle of celebratory champagne (right). The strain of the long voyage shows in our faces, but there is no disguising our joy. For centuries man had dreamed of sailing the Northwest Passage by wind power alone, and we had done it. That day, August 17, 1988, I made a final entry in my journal:

"I sit here . . . snug in the ruins of a Thule Inuit hut that is centuries old; as old, perhaps, as the dream of sailing the Northwest Passage. A four-foot-high wall of rock and whale bone protects me from the howling wind. Orange lichen, which takes more than a century to grow, is creeping over its surface. I am . . . writing with bare hands—a luxury not often permitted on this voyage. I've been up for nearly 23 hours, but I cannot sleep. The joy and excitement are too great.

BOTH BY BILL CURTSINGER

"Our Hobie Cat . . . was, as I'd hoped, the ideal vessel for this voyage. In light wind she glides along swiftly and in storms she is stable, though frighteningly wet, and she can be beached when the going gets too tough. When ice is an obstacle she can, with considerable effort, be hauled up and over the ice by her crew. In fact, she embodies the watchword for survival in the Arctic—adaptability."

We owe her not only our success but also our lives. □

The Baltic:

By PRIIT J. VESILIND NATIONAL GEOGRAPHIC SENIOR WRITER

A stiff breeze buffets a Soviet sailor on a submarine in Leningrad, Russia's window

Arena of Power

Photographs by COTTON COULSON

on the Baltic. For the seven nations of this northern sea, the winds of change are blowing.

IN LENINGRAD I met a defector from America.

He was wearing sunglasses, sitting alone on a small towel beside the Neva River, by the walls of the Peter and Paul Fortress where Leningrad insiders swim and play volleyball on weekends. He had lived in the Soviet Union for 28 years.

A Russian friend pointed him out: "He is from San Francisco. Perhaps he will want to talk with you."

The defector was a bland man, with a face that betrayed no content. "What did you do in the States?" I asked him.

"National Security Agency."

I told him I was born just a few hundred miles down the coast, in Estonia, and fled west during World War II with my parents.

"We went opposite ways," he said, smiling. "I guess all cultures have their defects."

In Leningrad I met a lady.

She was sitting at the hard-currency bar of the Hotel Moscow, sipping gin. She liked to read John Steinbeck, she said, and she was a cardiologist by profession. But the lady was also a prostitute. In one night she could easily make $250, the average monthly salary of a physician in the Soviet Union.

"You are looking at me," she said abruptly, "and saying, 'Poor doctor!' Well, this is what our system does. And now, now we can say it." Her words spat across the table.

In Leningrad I met an admiral.

He was commander of the Leningrad naval base. In a VIP boat we followed his launch down the Neva to celebrate Navy Day, past four destroyers and three submarines lined up for inspection, each with its brass band, each with its sailors stiff in dress formation.

"How is it, comrades?" the admiral shouted through a bullhorn at each ship.

"Rah, rah, rah!" the sailors shouted back in unison.

That evening we photographed the fireworks over the Neva from the roof of the admiralty building, a top-secret facility. Thousands lined the riverbank. Strings of lights outlined the warships below, and the bronze statues atop the Winter Palace of the tsars stood black against the rockets' red glare.

"What's going on around here?" the admiral had demanded. "We haven't let even our *own* photographers on this building, and now we have American journalists? Up there? . . . Well, why not?"

THESE ARE HEADY, risky days on the eastern Baltic, front lines of the Soviet experiments in openness *(glasnost)* and restructuring *(perestroika)*. What was closed is open; what was secret lies revealed. Palms sweat among those who have held power by fear or graft. Officials throw up their hands, unsure of the new rules. Soviet society has never been on such display. Leningrad, Russia's traditional window on the West, finds the world peering back in fascination.

In the Baltic States of Estonia, Latvia, and Lithuania, three of the Soviet Union's fifteen constituent republics, last year's most dangerous fantasies have been sanctioned by the government itself. From Moscow has come the admission that, yes, after all, the Soviet Union occupied these nations by force in 1940, against the will of the people. Estonia has declared itself a sovereign state and is drafting ambitious plans for economic autonomy. The old national flag, stripes of blue, black, and white, a one-way ticket to Siberia only last May, waves over farmhouses.

Emotions fly between euphoria and cynicism in Estonia. Many fear a short spring, the rumble of tanks. Others sense the beginning of the disintegration of the Soviet Union as a colonial power.

A consensus prevails that there is no alternative to radical change. Like Peter the Great, the Russian tsar who imported Western architects to build Leningrad on the marshes of the Neva, Soviet President Mikhail Gorbachev must reach out. He needs Western technology and expertise to prop up his foundering

giant before it sinks into Third World status.

Six industrial nations—Finland, Sweden, Denmark, West Germany, East Germany, and Poland—share this shallow, brackish Baltic Sea with the Soviet Union. Now the careful equations that have governed business, diplomacy, and military balance among them have been altered in three short years, and in one bold summer.

The Baltic has been a buffer zone and a battleground between East and West since the days of the Vikings, with seafaring tribes sacking each other in a cycle of cruelty and revenge. Only for a brief two centuries in the Middle Ages did a Baltic community coalesce, under the Hanseatic League of prosperous cities that valued trade over plunder. Since then, East and West have pursued their violence with the usual zest, culminating with Adolf Hitler and Joseph Stalin dividing people and nations between them as if they were cattle.

The Baltic remains on military alert, grouped into three forces: NATO, with Denmark and West Germany; the Warsaw Pact, with East Germany, Poland, and the Soviet Union; and two skittish neutrals, Finland and Sweden, gamely in the wings. The sea has become a chessboard for their maneuvers, patrols, provocative flight patterns, and electronic surveillance, with each side monitoring the other into a kind of half-cordial, grudging stalemate that wastes millions of dollars and thrives more on momentum than on crisis.

Deep suspicions remain between nations, and generals still talk like generals, but the thaw in the East has offered new hope; the Soviets have declared that the Cold War is over. And now a common enemy—pollution—promises to press the littoral nations of the Baltic into common cause. Environmental scientists already talk like citizens of a community. What I began last spring as a story of confrontation has turned into a story of optimism.

My journey starts on the blank page of the frozen Gulf of Bothnia between Sweden and Finland, about a hundred miles south of the Arctic Circle. On this foggy morning we fly by helicopter from the Finnish town of Oulu over farmhouses and birch forests, droning out to sea over an open *(Continued on page 613)*

***A friendly nyet wards off more pictures** of Adm. Vladimir Samoilov, at right, commander of the Leningrad naval base. In the spirit of glasnost (openness) the admiral allowed the Western press full access to Leningrad's Navy Day celebrations in July 1988. The Soviet Baltic has emerged as the cutting edge of the nation's social, economic, and political experiments. East and West still eye each other warily across the sea, but the Cold War has begun to melt.*

Giselle fills the stage with a whisper of tulle at Leningrad's Kirov Ballet, a blend of European grace and Soviet discipline. Along the Baltic rim the cultures of

Russia, Scandinavia, Germany, and Slavic Europe have both cross-pollinated and collided as nations waged bitter wars to settle their differences.

CHILDHOOD has its privileges on slushy Nevsky Prospekt, showcase avenue of Leningrad. Founded in 1703 by Peter the Great, the city was intended to raise Russia to the European standards the tsar admired. Leningrad still emulates the West, with more than 750 rock groups like DDT (lower left) that mesmerize followers with fresh irreverence.

Around major hotels thrives a street subculture of illegal money changers, black-market traders, and young people thirsty for foreign contacts. Two Leningrad students coveting fashionable clothes and cosmetics work the fast lane at a hotel discotheque. For Western tourists the city is no longer cheap. Under perestroika (restructuring) private restaurants and clubs now charge as much as the market will bear.

THE LURE OF THE SEA loosens the apron strings. At Leningrad's naval cadet school a class of 15-year-old recruits prepares to leave for summer boot camp. As Soviet warships and a patrol craft get ready for Navy Day inspection on the Neva River (left), a young recruit from Moscow, hands shaking, takes his final oral examination before a panel of naval officers (below). "Don't be so nervous," school commandant Rear Adm. Lev Stolyarov says kindly from behind his desk. "Tell me, what is the population of Moscow?"

"Eleven million, including foreigners," the boy answers. The panel erupts in laughter.

A Ukrainian mother and her new-shorn son share the final awkward moments over a jar of preserved cherries from home (lower left). Next afternoon the recruits board a train at Finland Station (bottom). Parents push cookies through the windows and linger over the bittersweet moment when a boy becomes a man.


DENMARK
AREA: 43,069 sq km
(16,629 sq mi)
POPULATION: 5,126,000
SWEDEN
AREA: 449,964 sq km
(173,732 sq mi)
POPULATION: 8,393,000
FINLAND
AREA: 337,032 sq km
(130,129 sq mi)
POPULATION: 4,950,000
ARCTIC CIRCLE
AIR AND NAVAL BASES
Warsaw Pact country
Neutral country
NATO country
AVERAGE ICE EXTENT
Land
Jan. 1
Feb. 1
Feb. 21
Open water
Ferry route
NORWAY
SWEDEN
FINLAND
Luleå
Kemi
Oulu
Umeå
Kokkola
Vaasa
Härnösand
Sundsvall
Gulf of Bothnia
Gulf of Bothnia
Pori
Tampere
Åland
Turku
Helsinki
Oslo
Oregrund
Mariehamn
Uppsala
Mälaren
Stockholm
Sandhamn
Hiiumaa
Gulf of Finland
Tallinn
Tartu
ESTONIAN S.S.R.
Pärnu
Saaremaa
Gulf of Riga
Vänern
Vättern
Norrköping
GÖTA KANAL SHIP ROUTE
MUSKÖ NAVAL BASE
Visby
Gotland
Oskarshamn
Kalmar
Oland
Karlskrona
Skagerrak
Göteborg
Frederikshavn
Ålborg
Varberg
Kattegat
North Sea
Karup
Århus
Helsingør
Helsingborg
Copenhagen
DENMARK
Flensburg
Malmö
Ystad
Christiansø
Ronne
Arsdale
Bornholm
Pama Peninsula
Sassnitz
Rügen
Stralsund
Rostock
Kiel
Heiligendamm
Warnemünde
KIEL CANAL
Priwall
Travemünde
Hamburg
Lübeck
NETH.
WEST GERMANY (FRG)
EAST GERMANY (GDR)
Mecklenburg
Swinoujście
WOLIN NATIONAL PARK
Pomerania
Szczecin
Oder
Berlin
Kolobrzeg
Puck
Gdynia
Sopot
Gdańsk
POLAND
Vistula
Warsaw
Baltic Sea
Ventspils
Jūrmala
Sloka
Riga
Daugava
Liepāja
Lielupe
Liepāja River
LATVIAN S.S.R.
Klaipėda
Neringa
LITHUANIAN S.S.R.
Kaliningrad
R.S.F.S.R.
Kaunas
Vilnius
U.S.S.R.
100 km
100 mi
WEST GERMANY
AREA: 248,030 sq km
(95,997 sq mi)
POPULATION: 60,999,000
EAST GERMANY
AREA: 108,178 sq km
(41,768 sq mi)
POPULATION: 16,597,000
POLAND
AREA: 312,677 sq km
(120,725 sq mi)
POPULATION: 37,858,000

The Baltic

Civilization has washed its hands too long in this shallow, brackish, lakelike sea, which is surrounded by one of the most industrialized areas of the world. Excesses of toxic waste, farm fertilizer runoff, oil spills, and the sewage of 70 million people pour into its waters, whose saltwater circulation is so weak that stagnation occurs naturally. In response, all seven nations of the Baltic community signed the Helsinki Convention of 1974, the world's first pact to protect an entire sea against pollution from all sources. Since then, oil spills have been dramatically reduced, toxic chemicals curtailed, and endangered species such as seals given new hope for survival.

Despite the fact that ice blocks its harbors in heavy winters, the Baltic has become one of the world's most active seas. Icebreakers cut channels for year-round commerce, and dozens of ferries link the seven nations. The sea also teems with navies: those of Denmark and West Germany of NATO; Poland, East Germany, and the Soviet Union of the Warsaw Pact; neutral Finland and Sweden.

U.S.S.R.
AREA: 22,274,900 sq km (8,600,387 sq mi)
POPULATION: 286,435,000

The Baltic States, independent nations before their forced annexation in 1940, make up most of the Soviet Baltic. Many Western nations do not officially recognize the annexation. In 1988 each republic regained the unofficial use of its former national flag (below). Kaliningrad is part of the Russian Republic.

LITHUANIA LATVIA ESTONIA

From an island in the Stockholm archipelago, a member of the Swedish Home Guard scans for infiltrators. For the past nine years Swedes have been frustrated by foreign submarines probing their coastal waters. The video camera sits ready to record incidents.

channel bobbing with ice curds. At noon we intercept one of the world's most modern icebreakers, the six-story, 30,000-horsepower *Otso*, owned by the Finnish government, from whose immaculate decks I would have eaten scrambled eggs.

The *Otso* crushes rather than cuts the ice, bellying up on the sheet with enormous mass. The ice crumbles off in shards, the smaller ones churning in the wake and flashing shades of green as the seawater soaks through their layer of snow. Cracks rip off into the horizon, zigzagging as if they were chased.

In our wake is the Polish freighter *Eugenie Cotton*, fast for Kemi for a load of paper pulp. In hard winters national flags and borders have little meaning to traffic on the Baltic. Under a pragmatic agreement among the seven nations, their combined 34 icebreakers are shifted around from an office in Helsinki just by a few phone calls: "Say, Ivan, we need your boys over in Sweden."

At night we sit high on the bridge, hypnotized by the pale lights of the computer and radar screens and the deep, steady rumble. The moon and Venus hang like ornaments in the cold. Sibelius is on the tape deck. It seems as if we have left earth altogether and are headed for the galaxies, warm, powerful, in charge.

Even in normal winters, thick ice grips the

sea as far south as the Swedish island of Gotland. "If we stop for a day," says First Officer Christian Wennerstrand, "we have chaos."

Finland, the world's only nation with no ice-free ports, builds more than half the world's icebreakers, many for the Soviet Union. Finns regard perestroika with caution. Already faced with shrinking orders in a bleak era for European shipbuilding, they must now deal with the economic instability of one of their biggest customers. Says Pekka Laine, president of Wärtsilä Marine Industries, Finland's largest ship maker, "There is no longer just one market in the U.S.S.R., but many. In Murmansk, for example, the decisions to buy are made on site, rather than in Moscow."

Finland signed the Treaty of Friendship, Cooperation, and Mutual Assistance with the Soviet Union in 1948. In exchange for her freedom Finland will allow no invasion of the Soviet Union through her territory. Finlandization has become a generic term for one nation's accommodations with a neighboring superpower and is sometimes used to suggest a kind of national castration. Said Finnish Prime Minister Harri Holkeri when he visited Washington, D. C., last summer, "From the depths of my heart, I hate that term."

Culturally and economically Finland is a Western nation. But would the Finns fight if the Soviets tried to use Finnish territory as a springboard to attack NATO?

"We would damn sure defend ourselves," Finnish Vice Adm. Jan Klenberg says succinctly at General Headquarters in Helsinki. "We have to make it clear that it is not possible to *use* Finnish territory.

"We know we wouldn't win another war—but we are prepared to fight." An acid mix of pride and frustration rises in his throat. "They test us from both sides—both NATO and Warsaw Pact. Almost every day we send up interceptors. If some skidoo has come across a land border by even two meters, we respond."

Ripping a gash in the Gulf of Bothnia, the Finnish icebreaker Otso leads a timber-laden Soviet freighter from the port of Kokkola, Finland. A multinational fleet of 34 icebreakers, most built in Finland's Wärtsilä shipyards, operates in the Baltic.

With its Leningrad architecture Helsinki retains trappings of the days when Finland was a grand duchy of the Russian Empire—samovars and borscht, the dark brocade of old restaurants. For many years Finland even had serious Communists. But I see in the newspaper, while sitting at McDonald's on Mannerheim Street, that Arvo Aalto, head of the Finnish Communist Party, plans to resign next week because the party suffered heavy financial losses in the stock market.

FROM HELSINKI's South Harbor, the Baltic's elegant car-and-passenger ferries put forth to Leningrad, Gdańsk, Travemünde, and my own destination, Stockholm via the Åland Islands, an overnight cruise that threads an island world of pine forest and granite.

The ferries make money. Slot machines occupy the idle. Duty-free shops push cognac and silk scarves. A ten-piece band pumps waltzes over a smorgasbord rich in herring. On the deck gentlemen Swedes in gray suits stroll like storks, with their hands folded behind their backs, saying, "Yaw, yaw."

In the Åland Islands, the autonomous archipelago between Finland and Sweden, 23,000 Ålanders fly their own flag and lick their own Åland Islands postage stamps. They speak Swedish but belong to Finland, which is responsible for their defense. Formerly a Swedish province, the islands petitioned to be returned to Sweden as the Russian Empire disintegrated in 1917, but the League of Nations honored the Finnish claim and confirmed

the islands' status as a military-free zone.

Their history bristles with sea captains and merchant sailing fleets, and today Ålanders own many of the ferry lines—Viking, Birka, Eckerö—that haul more than eight million passengers each year in the Baltic. Through the tax-free sales they have prospered.

"We are a privileged people," an Ålands gas station owner tells me. "There's no poverty here, no racism, because there are no 'guest workers.' There's almost no serious crime, few drugs. I wouldn't go anywhere else."

And what can be sweeter than early summer in the Ålands? The spangle of sun on water, the sharp smell of mown grass, apple blossoms, and lilacs. Queen Anne's lace that billows beside country roads like snowdrifts. And shocks of dandelions growing brazenly in the long daylight, their thick, hollow stems wet as rhubarb.

STOCKHOLM ARRIVES in the early morning, through mist and a maze of small islands, with a skyline of church spires and sailboat masts, their sharpness always reaching toward heaven. The city rests on 14 islands, clinging by tentacles of bridges and causeways to the rocks. Half the city lies

Questions of power and purpose hang heavy on Poland's independent trade union, Solidarity, outlawed in 1981 but recently invited back into the national dialogue. At a strategy session in Gdańsk, founder Lech Wałęsa, at right, and local president Alojzy Szablewski, middle, hear from a member. At Gdańsk's Lenin Shipyard (below), Solidarity's birthplace, sandblasters restore a Soviet ship. The yard may soon close. Politics, says Solidarity.

beside Lake Mälaren, half beside the Baltic.

Swedes are a confident people. Sweden has not warred for 175 years. With no pain to endure, no heroes to worship, no warriors to bury, they have a human advantage: They carry no self-hate and so are not apt to hate others. They seem indifferent to defense. Says air force Lt. Col. Gösta Edwards, "Society looks at us as if we don't belong."

But bad things happen to nice people. The Swedes are deeply troubled by the assassination of their charismatic prime minister Olof Palme three years ago. And for the past nine years they have been plagued by foreign submarines, arrogantly, systematically, probing their coastal waters.

No one knows why. Training? Espionage? One Danish naval officer theorized that the Soviet Union is getting navigational fixes on the Swedish coast so it can hide nuclear submarines in case of war and push the buttons from there. "They know now that the Swedes can't find them," he told me.

Since 1981, when a Soviet Whiskey-class sub ran aground near the Swedish naval base at Karlskrona, no physical evidence has been found, no foreigners confronted. With photographs of bottom-crawling mini-sub tracks

creeping within a few miles of Stockholm, and night sightings of frogmen, the hunt has taken on the comic overtones of the Loch Ness monster. The Swedish Navy has lost face.

With the loss has come a new toughness. "I'm in charge of military readiness," Swedish Army Brig. Gen. Bertel Österdahl tells me at the garrison in Stockholm, "a job that gives me trouble from time to time. There's quite a lot of activity in this area, and we have to act too, just to show that we are present."

"But what happens," I ask, "if you actually destroy a submarine and have Russian or Polish bodies floating in Stockholm Harbor?"

"In our territorial waters we'll shoot without warning," he replies.

To see the complexity of the submarine chase, you must sail an archipelago of 25,000 islands, past thousands of granite skerries flush with blueberries, past summer hideaways and small boys fishing on piers, through waters thick with sonar-foiling thermal layers, inconsistent salinity, and erratic bottoms, and extending hundreds of miles on a coastline as long as from Long Island to Key West in North America.

"The Baltic is good for submarine warfare," says Comdr. Carl-Gustaf Dybeck of the

Medieval-style houses haunt the heart of Gdańsk, Poland's main seaport, reminders of past glories. Once known as Danzig, it was a Germanic pillar of the Hanseatic League of merchant cities that dominated northern Europe.

Swedish Navy. "In some parts of the year it's almost impossible to hunt submarines except with other subs."

From Muskö Naval Base, south of Stockholm, we sail out one morning on H.M.S. *Umeä*, a Swedish sub hunter powered by Rolls-Royce aircraft engines and carrying a payload of eight Swedish RBS-15 missiles and six torpedoes. The *Umea* is part of a ten-ship joint exercise. It is the fastest conventional ship in the Baltic, like a greyhound at 38 knots in rough seas, streaking through narrow passages, spilling our wake on the rocks.

Comdr. Anders Stävberg, head of the squadron, joins me on deck as I grip the railing: "Only a helicopter can follow us along. In two hours we can reach Soviet waters with missiles; it's only five hours south for action against Poland and East Germany."

"But what about these subs?" I ask. The commander winces. "It's a little irritating that

we can't do it better. In 1972 we had the forces to hunt submarines, but then parliament figured there were better things to spend money on. By 1992 we'll have four more corvettes, and we'll start to hunt with effectiveness."

In the wardroom of the *Umeå* we feast on roast pork, lingonberries, and steamed potatoes. Says the ship's skipper, Lt. Comdr. C. A. Klingspor, "Frankly this sub crisis has put such a strain on the navy, no one has had time to take care of wife and family. Two weeks out, a weekend in. Living on a small craft. They've been holding seminars to help families stay together."

THE BALTIC is not a lonely sea. Joining the military parade are thousands of fishing boats, yachts and freighters, crisscrossing ferries, tankers, scows, research vessels, reefer ships, and transatlantic merchant vessels flying Liberian flags. From West Germany, daily "butter ships" selling groceries carry *Hausfrauen* back and forth to Denmark at nominal charge, so they can save some money on tax-free food and get a good chat in too. Robinson Crusoe would have been picked up and been back home by Friday.

As traffic swirls around it, the Kingdom of Denmark guards the Baltic like a sentinel. Its most easterly outpost is the island of Bornholm, an early-warning platform for NATO intelligence. When a Soviet cruiser eases out of Kaliningrad Harbor, on the Baltic's southeastern coast, it announces itself to the entire Western world. On Bornholm, Comdr. Ole Bretting picks up an echo from the cruiser's hull on his radar and sets the process of snoop-versus-snoop in motion.

"We'll shadow along and identify her," Bretting says. "A Danish patrol craft will hand her over to a West German boat that will follow her through the Danish straits. A helicopter will go out to take pictures. Finally she'll be handed over to the Norwegians. This is daily life. The Red Navy has grown to disproportionate size. It's their lake. But we can pinpoint all the ships to see if there is an incoming or outgoing trend. If there's an outgoing trend, something is going on in the world."

War and confusion suit Bornholm badly. In the village of Årsdale on the east coast, set in hollyhocks and lace curtains, red-tile roofs and half-timber cottages, I walk down the street and hear only the piping of swallows, the hush of waves against the harbor wall, and smell the alder smoke from herring being cured.

Like many parts of the Baltic, Bornholm was occupied first by Germany, then by the Soviet Union in the shifting fronts of World War II. Old fisherman Svend Clausen remembers: "One man hung his best suit of clothes on the apple tree outside. 'If they bomb the house,' he said, 'at least I'll have my suit.' "

Mr. Clausen deals rather briskly with German tourists: "They ask me where to go. 'You must know,' I tell them. 'You didn't ask directions in 1940.' "

The West German tourist fights the past all over Europe. And even the best beaches of the old German shore are now in East Germany and Poland, not prime travel destinations.

Once the German Baltic coast was the playground of the *Wandervögel*, youth groups of the early 1900s whose physical-culture movement was preempted by the Hitler Youth and muddled with their notions of Aryan supremacy. After the war West Germans had to rediscover their culture, and restoration of beach life at Travemünde, north of the old

Standing short for law and order, a statue playfully honors an imaginary market policeman in the Finnish port of Oulu. Before powerful icebreakers, Oulu celebrated FOW Day, for First Open Water of spring, when ships could get through with fresh goods.

Ten miles offshore, an ice fisherman checks a net by his portable hut (facing page). A branch marks his fishing hole. Hundreds of such Baltic fishermen work through the winters, ice or no.

city of Lübeck, was one of the first steps.

Since then, the Ostsee, or East Sea—as the Germans call the Baltic—has become a sort of German New Jersey shore, a frugal choice for the holidays. The region is suffering a mild depression, despite the 70,000 ships that annually use the Kiel Canal to bypass the Danish straits for Baltic ports. Lübeck alone has lost 12,000 laboring jobs in the past 15 years, many in the shipbuilding industry.

North of Kiel I wander along a beach where the shoreline is hacked off by the sea and the prevailing west winds as if by a butcher knife, leaving half a barley field, half a cow pasture. Offshore oil derricks sit like docked aircraft carriers in the haze.

On a sunny weekend some 50,000 come to fill the wicker *Strandkörbe*—beach baskets—of Travemünde, cocoons against the brisk wind. Thousands camp on the hook of land called Priwall, by the border with East Germany, the northern tip of what used to be the Iron Curtain. Behind an ordinary pipe fence painted red and white is an empty shore of Eden-like beauty, fragrant with new blooms of wild roses and flowering shrubs. The East German guard tower stands in the distance.

I walk down the fence, along the shoreline of a tidepool. Behind me a West German border guard leads his attack dog. He stops to smoke and throw a stick into the water, which the beast chases with foolish enthusiasm.

WHEN HERMANN AXEN, a leader of the Communist party in the German Democratic Republic (GDR), came to Washington last spring, he said quite bluntly: "You cannot mix socialism and capitalism, as you cannot mix fire and water."

To be a German is burden enough. To be a German Communist carries a double stigma that has toughened the leaders of the GDR, the little nation that could. Because East Germany has made communism work better than anyone else, they remain cold to the pressure for glasnost and perestroika and deny the failure such radical restructuring implies.

Says Dieter Noll, director of the port of Rostock, "There are many people who have two opinions—one private and one official. I'm not rich enough to have two opinions; official ones have served me well."

Noll, an impatient, broad-shouldered man, has no time for doubt; more than 3,800 ships a year pass in and out of his harbor, bearing the commerce of a nation: pulp and paper from Finland, chemicals from Latvia; trucks to Vietnam, rolls of steel plate to the Third World, urea and rock salt to the United States. Nearly 44 percent of all cargo involves the Soviet Union; 10 percent is transit goods for the landlocked European interior—Czechoslovakia, Hungary, Austria.

"At the end of the 1950s," Noll says with pride, "there was only a small harbor here. Hamburg and Lübeck were already world renowned. We built this from scratch into one of the largest seaports on the Baltic."

Noll scoffs at the prospect of independent trade unions like Solidarity in Poland. "Bargaining?" he asks. "The word 'bargaining' is a foreign one; we do not use this word. If the trade unions in our harbor want anything improved, they simply apply to the management. I've never heard a discussion—like in Poland—that they would demand more."

Dieter Kuntze, 38, lives in a four-room flat with his wife and two sons, within sight of the crane he operates for the harbor. He has been selected by the collective for this interview, but he is his own man. "We sometimes make a show—as if everything is great," he begins. "This is not right, huh?"

They could use a better stereo system, says Dieter, and the furniture is a bit old, but living standards exceed those of some Western

"They're still clean," says Danish fisherman Per Jørgensen of the codfish he nets off the tiny island of Christiansø near Bornholm, a yet unpolluted area of the southern Baltic. A rubber-roller winch helps pull in the catch. Jørgensen eases his one-man boat through November breakers into Christiansø Harbor (far left), later relaxing at tea with daughter Sara and wife Vita. Although pollution has reduced the number of its species, the Baltic is not yet overfished, thanks in part to a 1976 zone system that sets national boundaries but irritates fishermen accustomed to complete freedom.

An ill surf washes most Baltic beaches. In Estonia slaughterhouse waste from nearby collectives shut down Pärnu Beach, where a sign warns: "Seawater does not meet standards. Swimming is not advised." Experts say such pollution has plagued the water for years; only now have most governments given warning.

At the headquarters of a chemical company in Helsinki (above), a Greenpeace activist chains himself to a door to publicize ulcerous fish caught near the titanium dioxide plant in Pori.

nations such as Greece or Portugal. Even the long years of defensive isolationism seem numbered. In 1988 East Germans were permitted seven million trips to the West. Such travel is on the hostage system, of course; a family member must stay behind. Still, defections were quite high to West Germany.

"Those who have left have to prove to me that they have it better on the outside," Mrs. Kuntze says defiantly. "I have my job, and it's good wages. There's something on the table every day. If there is some lack, someone has not done the people's work."

"Well," says Dieter, "in our society those who don't work well get paid as much as those who do, and that's a big problem. People are lazy. But when you have competition, you have to get up early in the morning."

Mrs. Kuntze seems alarmed at her husband's drift. "There will be a time when capitalism will disappear," she says. "Social science will grow and grow. Of course, it will take 200 or 300 years."

THE PLAINS of Mecklenburg around the medieval Hanseatic town of Rostock always grew their cabbages, potatoes, and stubborn Junkers, landowners who resisted change and kept north Germany too long in military feudalism.

The roads are lined with trees, like soldiers planted at attention. Fields are bemedaled with scarlet poppies. In the evening, fog rises from the land, and families of wild boar snort along the forest edge. Not a billboard desecrates the open road. There is a sad nostalgia in the landscape, like a faded picture book that shows the innocence of better times.

My eyes sting from the soft coal burned for heating and industry and from the exhaust of inefficient two-stroke East German auto engines. I ask the head of the famous health spa

at Heiligendamm, famous for asthma cures, how he and other doctors can pressure the government to clean up the air.

He sniffs the sea breeze and says simply, "My air here is very good." But this is the summer to press the point, and finally he answers in impeccable social-speak, "In the frame of the possible, we are as angry as we can afford to be and remain progressive."

The plains sweep north along the fragile coastline, buttressed there by wooden pilings driven in the sand against the thieving surf. In a claustrophobic nation the seashore is the chance to breathe free. Thousands elbow into health spas, campgrounds, and beaches. Holidays are organized and monitored by trade unions; many have their own low-cost resort dormitories on the coast. Government-organized nudist beaches and camps rival "textile beaches" in number. Vacations on the Baltic are highly prized but available to the average worker only once in three years or so.

Much of life in the GDR seems drawn on graph paper, a life of straight lines and right angles, each worker in his little square, a unit in the grand design of state. So it is a pleasure to find a little silliness in Warnemünde, a resort town north of Rostock, where the Baltic Sea Festival features races between goofy boats built of plywood and inner tubes.

One boat is manned by "workers" in construction helmets; another is powered by "bureaucrats" in coats and ties, typing at a floating desk. King Neptune comes upriver with his entourage—a cassocked priest, a crew of frogs, and maidens dressed in seaweed.

The crowd gathered by the riverbank is tentative—not quite knowing when to clap and when to cheer. They haven't had any practice laughing at themselves. But they have had their bread; now they have their circus. So far, so good, says the government. Stick around.

Stereos and microwaves are on the way. But we're going to do it on our own—from scratch if possible, without that perestroika.

FROM THE SANDSPITS of the GDR the road rolls into the Polish People's Republic, a wounded nation just plain uninterested in communism, now or in 300 years. "In the GDR," says journalist Rafał Jesswein in the port city of Świnoujście, "they haven't noticed that Stalin is dead."

By the Bay of Szczecin, in Wolin National Park, a white-tailed eagle named Kuba sits brooding in a small aviary. Kuba is not well, for a national symbol. First of all, he has been without his royal crown since 1945. Second, his breed is dying in the Baltic, because the fish the eagles feed on are contaminated. Only five nests survive in the park.

The Baltic is burdened by 70 million people and their massive industrial output. The sea is sluggish and virtually tideless, much like a lake. Its salinity is replenished largely by storms that force North Sea water through the Danish straits. Such a flush is vital to marine life in the Baltic, but the sea has remained stagnant now for a record ten years. Its deeper layers have spent their oxygen, and some areas are completely devoid of life.

Man has compounded the Baltic's own limitations by overloading the sea with pesticides, toxic industrial wastes, and excessive nutrients in the form of nitrogen and phosphorus from municipal sewage and agricultural fertilizers. Some species of wildlife, such as Baltic seals, have been brought to the edge of extinction. Last summer, for the first time, most of the beaches on the Baltic were closed.

Yet the Baltic is not the most polluted sea in the world. Says Estonian environmentalist Harald Velner, "It is merely the most examined." In 1988 Professor Velner was executive secretary of the main group of examiners, the Helsinki Commission, the permanent committee established to implement the Convention on the Protection of the Marine Environment of the Baltic Sea Area—an extraordinary working agreement signed in 1974 by all seven Baltic nations. The commission is chaired in turn by professionals from each nation and meets annually.

After a decade there is progress: a decrease in DDT and PCB levels, a reduction in mercury concentration in fish, the control of discharges and oil spills from ships. At their meeting in March 1988 the states agreed to cut by 50 percent their input of nutrients, heavy metals, and organic toxins by 1995.

Among Baltic polluters Poland has been a heavy contributor and faces a stiff challenge with the new guidelines. Practically the entire nation—the coal mines of Silesia, the cities of Warsaw and Kraków—feeds the Baltic. Its population of 37 million is more than twice that of Finland, Sweden, and Denmark combined. But now Warsaw has a new sewage-treatment plant, and 25 others are being built on the coast. Most are due on line by 1992.

Says Anna Trzosinska of the Institute of Meteorology and Water Management in Gdynia, "Sixty percent of our nutrient input comes from agriculture. In heavy rains it's just drainage off the land. We will never reach this 50 percent removal. . . . All the countries will have trouble making it. When we signed, we signed the text that the countries will be *trying*—a goodwill act."

THE POLISH COAST rests on two urban-industrial pillars—the Szczecin/Świnoujście complex on the west and Gdańsk on the east. Between them hangs the potato kingdom, Pomerania, with its fields of white potato blossoms, tufts of dense forest, and seaside lagoons inhabited by wild swans.

For centuries Pomerania was trampled by some form of Germans on their way east—Teutonic Knights, the armies of Brandenburg, Prussia, and the Third Reich. Gdańsk was the free Germanic city of Danzig. Slavic Poland was largely impotent, often blocked from the Baltic coast, carved up among successive powers. Today Pomerania is finally rid of its Germans but occupied still; until midnight Soviet fighters thunder in and out of their training base east of Kołobrzeg, keeping the tourists restless.

The Poles are well dressed, handsome, and somehow on a larger scale than their surroundings, as if they have grown since the war and Poland itself has not. They walk about their shabby, construction-site cities like cavaliers, with the hint of the Tatar in them, kissing the hands of women in greeting. In Leningrad it was just the opposite: The people seemed too small for the buildings.

Across rural Poland, through villages and goose farms, past manure piles and storks' nests, rose gardens, and shrines guarding

crossroads, I reach the resort of Sopot, once known as the Pearl of the Baltic. Here too the beach is closed. Sopot was once the playground for the people of Gdańsk, whose own bay has sunk into squalor. Now there is nowhere to swim within 100 miles. But some still venture into algae-rich water the consistency of broccoli soup. I see one man bobbing his infant son up and down in the water.

"I *paid* for my vacation," he tells me, "and I should enjoy it. If it's so dangerous, people should have been warned about it earlier. Hey, they say if you don't get sick in three days, then you're all right. The water's warm. It's a shame to waste it."

Gdańsk, a city of aged and spiraling ironwork and guild houses left from Hanseatic days, has made its modern mark as the home of Solidarity, Poland's independent trade union and unofficial popular front. Solidarity grew from the Lenin Shipyard here and threatened a Polish spring before martial law was imposed in 1981. Now Lech Wałęsa is negotiating with authorities again, and the union has found new legitimacy as Poland grapples with its economic demons. But the shipyard itself may soon be closed; lack of orders, the government says. Here, as elsewhere in Poland today, workers are looking for a way out. Thousands have left Poland for good.

"It is a very big shame," says ship worker Benedykt Bruski when I visit the yard. He waves his hand to dismiss all dissent. "If I have a wife and children, I should support them and not send them to the neighbors for food and clothing; it's a matter of pride. That's what our government has done. They should have been a better father. But still, I'm also ashamed of all the Poles who stay abroad. They're deserting a sinking ship."

Polish women seek desperately for any warm body of a Swede or West German to marry. University professors wash dishes abroad and return to buy villas. And there are thousands like Zbigniew Potrzuski of Szczecin. He has contracted to work for a year as a chemical engineer in a developing country, where he will be paid in hard currency.

"Libya is my perestroika," he says. "One of our leading Communists has said that every man is responsible for his own wealth."

"That's a very capitalistic idea," I offer.

"It's a very human idea," he says.

NEW IDEAS, seductive and bordering on the seditious, have spread epidemically in the Baltic States of the Soviet Union. "Popular fronts" in support of perestroika have materialized almost overnight in Estonia, Latvia, and Lithuania to test the limits of possibility. The bottom of orthodox communism has collapsed, revealing a stagnant center. Hard-line Stalinists have been ousted. The truth about the Soviet Union's annexation of the Baltic States, crated and buried in revisionist history for two generations, has been resurrected and paraded in public like a hero. Speech has become the new intoxicant. Once forbidden words, sentences, emotions, tumble over one another, leaving the population light-headed in disbelief.

Gentler waters rinse a family at an East German nudist camp on the Darss peninsula, where bare beaches outstretch "textile beaches" five to one. "Everyone here is equal, no trouble," said one camper. "It's different in textile areas. Maybe when you take off your clothes, you take off your aggressions too."


VISA GOLAND RUNT
GPI
GPI
GPI

Life's a breeze in the Åland Islands (above), a military-free archipelago between Finland and Sweden. Ålanders speak Swedish but are citizens of Finland.

Visa and other corporations sponsor Baltic yachting events such as the Gotland Runt in Sweden (far left). After the race a winning crew pops its corks on the island of Sandhamn. At Kiel in West Germany (left) yachtsmen beach their craft after an international regatta.

Until last year the people of the Baltic States felt like American Indians—left with their dances and songs and language. They had watched an immigration of Russian and other Slavic workers tip the population balance until Latvians lost the majority in their own nation and Estonians composed only 60 percent of theirs. Only Lithuania successfully kept its ethnic population, at 80 percent. Now Russification is open to criticism. Many speak of a national rebirth.

All this has been a calculated gamble, roughly choreographed by the Kremlin. Estonia, Latvia, and Lithuania were independent parliamentary democracies for 22 years. They are the Soviet Union's link to the West, the only people with a living memory of free-market economics, and thus the prime candidates for experimental change. Their success would legitimize perestroika and quicken more sluggish parts of the Soviet Union.

Politically the Baltic experiment plays with a deep-smoldering fire. So far the Communist Party has been a participant in the movements, hoping to control more radical elements, but the Baltic people also remember with vividness and hostility the deportation of thousands of farmers, teachers, merchants, and intellectuals to Siberian labor camps in 1940 and the brutal humiliation that followed. For many, support for perestroika is only the first step toward the national dream, to rid the nation of its Vandals and Visigoths. Moscow may have underestimated the impact of offering such people free speech.

PHOTOGRAPHER Cotton Coulson and I were the first Americans in decades to visit Neringa, on the delicate pine-scented sandbar that links the Lithuanian port of Klaipėda to Kaliningrad, a closed and secretive oblast of the Russian Republic wedged between Lithuania and Poland.

Even in this vacation hideaway conversation quickly turns, unsolicited, to politics. "I think about these problems every day—every night," a man from Vilnius tells me on the street. "People are at a boiling point. For many years we have been in chains and handcuffs. Now the Russians are looking to us for success. They need Lithuanians to begin these things. But we are only a drop in the sea."

Lithuania looks prosperous. The earth is a dark chocolate, and farmhouses are smothered in flowers and fruit trees. Silos and haystacks, iron red cattle, and fields of clover rush by the windshield of our microbus. Buildings are better painted, brickwork tidier, shops a bit brighter than in Poland. In Klaipėda we marinate in a traffic jam worthy of Rome. Along a peaceful canal in the rebuilt city one evening I chat with two worm fishermen, Anatoli and his son, Kostya, age seven.

"I grew up under Stalin," says Anatoli, "but he turned out to be the enemy. Hah! I've seen lots of leaders come and go, but Gorbachev is the best yet."

Anatoli knows all about American politics too; he quizzes me on Jesse Jackson. I ask if he would like to travel to America. The idea seems suddenly less preposterous to him. "But I'd have to save for three years," he says, smiling. "Oh, I'd go someday."

"If Mama lets you," says Kostya wisely, biting into a green apple.

The Baltic States are among the smallest of the Soviet republics, but the most urban and literate. From one state to another, culture changes sharply. Lithuanians are Roman Catholics with historic ties to the Poles. Latvians are Lutherans and speak a different Indo-European tongue. Estonians are Lutherans, linguistically among the Finno-Ugric stock, which includes Finns and Hungarians.

For years the republics have shrewdly used environmental issues as safe but vital battlegrounds to resist the central control of Moscow. In Estonia dangerous and unwanted plans by central ministries to strip-mine more phosphate near the Baltic coast, to build an oil terminal near Tallinn, and to construct more shale-oil-burning electric power plants have been thwarted by popular resistance. In Latvia a grass-roots group called VAK has taken the initiative, leading a protest march of 15,000 people to temporarily halt the construction of a subway under the capital city of Rīga.

"A subway would require the importation of workers from Russia," says a young man from Rīga. "And besides, Russian construction is so bad that we don't trust them blasting and tunneling under the old city."

The closing, for at least five years, of Rīga's Jūrmala Beach was a heavy blow. At the acerbic local newspaper, *Jūrmala*, editor Aivars Baumanis is indignant: "We can't swim in the sea—it's the first summer. . . . It's absurd!"

Jūrmala is soiled mostly by the ancient Sloka pulp-and-paper plant, only 15 miles upstream, that spews its poisons into the Lielupe

River and the Gulf of Riga, now one of the dirtiest bodies of water on the Baltic.

"Our factories have been controlled by all-union ministries in Moscow," says Baumanis. "Such ministers don't care about the ecology of the republics. Five years ago we couldn't say anything. It was taboo to discuss dirty water. It was *top secret!*"

Baumanis laughs heartily and lights another cigarette. "But now it's changed. Now we talk openly about it. Glasnost! Now they have the commitment. . . . The Sloka factory will be closed by March 31. We can clean up our water. We have to overcome barriers—lots of fools are still in the way. But we can do it."

BETWEEN LATVIA and Estonia we pick up a Russian woman and her daughter, hitchhiking to catch a Moscow train. They had been camping on a Latvian beach. "I've had a lot of arguments with people here," she tells us. "We Russians want to make all nationalities happy, but these Estonians and Latvians. . . . It's a shame. They say that only *their* country is their motherland. It's like Californians saying that their state is their only country. I don't understand."

In Estonia there have been no burning tires and tear gas in the streets; intellectual force and restraint have been the weapons of rebellion. And Moscow has given Estonians remarkably free rein. Hundreds of thousands, including new Communist Party leader Vaino Väljas, have gathered in Tallinn to sing full-throated and righteous patriotic songs. Flag-waving demonstrators gather daily in Tallinn. Since last June, police have watched from a benign distance.

On August 26 I join a protest to mark the anniversary of the Molotov-Ribbentrop Pact of 1939, whose secret protocol divided Eastern Europe between Germany and the Soviet Union and led to the Soviet annexation of the Baltic States. At a rally in Hirve Park, Hitler

A short history of Latvia, one of the Soviet Union's three Baltic republics, plays out on the streets of Rīga, the capital, as Latvian girls dressed in ethnic costumes for a folk dance share the sidewalk with Soviet police. The Baltic nations, now asserting themselves, were forcibly occupied by the Soviet Union in 1940.

and Stalin are called "colleagues," and Russians are rudely invited to "go loaf around in their own country." The old Estonian Hymn is sung, haltingly but reverently. In a bizarre touch, a police car leads the mass march down the avenue to the harbor to the chant, "Russians go home! Russians go home!"

Says Endel Lippmaa, a scientist and veteran of Kremlin corridor battles over the environment, "Gorbachev is using Estonia to demonstrate that he is a man of goodwill. In order to make perestroika credible, he must use some bait—it suits global politics. I hope that he is sincere. But, at any rate, we must use this situation to put our house into better order."

Few feel the Baltic States can con their way into full independence. The Kremlin has already squelched hyperventilated calls for a separate Estonian currency, diplomatic corps, and membership in the United Nations and the Olympic committee. The Kremlin needs Estonia to perform; it wants to see black ink, not rebellion, in return for the risk.

But Estonians feel that economic success must be predicated on full autonomy. "Look at it this way," says the erudite secretary of the Estonian Writers Union, Lennart Meri, "the most peaceful and effective border of the Soviet Union is with Finland, not with the satellite countries like Poland . . . because Finnish-Soviet trade is extensive and beneficial. This border could extend to the Baltic States. Ten years . . . give us ten years to begin to offer the same economic advantages to the Soviet Union as Finland does. It would work."

Estonia, with less than one percent of the Soviet population, already has more than half the nation's joint-venture enterprises with the West. Private cooperatives such as coffee shops and grilled-meat stands have sprung up by the roadsides. A group of young wits from the resort town of Pärnu sells cans of seawater as gag gifts; on the labels they list the high pollution levels and give medical instructions.

In Pärnu the beach is closed, but the Neptun cooperative still runs its beachfront shop, renting surfboards and beach chairs. The crowds have been thin. "But it's not just the pollution," says the young manager. "The Russians are just as afraid of our blue-black-and-white as they are of our water. In Moscow they tell each other that Estonia is dangerous now—like we were going to kill them or something!"

In other parts of the Soviet Union such raw enterprise is still controversial. Not so in Estonia. "We've earned everything honestly," says Andrus Sukles, one of the founders of Neptun. "The only trade-off has been our nerves, our stress.

"But you know what I really like about today? They tell us, 'If you're a man, do it!' That's what I like."

PHOTO J. VESILIND

Bitter memories fuel Estonians in the capital city of Tallinn, demonstrating on the anniversary of the 1939 pact between Germany and the U.S.S.R. that paved the way for annexation of the Baltic States. "A free Estonia," reads one banner. On a Tallinn street (opposite) a sign demands: "KGB under control of the people!" So far, Moscow has been tolerant.

WE DRIVE ALONG the southwestern shore of Estonia in a storm. The beach is scrubbed by gray waves that foam through the reeds. The rain sweeps in, fresh from the west, as we stop at a campground where families from the village of Türi have come for their holidays. Above their tents flies an immense old


KGB.
RAHVA
KONT-
ROLL
ALLA!

The Iron Curtain just dribbles into the sea at Priwall in West Germany, where visitors come to gaze quietly across the border with the German Democratic Republic. In a time of hope the Baltic may be moving toward a true community of nations.

Estonian flag, resurrected from someone's attic, where it had been hidden since 1940. They embrace me like a lost son, offering champagne, talking all at once, eager to tell about their remarkable summer.

"In our village we're digging out the monument to the Estonian War of Freedom from under the asphalt," says Theo Aasa, one of the leaders. "People remembered where it was buried by the Russians. This is a mass movement. It's everywhere! You can't stop it!" His face brightens. "And no one is trying."

So far. So far. We take pictures of their beautiful old flag. "The old people are

weeping," says Aasa. "This was unexpected in their lives."

We leave them gathered around the flagpole, these people from Türi, and walk back toward our microbus. Suddenly I hear applause behind us, warm and steady. They are clapping for us, for themselves, for the truth that electrifies the Baltic air, that men should be free. I try to wave good-bye from the window as we pull out, but my eyes well over, and I bury my head on the back of the seat in front of me.

My mother has always told me that the Baltic Sea is shaped rather like a woman kneeling in prayer—her cowled head bowed between Finland and Sweden, her robe trailing off into Denmark and the Germanys, her knees pressing down on Poland. But her arms—they are embracing Estonia.

My journey ends with a full heart. Men of goodwill are about, and there is hope. The warships of seven nations still glare at one another. Pulp mills and chemical works still disgorge their poisons. But now we know that we all live on the same sea. Surely we can solve the ancient riddles that divide us. As the admiral said in the confused but expectant city of Leningrad, "Well . . . why not?" □

ARE THE SWISS FORESTS IN PERIL?

IN THE VERTICAL REALM of the Swiss Alps, mountainside forests called *Bannwälder* guard towns and farms, roads and railways from snow avalanches, toppling rocks, and earth slides. The village of Andermatt on the northern approach to the St. Gotthard Pass is sheltered by a Bannwald set aside for protection in 1397, supplemented today by artificial barriers. Centuries ago overcutting denuded many Swiss valleys. Resulting disasters gave rise to an ethic of conscientious forestry, and the Swiss have invested enormous amounts of labor and expense to maintain the vital trees. Yet today more than half the trees in the Swiss Alps show signs of stress and decay; some forests are near collapse. Air pollution, human alteration of land surfaces, past forestry practices, and weather extremes are leading causes of damage. With some of the strictest pollution-control laws in Europe and a massive emergency-care program, the Swiss have begun to battle back. CHRISTIAN MEHR

Text by CHRISTIAN MEHR

Photographs by
the author and SAM ABELL

LIKE MOTH-EATEN HOLES in a carpet, unsightly clearings appear in forests afflicted by both natural forces and human-induced stress. Photographed in June of 1985 (top), a hillside above the village of Bristen, in the valley called Maderanertal, three months later shows an expanding hole scarring the weakened forest (above right).

Stumps stand where dead or dying trees were cut and removed by forest crews to prevent infestation of neighboring trees by bark beetles, which breed in weakened trees. Felled trunks serve as temporary avalanche barriers (above), erected above their homes by villagers from Bristen on a slope recently cleared of damaged trees.

Traditionally the forest workers of Bristen spend autumns and winters in the woods, summers in the fields and steep pastures of small farms handed down through generations. Their local forests are communally held, as are most of those in Switzerland. Nationwide 26 percent are privately owned, while only 6 percent are held by the state. A century ago Switzerland was a rural, wood-burning country, and timber was a prime building material, providing income as well as protection from avalanches.

But today incomes from small mountain farms are meager by high Swiss standards. Rather than work for low pay in the forests, "rucksack farmers" stream down the mountain roads to jobs at building sites,

ALL BY CHRISTIAN MEHR

factories, or tourist-oriented facilities in the more developed main valleys. Consequently, many formerly well-groomed forests have fallen into neglect.

So vital to the country that they were placed under strict federal conservation laws a century ago, Alpine forests have drawn attention throughout Switzerland due to the extent of damage they have suffered in only half a decade.

After windstorms threw down trees thought to be weakened by environmental conditions, lack of care allowed beetle infestation to enlarge the damage. Less visible but equally to blame are forestry practices that led to single-species forests with trees of uniform size and age. But it is air pollution, wafting into the high Alpine valleys on the breath of the 20th century, that is one of the main suspects in the forests' present ill health.

Alpine forests grow in extreme conditions. Under a thin layer of soil on steep slopes, roots penetrate the finest crevices to anchor trees to rock. Climate is harsh, and trees often cling to the margin of survival.

Air pollution, as with acid baths of rain and fog and increased ozone, can injure needles and leaves, while also changing the chemistry of soils and plants' ability to absorb nutrients. Such strains may be the final insult to an already stressed tree and push it over the edge of health into needle loss, reduced growth, susceptibility to disease and parasites, and root damage that increases vulnerability to wind.

Threats to an Alpine Valley

THE TRAFFIC OF CENTURIES has traveled along the Reuss River Valley and over the St. Gotthard Pass, a portal in the mountain barrier between the Germanic north and the Mediterranean south in use since the Middle Ages. The crossing, once a strenuous and dangerous hike of several days and much celebrated in Swiss legend and history, now takes an hour or two. A road tunnel carries more than four million vehicles through the pass each year—a figure that grew rapidly with the completion of the tunnel-and-highway system in 1980, bringing with it a burden of increasing air pollution.

More than 58,000 trains roll through a railway tunnel each year, hauling 5.5 million passengers and 12 million tons of goods, making the Gotthard commercially and strategically important to much of the Continent—a fact not lost upon the Swiss.

Engineering feats costing billions of Swiss francs have gone into steel barriers that trap snow and rocks, thick protective roofs of reinforced concrete over roads and railroads, and enormous catchment systems for the control of flooding and erosion in this wild mountain valley. Yet even such elaborate fortifications cannot take the place of sheltering trees. As forests thin in critical areas, dangers of rockslides and avalanches (arrows) will increase, while flooding could grow more severe from deforestation throughout the drainage area. The Gotthard region is not alone—a survey of local foresters in 1985 identified an Alps-wide stippling (map below) of areas perceived to have seriously declined in the three preceding years (yellow dots) or to have reached a point near collapse (red dots).

New rockslide danger with continued forest deterioration

New avalanche danger with continued forest deterioration

Severely damaged forest

Disintegrating forest

Flood zone

Avalanche barrier

Declining Swiss forests

- Forest decline above average
- Forest in critical state

NGS CARTOGRAPHIC DIVISION; PAINTING BY CHRISTOPHER A. KLEIN; RESEARCH: MICKEY EDWARDS, UDO MERZ; PRODUCTION: BARBARA TARRIGAN, JAMES E. MCCLELLAND, JR., MEGHAN M. RYEFIELD; MAY KOTOW/ GUS PLATIS


to
St. Gotthard
Pass
Oberalppass
Bristen
3,072 m
10,079 ft
Andermatt
Gotthard
tunnel
entrance
Göschenen
Zugwald
Reuss
Bristen
Gurtnellen
Amsteg
Erstfeld
Reuss
Altdorf
Gotthard
highway
Urner See
434 m
1,424 ft
NORTH
Scale varies in this perspective.

CUTTING A TREE to save a forest, the local chief of forestry fells a spruce whose weight threatened to rip out an eroded patch of soil on a steep slope above the resort town of Flims. Much of an Alpine forester's work is in such emergency care, wrestling with the elemental forces of the mountains while fighting against creeping decay. After recent replanting efforts, 2,500 seedlings slipped over a cliff face above Flims when the exposed soil

SAM ABELL (TOP LEFT); CHRISTIAN MEHR

liquefied after a summer's rains.

Better fortune is expected for seedlings on a slope near the Maderanertal (above right). Tripod protective poles should prevent shearing off by sliding snow on a mountainside steep enough for avalanches—one that healthy trees can stabilize and keep safe.

Healthy trees usually present themselves as close, compact, dark silhouettes against the sky when viewed from a tree-length distance (far left). A suffering tree is revealed when large parts of the trunk and the skeleton of the branches become visible and patches of sky show through a shredded cover of needles (left) or leaves.

Confusing scientific counterclaims swirl around the question of what percentage of needle or leaf loss constitutes ill health or represents a threat to a tree. Some argue for a definition of 25 percent loss, others for a higher or lower figure. Arrested foliage loss in 1988 may be due to ideal seasonal conditions. But a hike through Alpine forests can show even an untrained eye what the Swiss Federal Institute of Forestry Research disclosed in December 1988 for the third consecutive year: More than 50 percent of the trees in the Alps show a disturbing loss of vitality.

A dense crown canopy protects the forest against storm attacks. Once just a few trees collapse, the wind can sweep into the gap and expand the hole. Then erosion often becomes the major concern: A few heavy rainfalls can strip newly denuded soil from a steep slope, and no new forest can take hold on bare rock.

AN AVALANCHE brooks no debate in its course, traveling as fast as 300 kilometers an hour, carrying with it whatever lies in its path. Dirty stains on the mountainside above Bristen mark the paths of avalanches through the woods, over pastures, and past farmhouses below the thinning Zügwald, as Bristen's forest is called. Residents in exposed farms sleep in their basements during nights of avalanche danger. In the spring of 1987 torrents of snow, soil, rocks, and trees swept into the Maderanertal, burying fields, roads, and footpaths used daily by farmers and schoolchildren. Walls of debris bordered the newly cleared roadway (right).

Avalanches have always plagued Switzerland's valleys, and mountain dwellers have traditionally built in the shelter of dense forests. In the disintegrating Zügwald, construction began last summer on a costly system of steel barriers to prevent avalanches where collapsing forest has created new danger zones. Erosion is already attacking the thin layer of soil. In a race against time the foresters and farmers of the valley are engaged in a painstaking program of reforestation.


HB-XFM

HAULING HAY by skyhook, a helicopter lifts a load from a high pasture in an effort to protect the stability of slopes in the Alps. Steep slopes were formerly cut by farmers to whom the hay was worth the climb. Left uncut because of changing economics, tall grasses provide a slick surface for snow burdens to avalanche.

More dependent on its forests' protective role than perhaps any other European nation, Switzerland in 1983 launched an impressive program called Sanasilva, in which trees at points of intersection of a four-by-four kilometer grid over the entire nation are checked each summer by federal inspectors. Forests are also analyzed through infrared aerial photography. In 1985, 42 percent of the trees in the Swiss Alps showed signs of damage, 27 percent in nonmountainous areas. In 1987 the figures rose to 60 percent in Alpine areas, 48 percent in nonmountainous regions. Some improvements were reported in 1988, a year of exceptionally good growing conditions.

Widely divergent theories at first attempted to find single causes for the forest damage. Today it is generally accepted that the problem stems from different kinds of stresses, varying from one locale to another. With its staff increased in recent years to cope with massive research demands, the Swiss Federal Institute of Forestry Research is studying the influence of climate, site conditions, ozone, sulfur dioxide, and other environmental factors.

Through experiments in open-top chambers (top right), scientists are investigating the effects of ozone. Recent studies of Scotch pines exposed for several weeks to ozone concentrations of 100 micrograms per cubic meter—what you would expect on an average Swiss summer day at 1,600 meters (5,250 feet)—have shown noticeable changes of biochemical processes in the needles. Research is also directed into chemical changes in the soil.

Because of the complexity of the forest ecosystem and the mass of influential factors, no definite answers have yet emerged. However, as institute director Rodolphe Schlæpfer says, "new and widespread symptoms of forest damage cannot be explained in most cases without the influence of excessive, man-made air pollution." Easter weekend at the Gotthard tunnel's entrance (above) brings not only a day-long jam of travelers headed for sunnier climates but also higher levels of stress for nearby forests. Pollutants from more distant sources—Europe's major industrial centers—can also reach the Alps. The situation is intensified when weather conditions trap air in steep valleys, increasing the concentration of pollutants.

While Switzerland has toughened its antipollution laws, some of its neighbors have not. Fume-billowing foreign trucks add greatly to pollution in Alpine valleys. Restrictions on the size of trucks allowed on Swiss roads have brought angry calls for boycotts from other European countries that use them heavily. A proposed trans-Alpine tunnel-and-railway system to ferry cars and trucks through the country could help solve the problem. Meanwhile, Swiss trains are experimenting on a smaller scale: hauling trucks through the pass on railcars pulled by electric power.

SAM ABELL (TOP); CHRISTIAN MEHR

TERRIFYING FLOODS in the Reuss River Valley historically forced people to build homes close to the foot of the mountains to avoid the river in rage. They trusted in the Bannwälder to guard them from falling rock and avalanches. Forests also play a crucial part in flood control: Leaves and needles break the impact of hard rains and prevent erosion, while spongy soil with a fine network of roots soaks up a large amount of water.

In August 1987, after heavy rains in the sparsely forested Andermatt region, floodwaters jumped the river's banks, a rare occurrence in modern times. Water spread over fertile farmland (right), the Gotthard highway was badly damaged, railway tracks washed out, and all traffic stopped for several days. Damage came to more than half a billion Swiss francs (320 million dollars).

At Gurtnellen the Reuss nearly doubled its width, shattering homes and ripping away part of the massive stone church and its centuries-old graveyard (below). If Alpine valleys become more severely deforested, the destructive effects of hard rains could reach far into Switzerland's flatlands.

CHRISTIAN MEHR (ABOVE); BOB PHOTO AGENCY

WORKING to beat the devil, foresters prepare foundations for avalanche barriers in a steep section of damaged forest. In a legend the devil himself was the engineer who showed how to bridge an impassable gorge on the northern approach to the St. Gotthard Pass. He demanded in return the first soul to cross the bridge—so the locals sent a goat. A huge boulder placed by the frustrated devil stands by an entrance to the Gotthard tunnel, where engineers moved it to make way for the road.

CHRISTIAN MEHR (BELOW); SAM ABELL

The Swiss have indeed drawn on cunning and engineering to thrive in the Alps. The demand for permanent, safe, and easy passage over the mountains has resulted in an impressive collection of artificial protective structures costing billions. Steel barriers march across naked slopes (below), too high and steep for forest. But this costly security affords limited protection against the urge of mountainsides and their burdens to move. The use of artificial structures is sometimes impossible because of topography. Against floods and erosion there is yet no cure-all. Without intact forests the mountains' forces could banish humankind from much of the Alps. □

SAM ABELL

At the foot of an avalanche chute, a train en route to a popular ski resort creeps into a reinforced tunnel. This 1988 slide blocked the entrances, which had to be dug out overnight. Avalanches on this route have knocked trains off the tracks. A train engineer says of avalanche avoidance during times of high risk, "It's not knowledge. It's luck."

Boxful of mementos tied to American history is the legacy of Benjamin P. Field V (left). Most likely packed by Field's 19th-century ancestors, the box will be opened for a national television audience April 30. "The real mystery is what the papers inside reveal," says former Chief Justice Warren E. Burger, chairman of the Constitution's Bicentennial Commission.

in a Box

Is there a home without one, an old box sleeping in an attic or under a basement stair, filled with memorabilia of events past? Once in a great while it is opened, and the bittersweet scent of the vanishing past, cobwebs and gardenias, gives dimension to the present.

Rarely a family-kept repository celebrates a national event, and the private papers become of public interest. Last fall, Benjamin P. Field V of New York brought such a treasure to the Geographic, a wooden box covered and lined with metal that had been handed down in his family, from one Ben P. Field to another, for at least a century. His father told him that it was to be opened in 1989 and that it contained memorabilia of George Washington's first Inaugural.

Ben asked us to act as observers when he opened the box. It was a fascinating prospect, as though a missing cornerstone from the Washington Monument had suddenly materialized. We asked his permission to probe the box with remote-sensing techniques, so the opening would not damage contents (following pages).

As we viewed the CT (computerized tomography) scans, the colorful tapestry of the American past began to unfurl in the black-and-white images:

Washington was 57 when he took the first presidential oath of office on the balcony of New York's old City Hall, before a crowd so dense that "one might literally walk on the heads of the people." He spoke movingly of "my country, whose voice I can never hear but with veneration and love . . . ." It seemed his character and idealism were the most valued assets of a nation-to-be that had discarded the cohesive forces that bound together other nations—monarchy, aristocracy, and established church.

Historian David Ramsay spoke for all when he said, "A long time, and much prudence, will be necessary to reproduce a spirit of union and reverence for government."

That long time included the bitter Civil War, but by the time the 23rd President, Benjamin Harrison, celebrated the centennial of Washington's Inaugural, the United States was a land transformed and virtually completed.

In that year, 1889, and the next, Montana, South Dakota, North Dakota, Washington, Wyoming, and Idaho were added to the Union. The long and shameful trail of Indian blood had led finally to Wounded Knee and more than 200 deaths, two weeks after the first Army-Navy football game was played.

Even though farmers were going bust and factory workers were being exploited, many prospered as people never had. While factory workers worked 10 to 14 hours a day, individuals accumulated millions. Against such privilege rose organizations like the National Grange and the American Federation of Labor.

Harrison would soon be demanding indemnity from Chile for an attack on American sailors, and the organizational descendants of Washington's regiments would be drawn into the overthrow of the government of Hawaii.

Expansion and prosperity and the struggle for social justice, devotion to public education for self-government, acts of shame and cowardice, self-indulgence and generosity in public life, that elusive spirit of union, that hard-attained reverence for government—the democratic struggle recalled by memories from a box.

Joseph Judge

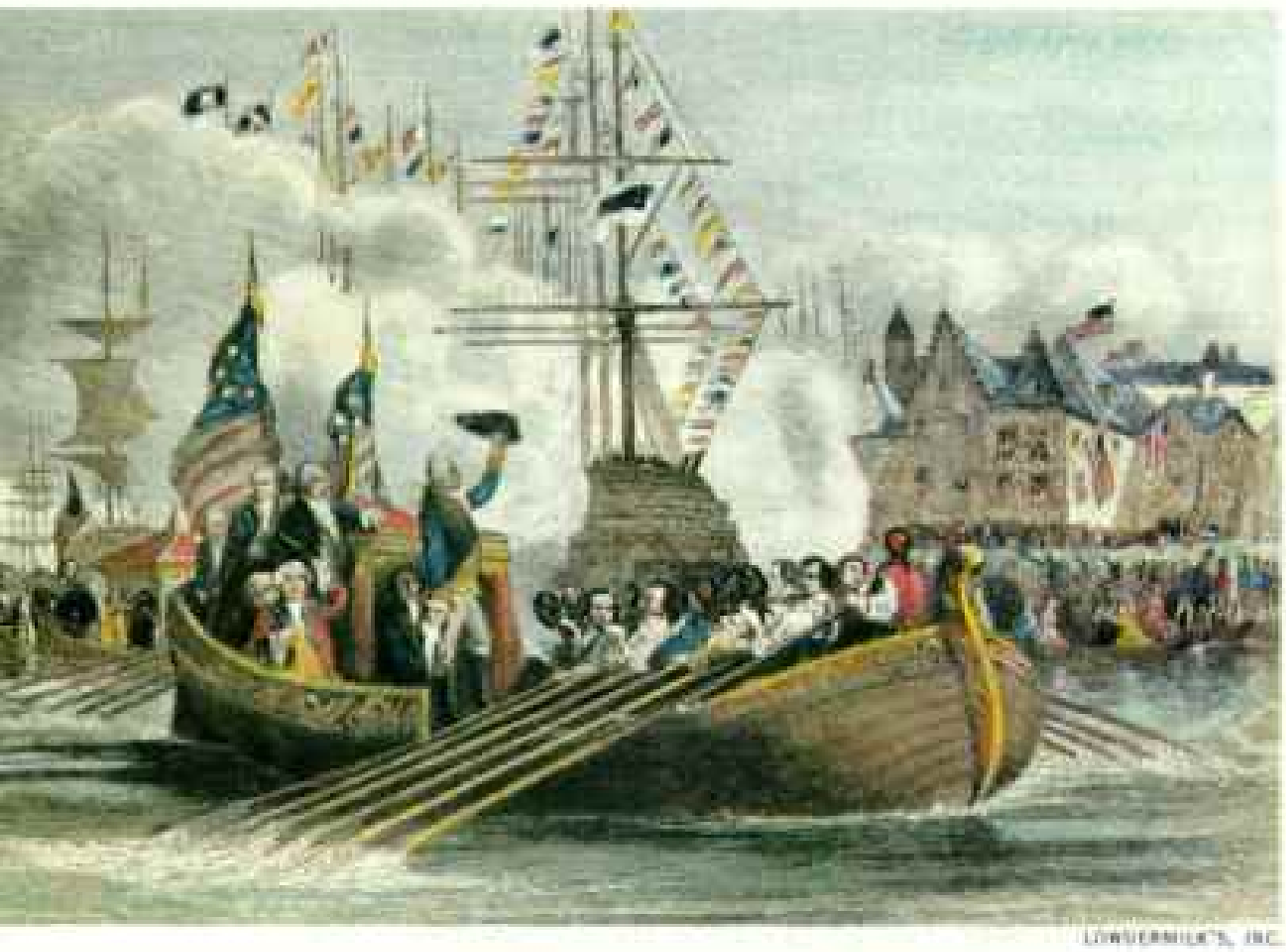
SENIOR ASSOCIATE EDITOR

By BENJAMIN P. FIELD V

Photographs by
SISSE BRIMBERG

BOUND for the nation's first presidential Inaugural, George Washington crosses New York Harbor and doffs his hat to an admiring capital city (below). "The music of the drums and the ringing of the bells were enough to stun one with the noise," an observer recalled. A week later, on April 30, 1789, Washington was sworn in.

To mark that event a century later, Congress declared April 30, 1889, a national holiday, and another new President, Benjamin Harrison, returned to the first capital for parades, speeches, and fireworks. Harrison, in a carriage, followed Washington's route up Wall Street, passing under a temporary arch erected by merchants (below). "The path of sight," said an organizer of the event, "was bounded on each side by the walls of immense high buildings, each structure radiant with rainbow-hued buntings . . . each window gleaming with bright eyes, every cornice fringed with faces." The language reflected the



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hopeful spirit of the times. By April 1889 the Civil War was a receding memory, the Western frontier seemed secure, and the future promised stability.

The centennial offered an opportunity to reflect upon the past and to mark a young country's progress. Exhibits of Washington memorabilia went on display in major cities, souvenir medallions and books were issued, and in the village of Babylon, New York, a tinsmith and inventor named Benjamin P. Field II is credited with assembling a box of mementos for his descendants. My great-great-grandfather's shop, where he probably built the time capsule, still stands (bottom left).

Almost 30 years have passed since I first saw the box. I was only 12 when my father showed me the trunk half-hidden under the stairs in the dim light of our basement on Long Island.

I remember running my fingers over the lettering on the box's metal exterior, wondering what secrets lay inside. Did it hold newspapers from Washington's day? Keepsakes from Harrison's era? Letters through which my relatives would speak across the years? Would the documents crumble on contact with air? Could I open the box without damaging its contents?

COURTESY BROOKLYN ACADEMY OF PHOTOGRAPHY, SMITHSONIAN INSTITUTION

COMPUTED TOMOGRAPHIC X-RAY IMAGERY FROM NASA'S GEORGE C. MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALABAMA

FROM THE OUTSIDE my mysterious birthright looked simple enough—a galvanized box that would fit under an airplane seat.

But inside was a package more complicated than I had imagined. I got my first peek during a visit to the Washington (D. C.) Hospital Center. There we ran the box through a CT scanner, an X-ray device that rotates around patients to produce images of their organs and tissues.

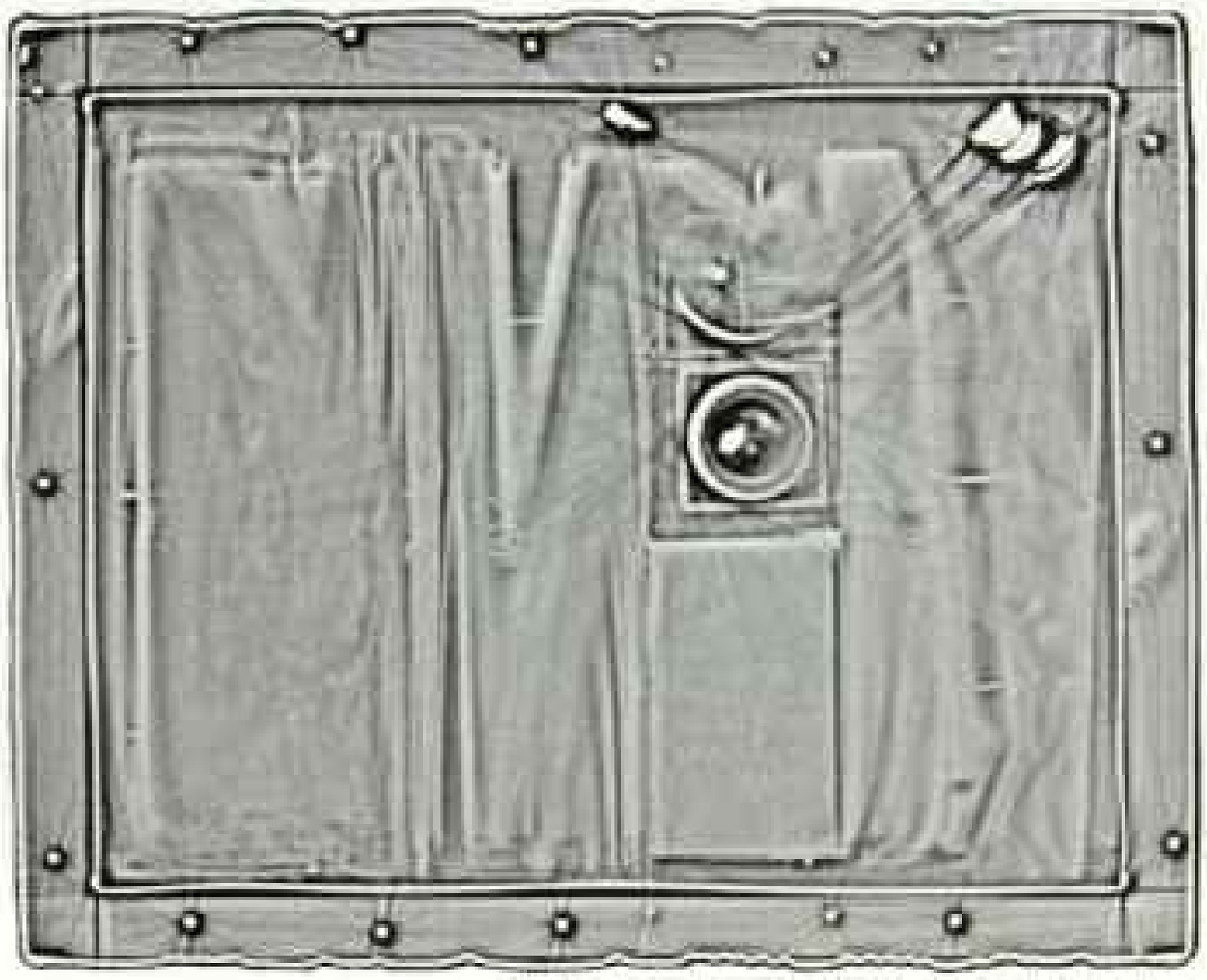
Our investigation showed that the box's outer metal skin was about a tenth of an inch thick; beneath that was a wooden container; that, in turn, was lined with another layer of metal. It reminded me of Churchill's phrase: a riddle wrapped in a mystery inside an enigma.

To penetrate further, we needed more powerful tools. We found them at NASA's George C. Marshall Space Flight Center in Huntsville, Alabama. Here engineers use a sophisticated X-ray instrument called ACTIS (advanced computed tomography inspection system) to find minute flaws in rocket nozzles, turbine blades, and other hardware of space exploration.

A red laser beam guided technicians in positioning the box on a metal turntable in NASA's scanning room (top left). For this portrait the "camera" is an X-ray device that fires a pulse with the energy of two million electron volts, capable of penetrating six inches of steel. Engineers, journalists, and others watch from another room, linked to the scanning procedure by remote monitors (above).

As the X rays pass through the box, they are absorbed to varying degrees by the materials within; the denser the material, the fewer the rays emerging from it. Sensors measure the attenuated beam and relay the information to a NASA computer. The computer, in turn, paints a composite picture from the digital data, making an image of more than a million tiny electronic squares on the screen. Some 60 images emerge in two days of scanning. Each one depicts a lengthwise slice of the box, each less than a sixth of an inch thick.

We see into the container as if it had been opened from the bottom. At a depth of about three inches, a small package appears, tied with a loop of twine (top image at far left). Just above that layer a nest of coins or medallions glitters (middle image). Higher in the box, another view reveals a metal disk. It is about two inches in diameter (bottom image) and is packed in a presentation box of its own. A computer enhancement brings out more detail (left), and the faint suggestion of a man's profile. It proves to be the familiar face of Washington, featured on many mementos from the 1889 centennial (circular image).



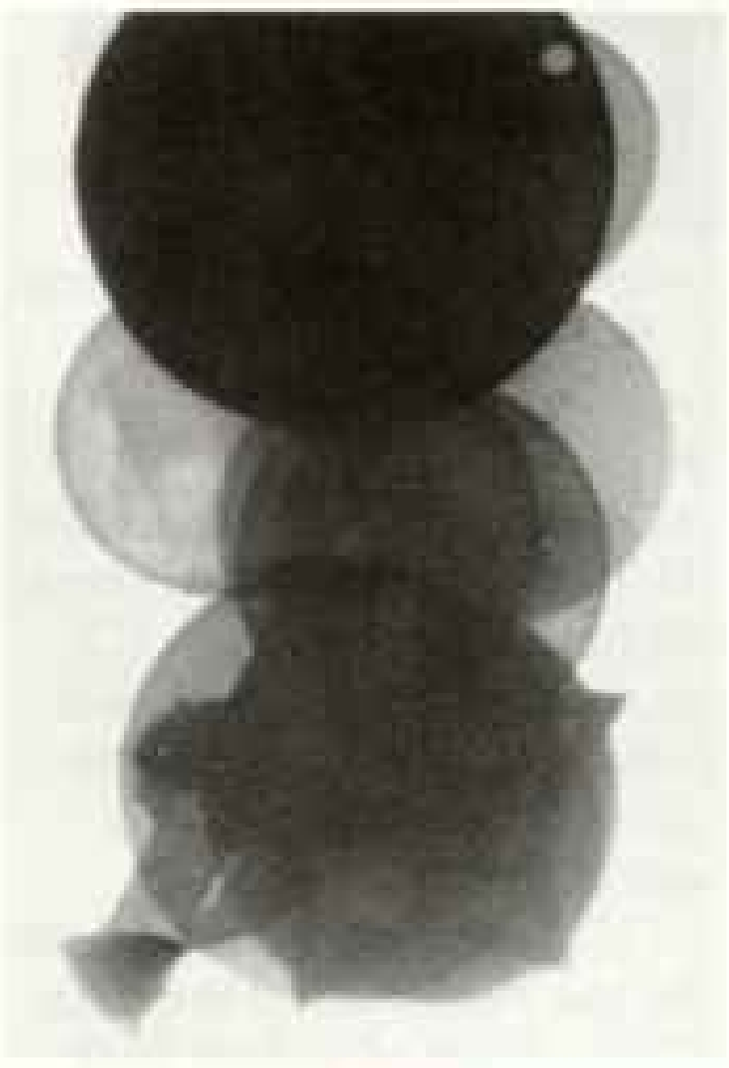
THE ANALYTIC SCIENCES CORPORATION (TASC) (ABOVE AND LEFT)

FRAMED by a dozen stars, a horseman sits at the center of a coin or medallion from the box (below). The metal disk, about two inches across, probably dates from Benjamin Harrison's day.

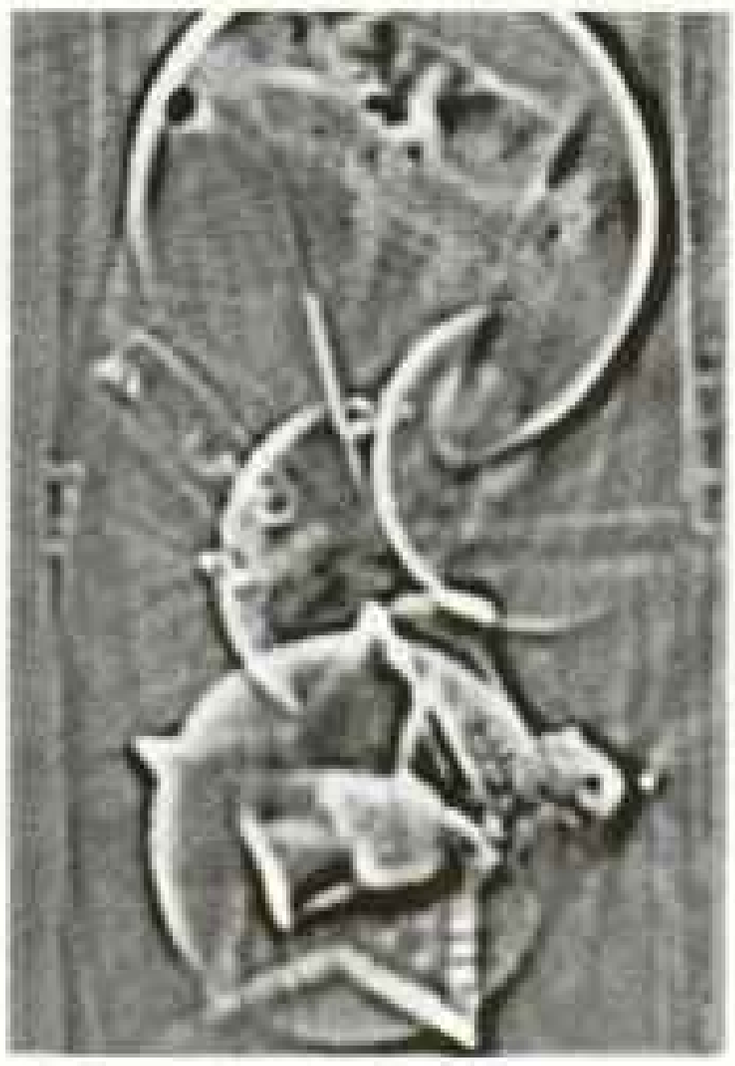
Computer specialists at the Analytic Sciences Corporation (TASC) of Reading, Massachusetts, created this enhanced image by merging three separate views of the same item, gathered earlier in NASA scans.

Steven J. Brzezowski, a member of TASC's technical staff, fed complex mathematical formulas into a computer, adding and subtracting shades of gray across each image to adjust the contrast on the thousands of individual squares that make the horseman's picture. "Each piece seemed to have a different detail," he said, "and I thought that combining them all, we would get the total."

For another perspective on the box, scientists at the National Institute of Standards and Technology probed the container with an industrial X-ray device. This tool, normally used to test new imaging systems,



TASC (ABOVE AND TOP LEFT, FACING PAGE)



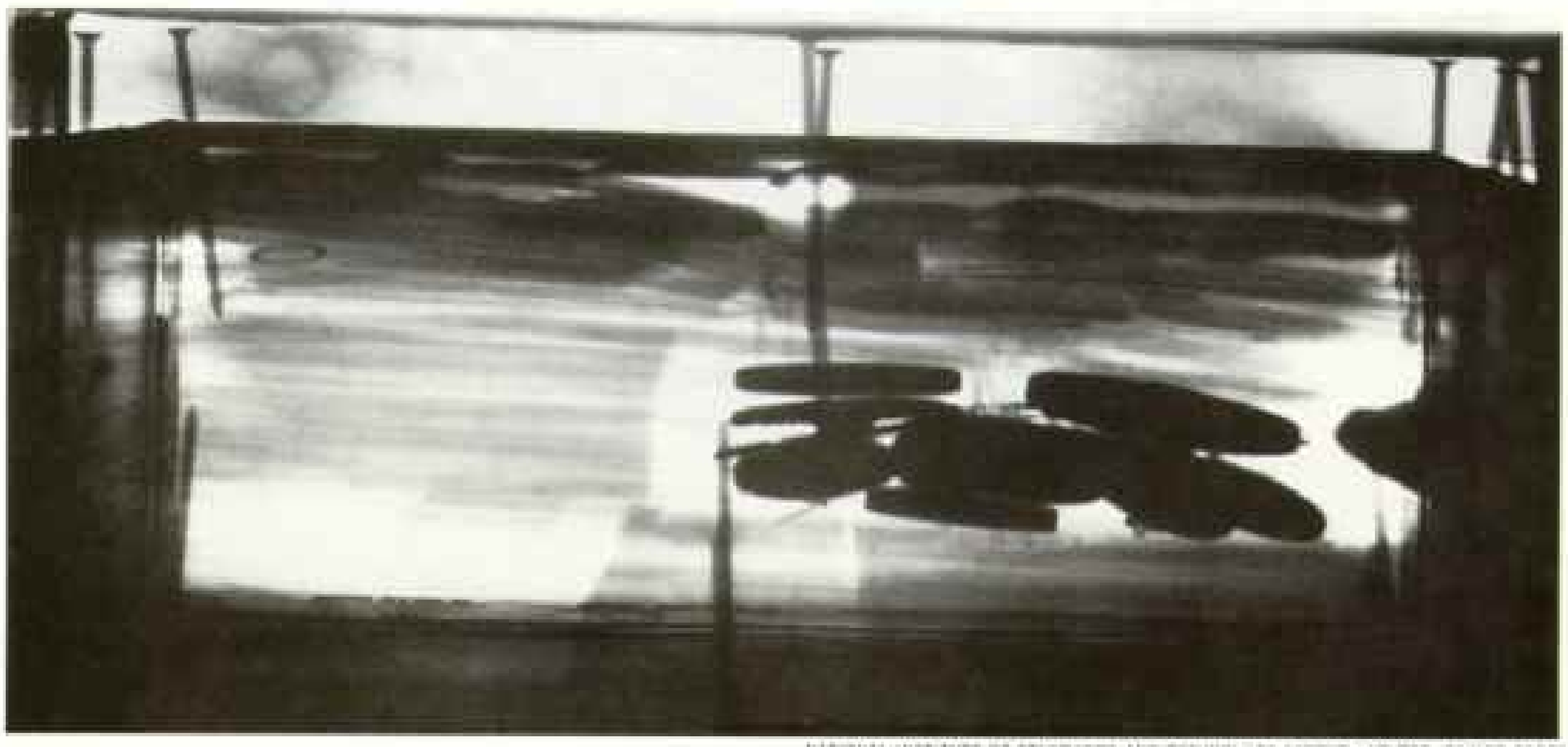
SMITHSONIAN INSTITUTION

penetrated the box with beams ranging from 70,000 to 300,000 electron volts (a chest X ray is 90,000 to 130,000 electron volts). Staff members study the resulting radiograph in their Gaithersburg, Maryland, laboratory (middle left).

Their imaging yields an end view of the box, in which the metal disks seem to float in space (below); some apparently have pins and clasps, like lapel buttons. Nails point into the box from top and bottom, their uniform shape suggesting a manufactured origin, probably in the 19th century.

Studying another view, focusing on the medals from above, observers believe they discern the date 1889 on the three-sided shield in the cluster of shadowy images (top, facing page). A later TASC enhancement of the medal produces a man's profile on a star (top left).

With these two clues we searched a catalog of political memorabilia at the Smithsonian Institution and soon found the twin of our medal. It is a commemorative pin issued for the Washington centennial in New York (top right). Our hopes began to dim that the box might hold objects from the first Inauguration.

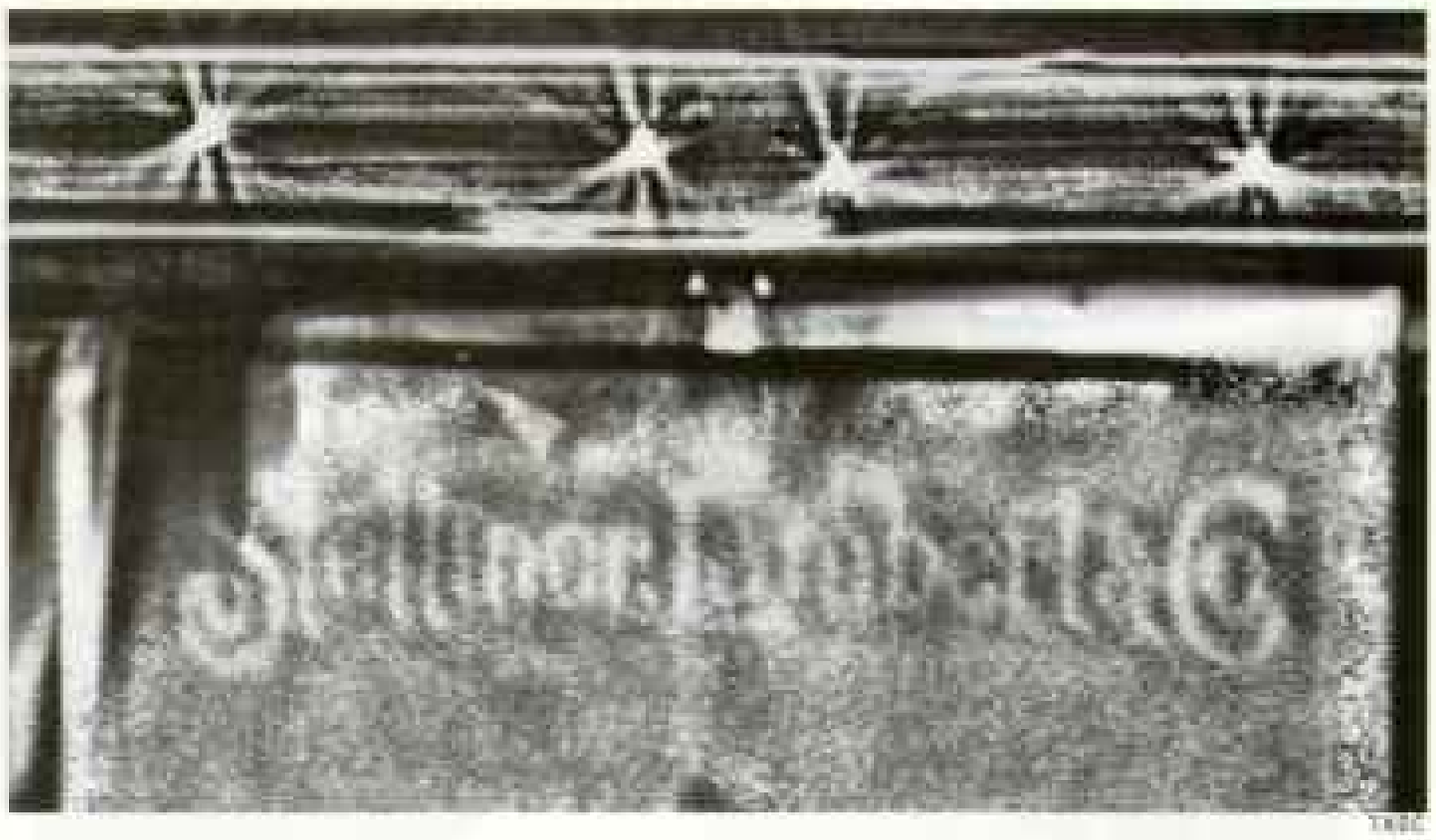


NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (ABOVE AND TOP, FACING PAGE)

OUR WEEKS of space-age study have borne abundant information, enough for this artist's inside view (below). The detailed sketch will help us open the box without damaging its contents.

At this writing the box remains sealed, yet the scans have already helped unravel some of its mysteries: We know, for instance, that the wooden container is built of pine or cedar, with three planks on the top, two on bottom. We know that at least 32 nails hold this container together. We can identify one medallion and can see the details of two others. We can even see a bit of printing on a paper or folder inside: "Slettiner Lambert & Co," it reads, shown in a computer-enhanced image (above). The title displays the flourishes characteristic of a late 19th-century style.

Inside and out, the careful metalwork supports the idea that my ancestor the tinsmith, Benjamin P. Field II, built the box. Even if the opening reveals no treasures, there is a personal reward for me, one that reaches back to link me with ancestors I never knew. For the first time I can envision one of them sitting at a table with the collection scattered around him: He is gathering folders, packing medallions, tying an envelope with twine, thinking ahead. □



TBS

The opening of the box will be televised on National Geographic EXPLORER at 9 p.m. EDT, Sunday, April 30, the 200th anniversary of Washington's Inaugural, on SuperStation TBS.

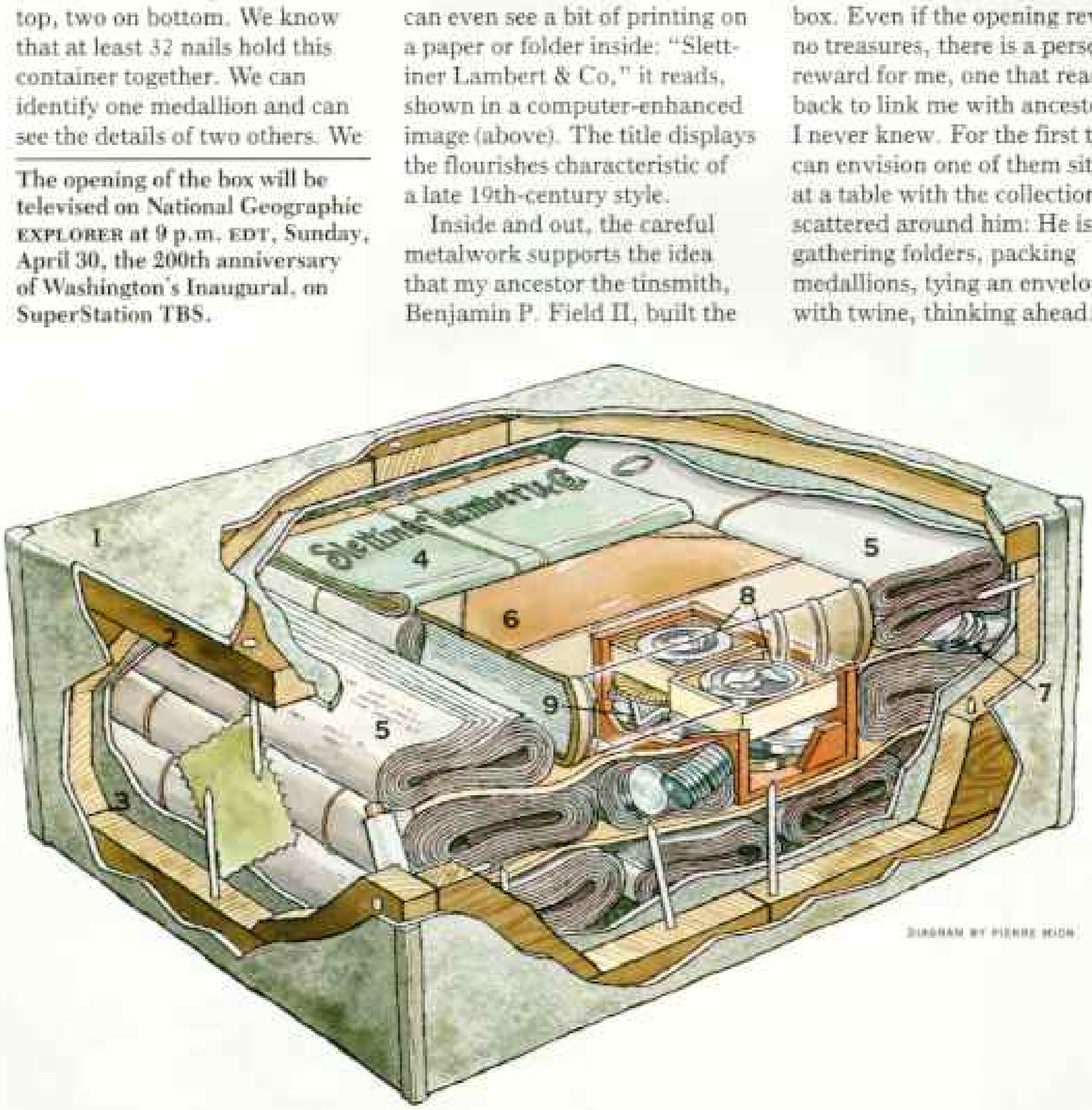


DIAGRAM BY PIERRE MION

Box's likely contents: 1 Galvanized metal cover 2 Inner box of pine or cedar 3 Inner metal liner 4 Folder with printing 5 Rolled-up newspapers or printed matter 6 Book 7 Quarter-size coins or metal buttons 8 Medallions in presentation cases 9 Washington centennial pin.

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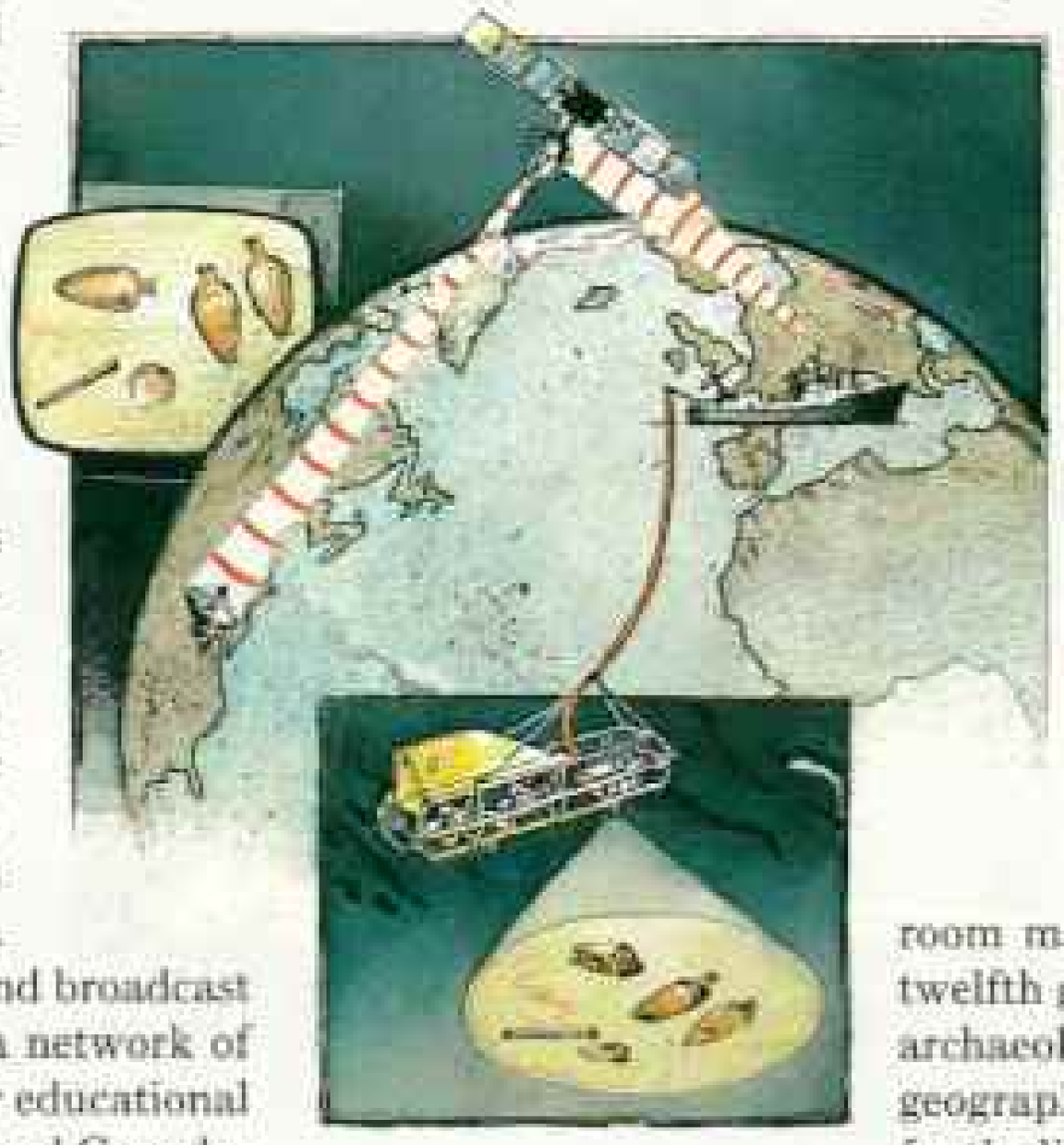
BUCKLE UP FOR SAFETY

Making science a contact sport

THE NATIONAL GEOGRAPHIC SOCIETY

THROUGH the magic of telecommunications, students gathered in Grosvenor Auditorium at Society headquarters this month will be transported to the floor of the Mediterranean Sea for a live adventure of discovery.

Cruising thousands of feet below the surface, they will marvel at the sight of glassy lava from an underwater volcano and take part in a search for strange and beautiful forms of life near hydrothermal vents. Their undersea craft will be *Jason*, a seven-foot-long, remotely operated vehicle that carries three color video cameras. These cameras will send live pictures through a fiber-optic cable to a vessel on the surface, which will beam them to a satellite above the Atlantic Ocean. From there the pictures will be relayed to a ground-based receiver and broadcast via another satellite to a network of nine museums and other educational institutions in the U. S. and Canada. It will be the first live broadcast of its kind ever attempted from the bottom of the deep sea.



CRADLED IN ARGO, ITS COMPANION SLED, THE REMOTE-CONTROL SUBMERSIBLE JASON SENDS LIVE PICTURES OF THE MEDITERRANEAN FLOOR ACROSS THE GLOBE VIA SATELLITE. ART BY RICHARD SCHLECHT.

This exciting project has been organized by Robert D. Ballard, Director of the Center for Marine Exploration at the Woods Hole Oceanographic Institution, whose team discovered the wreck of R.M.S. *Titanic* in 1985. Bob has hopes for the endeavor that reach far beyond its immediate goals. He wants to convince every student who participates that science is challenging and fun.

"I want to show kids that science, and particularly oceanography, is a contact sport done by people with the right stuff," he said. "I want them to look at their math homework as an athlete looks at push-ups—as something you need to do because you want to play in the game."

Bob expects as many as 250,000 students to take part in the interactive television programs, which will be broadcast from May 1 to 14. Through a telecommunication center at each of the participating institutions, students will be able to ask questions of Bob and other scientists aboard the research vessel to help the youngsters understand what they are seeing.

In addition to exploring the Marsili Seamount volcano, *Jason* and its companion sled *Argo* will be used to investigate a widespread area of wreckage, which Bob believes holds the remains of ships from the time of the Romans. A preliminary look at one site revealed amphorae used to export wine from Italy and Carthaginian jars used to carry fish sauce and oil. The National Science Teachers Association has developed classroom materials for fourth through twelfth grades on related aspects of archaeology, trade, seafaring, and geography to help students prepare for the live broadcasts.

This project would not be possible, of course, without the generous support of sponsors, especially the National Science Foundation, Quest Group Ltd., Electronic Data Systems Corporation, the Office of the Chief of Naval Research, and the Turner Broadcasting System. The National Geographic Society lent a hand in developing the advanced camera systems, whose images will be seen this fall in an EXPLORER TV documentary on TBS.

Bob Ballard and his team deserve a lot of credit for what they're attempting. Bob is not only an explorer but also a man with a vision. By bringing live television to the undersea world, he's doing for oceanography what we've been doing for geography—making the facts come alive. More than that, he's defining what it means to be a teacher in the 21st century by allowing students to share with him—in real time—the excitement of discovery.

Gilbert M. Grosvenor

San Joaquin Kit Fox **Genus:** *Vulpes* **Species:** *macrotis* **Subspecies:** *mutica*
Adult size: Length of body, 38-50cm; tail, 22-30cm **Adult weight:** 1.5-3kg
Habitat: Arid scrubland and grassland in the San Joaquin Valley in California, U.S.A.
Surviving number: Estimated at a few thousand Photographed by Tupper Ansel Blake

Wildlife as Canon sees it

San Joaquin kit fox pups huddle together, secure at the entrance to their den in one of this subspecies' last strongholds in California's San Joaquin Valley. The San Joaquin kit fox shares its habitat with other imperiled animals: the giant kangaroo rat, the blunt-nosed leopard lizard and Nelson's antelope ground squirrel. At one time, even the California condor, which today lives only in captivity, soared high above this wildlife community. The San Joaquin kit fox is one of many wildlife species in the area threatened by the conversion of native habitats to agriculture and urban development.

To save endangered species, it is vital to protect their habitats. Understanding the fragile balance of our world's ecosystem holds the promise for the future. Expressive color images, with their unique ability to reach people, can help promote a greater awareness and understanding of the San Joaquin kit fox and how it lives within its natural environment.

And understanding is perhaps the single most important factor in saving the San Joaquin kit fox and all of wildlife.

Members Forum

Coca

"Coca—An Ancient Herb Turns Deadly" (January 1989) serves as an excellent primer on illegal cocaine use. The article is one of the most comprehensive published for the general public.

CHARLES P. SMITH
Director, Justice Programs
U. S. Department of Justice
Washington, D. C.

This feature should be required reading for every American.

GEORGE D. HEAVEY
Regional Commissioner
U. S. Customs Southeast Region
Miami, Florida

As a member of the Society, I have never been so proud of the steps you have taken to help law enforcement educate citizens on the most serious problem we face as a nation. Last year 152 officers died in the line of duty in the United States, and almost all the deaths were drug related.

GERALD S. ARENBERG
Executive Director, National
Association of Chiefs of Police
Washington, D. C.

You state that six million Americans buy cocaine and that it brings them indescribable pleasure, unbounded energy—often misery, sometimes death. I hope you haven't appealed to six million more who may fall susceptible to the glamorous description portrayed and ignore the down side.

WILLIAM A. PITT
Carlsbad, California

I am a social worker investigating child abuse and neglect cases in the East Los Angeles barrio. In the past few years I have found most of my cases are drug related. I have observed many families, not just those on welfare but many middle-class parents, who get so hooked on drugs that they first lose their jobs, then start selling their furniture and other possessions to support their habit. Then they get evicted for nonpayment of rent and wind up abandoning their children with relatives or just leaving them alone in motel rooms. I hope your article will pressure the politicians to spend more on drug rehabilitation. We can't afford not to do it.

RICHARD H. SMITH
Burbank, California

Peter T. White's detailed coverage of the cocaine trade omits its marketing, sales, and distribution here in the U. S. Since the early 1980s the cocaine industry has moved from an era of independent entrepreneurship to a struggle for control between the drug syndicates forged by Jamaican, Chinese, and Colombian gangs and the drug corporations modeled on the *Fortune* 500 companies. In only two decades we have seen the recapitulation of American economic history as the cocaine trade grew from cottage industry to major corporation. Besides adopting organizational structure, it uses classic business methods like mass marketing, mass production, and economies of scale to make an elite product available and affordable to all. Cocaine has created a shadow industry that holds up a nightmare image to American business and society.

KAREN JESCAVAGE-BERNARD
Selden, New York

There is an ever increasing effect of cocaine that medical professionals are facing in intensive-care nurseries throughout the country. Cocaine use, even one "hit" of crack, can cause placental abruption, resulting in premature birth. We daily admit these "fetuses," many as young as 23 or 24 weeks of gestation. Even more frightening, current research has shown that a single hit of cocaine by the mother results in a continual dose for the fetus, as the drug converts to a metabolite that is repeatedly ingested by the baby as it circulates in the amniotic fluid. The damage to these infants at critical stages of development remains to be seen.

DIANE K. MCBRIDE, R.N.
Union City, California

Cocaine's potential for causing death is, in itself, insufficient justification for outlawing it. If we outlawed everything that could cause death, we'd have to do without tobacco, alcohol, all prescription drugs, firearms, automobiles, knives, ropes, matches, stoves, razor blades, and bathtubs, to name but a few. So cocaine kills 1,600 Americans yearly out of a population of 5.8 million regular users? That would make it one-twentieth as deadly as tobacco, which kills 200 times as many Americans each year out of a population of regular users that is only ten times as large. Yet tobacco cultivation is actually subsidized by the American taxpayer, while the product is easily available to any child tall enough to reach the quarter slot on a cigarette machine. Talk about hypocrisy!

TERRY PHELAN
Albany, New York

Sagebrush Country

I've never been to the U. S., but next time I'm stuck in a traffic jam I'll be thinking (dreaming

Ticket to Ride.

"Dad talks in smokescreens. Can't ever say what he really feels. Like this morning, getting ready to go. All he could talk about was the truck. Did I have the oil checked? How were the brakes? So I told him, I had the Goodwrench guys at the GM dealership look it over.
I did, too.
See, this truck is my ticket to the real world. My freedom to go where I want to go. You better believe I'm gonna take care of it.
Dad just nodded.
But I knew what he was saying."

Your truck is an important part of everything you do, whether it's hauling bales of hay or striking out on your own. That's why it's important to take it to Mr. Goodwrench.
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So whether you drive a Chevrolet, Pontiac, Oldsmobile, Buick, Cadillac or GMC Truck, bring it to Mr. Goodwrench. You'll find him at over 7200 General Motors dealerships coast to coast.

Goodwrench

Mr. Goodwrench

GM Parts

It's not just a truck... it's your freedom.

perhaps?) of those buckaroos disappearing over a rise in their "fresh-made world without fences." I'll be able to sense the smells of distant plains and sagebrush seas and hear the echo of thundering hooves. To Messrs. Chadwick and Schofield, many thanks.

PAUL O'SULLIVAN
Dublin, Ireland

Veterinarians have examined the stomach contents of coyotes often enough to know that these animals pursue the smallest desert creatures on which to make their meals. Now mice, ground squirrels, jackrabbits, and cottontails multiply out of proportion to their need because coyotes are relentlessly pursued and killed by those who think no further than the guns they use. I would expect NATIONAL GEOGRAPHIC to champion the ecological necessity of the coyote or, if your policy is intended to be disengaged from issues, to show both persuasions at work in Nevada.

JO BILLINGS
Imlay, Nevada

When I first came to Idaho in 1935, there were jackrabbits in incredible numbers in the Little Lost River Valley and coyotes everywhere. A big-time sheepman in Howe, Idaho, told me that in spite of hordes of rabbits his loss to predators, mainly coyotes, still remained at or near 10 percent of his annual lamb crop. Coyotes do prefer mutton over jackrabbit at any time, and so do I!

EMFRED ANDERSON
Blackfoot, Idaho

Stingrays

The public should not be led into the false belief or security that one can usually fondle stingrays. Having studied sharks and rays for over 30 years, I think articles that depict people playing with rays should be discouraged. *Rays are dangerous.*

FRANK J. SCHWARTZ
University of North Carolina
Morehead City, North Carolina

Many divers, and certainly all who love wildlife most in its natural state, experience a thrill far greater in seeing stingrays cautiously out of reach of humans than in having direct physical contact with baited rays begging for food from "as many as 150 divers and snorkelers a day." The hand-fed stingrays of the Cayman Islands are another example of man's selfish insistence on exploiting modified animal behavior to suit his entertainment needs.

NANCY MARSH
Redmond, Washington

Indonesia

Arthur Zich seems not to have seen the Aceh that I saw during a visit in late 1986. The Acehnese I met are among Indonesia's most productive, energetic, and creative citizens—and they are famous for these qualities in other parts of the country. Zich's account implies that Aceh suffers from its devotion to Islam. In fact, Aceh's fierce resistance to Jakarta (and to the Dutch in earlier days) reflects dedication to freedom and independence rather than simply religious fervor.

WILLIAM L. WILLIAMSON
Madison, Wisconsin

The situation in East Timor [includes] acts of violence and repression perpetrated by the Suharto regime against the Maubere people. Portugal, constitutionally committed to safeguard East Timor's right to independence, is not alone in condemning these abuses. The UN, the European Parliament, Amnesty International, and Asia Watch have supported East Timor's right to freedom.

LUIS A. DE SOUSA
Embassy of Portugal
Washington, D. C.

Author Zich cited 100,000 killed or dead of starvation and disease, 40,000 children orphaned or maimed, at least 600 missing civilians. He was refused access to the eastern part of East Timor.

Rowing to Antarctica

More than 10,000 students participating in the Student Ocean Challenge program tracked Ned Gillette and his crew aboard *Sea Tomato* by satellite during their daring row to Antarctica. Many thanks from teachers and students everywhere who can now fully picture just what it must have been like to experience the "most mad seas."

MAME REYNOLDS
Newport, Rhode Island

Society Membership

The Society celebrated its centennial with more than 2^{23} members in 1988. That means that in a hundred years membership doubled 22 times. In the same span of time, world population doubled only two times. If both continue increasing at the same rates, every person on earth will become a Society member by 2030. Then you'll either have to slow down a bit or start sending gift memberships to Martians.

JORGE E. OOSTRA
Ibagué, Colombia

By our calculations, based on steady rates of increase, we will exhaust the pool of earthlings by 2042. We're open-minded about new members.

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

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And they're delivering. J.D. Power and Associates, one of the industry's most respected research organizations, surveyed over 25,000 owners of 1987 passenger cars. The results clearly showed that owners of Chrysler-built cars were happier with the overall service provided by their dealers, and with the quality of their cars,* than Ford or GM owners. That says a lot about the way our dealers treat your car, and the way they treat you.

Last year alone, our dealer technicians received more than 500,000 total hours of specialized training in the most advanced repair procedures. That's an increase of almost 200% from 1981. With this hands-on knowledge, and the most sophisticated equipment available, they're prepared to handle any problem.

You have a right to friendly treatment, honest service and competent repairs. Chrysler...and every Dodge, Chrysler, Plymouth, Jeep and Eagle dealer...intend to see that you get it.

"SERVICE IS YOUR RIGHT. AND WE INTEND TO SEE THAT YOU GET IT."

Lee Iacocca

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*J.D. Power and Associates 1988 CSI Customer Satisfaction with Product Quality and Dealer Service for '86-'87 passenger cars. BUCKLE UP FOR SAFETY.

Back By Popular Demand.

At one time, peregrine falcons nested by the thousands throughout the United States. But with the widespread use of the insecticide DDT in the 1940s and 1950s, the species suffered greatly. In the eastern U.S., the peregrine falcon disappeared entirely.

Now peregrine falcons have made a comeback, thanks to efforts by conservationists.

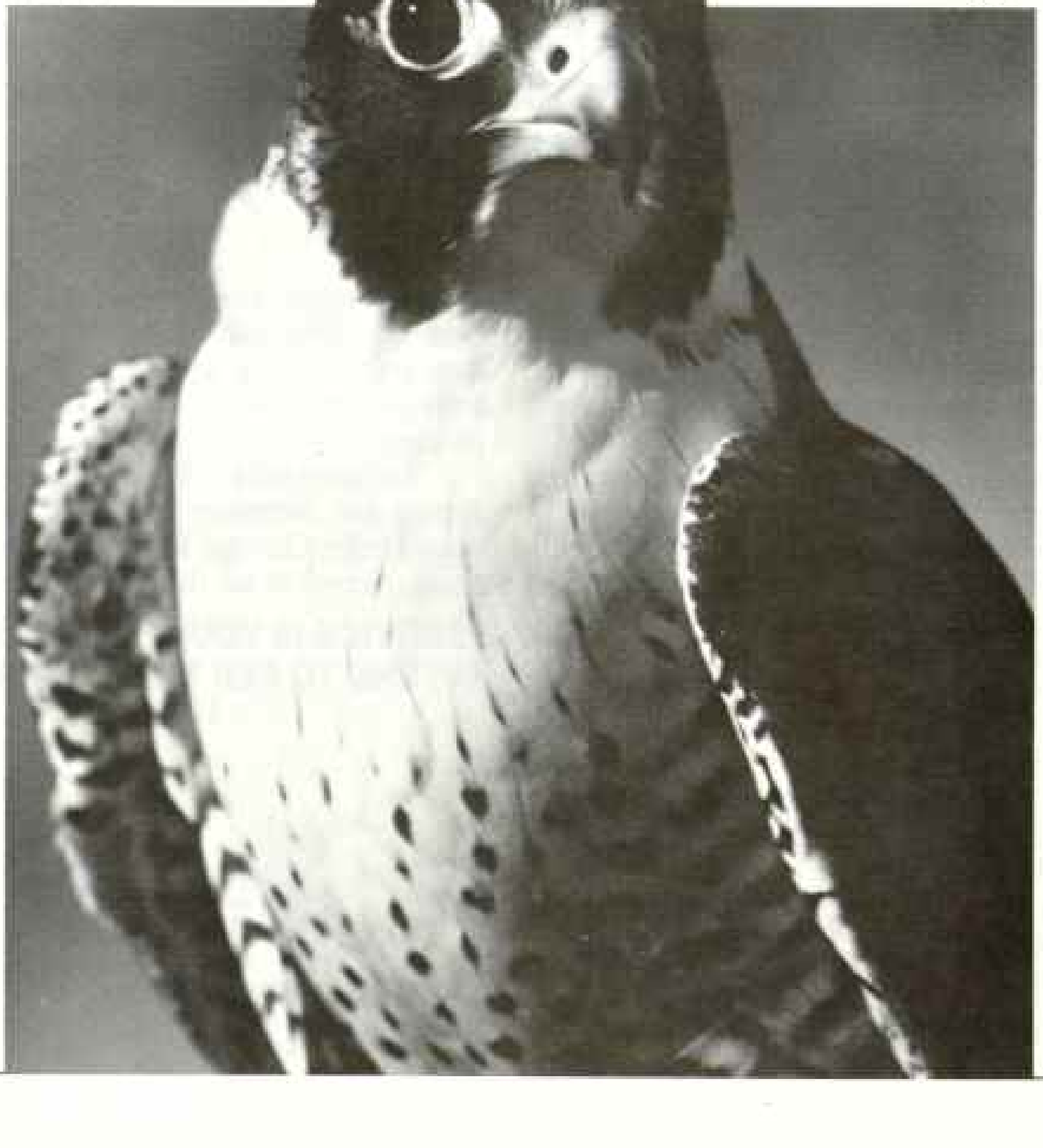
Since 1975 when recovery programs were established, 752 peregrines have been released in the eastern U.S., and there has been a steady increase in the nesting population.

With wise conservation policies, other once rare species such as the American alligator and the bald eagle have also made comebacks.

Help save our endangered species. Join the National Wildlife Federation, 1400 16th Street, NW, Washington, DC 20036-2266.

Working for the Nature of Tomorrow.®
NATIONAL WILDLIFE FEDERATION

Wayne Lynch



The 1932 Cadillac V-16 Sport Phaeton

Model shown much smaller than 9½" actual length

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Each metal part is polished before painting. Every single component is inspected before the replica is assembled by hand. When at last a replica is complete, it is hand-waxed before being released for shipment.

Available only from the Danbury Mint.

This extraordinary replica is available exclusively from the Danbury Mint. It is not being sold in stores.

You need send no money now. Simply return the Reservation Application. The price of $88.50 is payable in three convenient monthly installments of $29.50 each. For your convenience, you may charge your installments to MasterCard, VISA or American Express.

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Production of this superb, hand-assembled, hand-finished model cannot be rushed. Reservations are being accepted on a strict first-come, first-served basis. To avoid disappointment, please mail your reservation today.

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Please accept my Reservation Application to the 1932 Cadillac V-16. I need send no money now. I will pay for my Cadillac replica as billed in three monthly installments of $29.50 each,* the first in advance of shipment.

My satisfaction is guaranteed. If I am not completely satisfied with my Cadillac, I may return it within 30 days of receipt for prompt replacement or refund, whichever I wish.

**Plus $1.25 per installment for shipping and handling.*

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Check here if you want each monthly installment charged to your:

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MAY 1989

GEOGRAPHICA

NATIONAL GEOGRAPHIC MAGAZINE

President-elect Pledges Aid for Fragile Planet

Toasting "the window on the world that is the National Geographic Society and the exciting world we see through that window," President-elect George Bush pledged that his administration would "leave the planet in better shape than we found it.

"The plain fact is that many of the problems we face in the environment—global warming, ocean pollution, acid rain—are international in nature," the President-elect told guests at a dinner last November marking the Society's centennial. "I plan to use America's leadership in the world. . . . The only path to a cleaner, safer planet is global cooperation on the environment."

In introducing Mr. Bush, who appeared at the dinner only nine days after his election, Society President Gilbert M. Grosvenor (right, with the President-elect) promised the support of the National Geographic Society in protecting the environment. In keeping with the theme of the evening and of the dramatic hologram cover on the last issue of the centennial year—"Can Man Save This Fragile Earth?"—he also promised a commitment to geographic and environmental education in the Society's second century.

"Our knowledge has given us an

DAVID BROWNERS

understanding that we can no longer ignore, and that is that planet earth is at risk," Grosvenor said. "We have learned that the forces of man are now of such immense power they can alter the forces of nature. We at the Geographic are convinced that education is the only solution. To preserve and to conserve our world, we must understand it."

Noting the array of scientists, inventors, and explorers who were present to receive the Society's Centennial Awards (NATIONAL GEOGRAPHIC, December 1988), President Grosvenor said that "the Society and these illustrious award recipients are making a plea to the world: We must work together to save this fragile earth."

In an introduction to the evening's program Grosvenor paid tribute to the award recipients (below). "The individuals we are honoring understand the force of knowledge," he wrote. "And they understand how each of us has an individual responsibility to the cause of knowledge."

The 15 honorees were (seated, from left) George F. Bass, dean of undersea archaeology; Harold E. Edgerton, inventor of the electronic stroboscopic flash; Jacques-Yves Cousteau, marine explorer and co-inventor of the Aqua-Lung; mountaineer-cartographer Barbara Washburn; Mary D. Leakey, paleoarchaeologist; and Frank C. Craighead, Jr., and John J. Craighead, pioneer radiotrackers of animals.

Also (standing, from left) Sen. John Glenn, the first American to orbit the earth; Robert D. Ballard, underwater geologist and discoverer of the *Titanic*; Kenan T. Erim, leader of excavations at the ancient Greco-Roman city of Aphrodisias; mountaineer-cartographer Bradford Washburn, husband and colleague of Barbara Washburn; Jane Goodall, longtime researcher of chimpanzee behavior; President Grosvenor; Richard E. Leakey, paleoanthropologist; Thayer Soule, veteran travel filmmaker and lecturer; and Sir Edmund Hillary, first to attain the summit of Mount Everest.

DAVID BROWNERS

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

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NGS PHOTOGRAPHER VICTOR R. BOSWELL JR.

Slowly Restoring Leonardo's Masterpiece

Millimeter by millimeter the restoration of Leonardo da Vinci's "Last Supper" (GEOGRAPHIC, November 1983) continues.

Work has been completed on about half the mural, located in the refectory of a former monastery in Milan, Italy. Dr. Pinin Brambilla Barcilon, who has executed the restoration since 1977, is now working on the face of Christ and the upper part of the table.

Dr. Pietro C. Marani, inspector for the superintendent of fine arts in Milan, says another two years are needed to finish repairing damage from exposure to sunlight and fluctuating temperatures, stripping the layers of paint added by earlier restorations, and removing the grime accumulated over centuries.

Meanwhile, Marani hopes to install an air-conditioning system in the monastery this year to help prevent renewed deterioration as restoration work is completed. To reduce humidity, which also can cause serious damage, the number of visitors allowed to see the "Last Supper" has been limited to 25 at any one time.

Uncovering the Past: the Mastery of Fire

When did our ancestors first learn to use fire? That prehistoric advance—which ranks in importance with stone-tool making—seems to have occurred much earlier than scientists had thought.

The most recent evidence comes from Swartkrans, a large cave excavation near Pretoria, South Africa. Archaeologist C. K. Brain found charred animal bones scattered through limestone strata about a million years old and older. Experiments show that the bones were heated at temperatures as high as those occurring in campfires. And in the cave layers, remains of the ape-man *Australopithecus robustus* and a larger brained hominid, *Homo erectus* (GEOGRAPHIC, November 1985), suggest who tended those fires.

Previously the earliest strong evidence of fire use came from Zhoukoudian, a cave near Beijing, China. There, amid remains of *Homo erectus*, a layer of ash and burned animal bones dates from about half a million years ago.

Black-footed Ferret Population on the Rise

Things are looking up again for the black-footed ferret, which has gone through a perils-of-Pauline existence over the last decade.

The little animal, a member of the weasel family, had been considered extinct until a small group was found amid prairie dog colonies near Meeteetse, Wyoming, in 1981 (GEOGRAPHIC, June 1983). Their known population reached a peak of 129 in 1984 before a combination of a plague that killed prairie dogs, their chief prey, and canine distemper, which kills ferrets, caused it to crash. Authorities then captured ferrets from the wild and started a breeding program.

Early in 1989 the ferret population was up to 58, according to Tom Thorne, a veterinarian with the Wyoming Game and Fish Department, who is in charge of the program. Fifteen ferrets have been sent to two other facilities to prevent any new outbreak of illness from killing all captive ferrets, as happened in 1985. Thorne plans to reintroduce some ferrets into the wild when the population reaches 500, which he hopes will happen by 1991.

Soviet Geography Poll: Pandas in Panama?

An international survey conducted last year by the Gallup Organization for the National Geographic Society showed that Americans have a woefully limited knowledge of geography. As Society President Gilbert M. Grosvenor reported (GEOGRAPHIC, November 1988), young Americans did especially poorly when compared with residents of eight other nations, finishing last in a test of general geographic knowledge. A few of them said they thought pandas came from Panama and kangaroos from Lebanon.

Now Americans will be able to see how they compare with people in the Soviet Union when it comes to geographic expertise. Gallup will join with the Institute for Sociology of the U.S.S.R. Academy of Sciences in a Society-commissioned poll of 1,500 Soviet citizens, a thousand of them outside the Moscow area and the remainder in the capital. The Soviet respondents will be asked virtually the same questions as those posed in the earlier survey—questions to find out what importance they place on geography and to test their map-reading skills by requiring them to locate specific places or bodies of water.

Clovis Cache Discovery Points Up Old Debate

The discovery of a major cache of Clovis points in central Washington (GEOGRAPHIC, October 1988) has helped refocus attention on the vexing question of when the Americas were first peopled.

Such distinctively fluted spearpoints, dating from 11,500 to 10,500 years ago, have been found in southern Canada and much of the United States. Clovis points have turned up also at a number of sites in Mexico, Guatemala, and Costa Rica (map, below). Most were found on the surface and cannot be dated. But Alan Bryan of the University of Alberta, who excavated a Clovis

point in Guatemala, was able to date that site at about 10,700 years ago. A site in southern Mexico yielded a Clovis-like point dating back to 9,400 years ago.

Archaeologists agree that the Western Hemisphere was populated by people who crossed a land bridge from Asia into Alaska. By about 12,000 years ago they had begun to spread southward through the Americas via an ice-free corridor east of the Rocky Mountains, most believe, using sharp Clovis spearpoints to kill large game.

But Bryan, noting findings of non-Clovis artifacts 13,000 and more years old in South America, thinks that the original dispersal of people, perhaps along the Pacific coast, was much earlier and that Clovis points were just one of several technologies developed by their descendants.

JUST SAY NO.

America is hooked on foreign oil. Today, we import almost 40 percent of the oil we use—even more than in 1973, when the Arab embargo plunged us into gas lines, rationing, and recession.

The more we can use nuclear energy, instead of imported oil, to generate electricity, the less we have to depend on foreign nations.

The 110 nuclear plants in the U.S. have cut our foreign oil dependence by over three billion barrels since 1973. And they have cut foreign oil payments by over one hundred billion dollars.

But 110 nuclear plants will not be enough to meet our growing electricity demand. More plants are needed.

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NATIONAL GEOGRAPHIC MAGAZINE

A LOT OF PEOPLE are talking and writing about the threat of global warming. Roger Sant, Chairman of Applied Energy Services of Arlington, Virginia, which builds and operates power plants, is doing something about it.

"We're building a coal-fired plant in Connecticut that will release 15 million tons of carbon into the atmosphere over 40 years. Given the seriousness of the greenhouse problem, Sheryl Sturges of our staff came up with the idea of canceling out the pollution we're creating. We asked the World Resources Institute to find an appropriate way."

The result: Next month farmers in Guatemala, 2,000 miles from Connecticut, will start planting 52 million trees as part of the most imaginative and sensible program yet conceived to put the industrialized world's money where its mouth has been. For years we've asked developing tropical countries to stop destroying their forests; we need them in part to absorb carbon dioxide from our factories and automobile exhausts. Not surprisingly, they haven't, because most of the farmers who slash and burn forests are desperately poor. They do it to survive.

The project chosen for AES by the World Resources Institute will provide seedlings and training for 30,000 Guatemalan farmers in the next decade. Sant's AES started the fund with two million dollars. The Guatemalan government will add another million. Contributions in cash, labor, and food from CARE, the Peace Corps, and U. S. AID should raise the total to 14.5 million.

The project will be directed by CARE, active worldwide in reforestation, in cooperation with Guatemala's forest service and the Peace Corps. This February in Guatemala, CARE's Luis López told me: "We are working with 66 municipalities in the country. First we hold classes on conservation and sustainable forestry practices. Then communities plant and care for trees that will provide them firewood, fruit, and lumber."

Mark Trexler, WRI scientist, estimates that in 40 years the project should yield a net gain of 3 million tons of absorption capacity. "It's an experimental project," he said. "Unexpected population growth alone could invalidate our figures."

As we see in the article on Swiss deforestation beginning on page 637, it's not just the tropical forests that are in trouble. It will take a Johnny Appleseed attitude on the part of all of us to reverse the denuding of the earth's forests by human pollution. AES has set a fine example.

Wilbur E. Garrett

EDITOR

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*See dealer for warranty details. © 1989 Hyundai Motor America. Seat belts make sense.

On Assignment

JAMES A. SUGAR (ABOVE); BILL CURTSINGER

FLYING HIGH for this month's article on gravity, JOHN BOSLOUGH (above, at center) floats aboard a NASA KC-135. Used to train astronauts, the plane generates brief periods of weightlessness by carving parabolas in the sky. Although John sported a motion-sickness patch behind his ear, his euphoria faded after 12 of the flight's 33 maneuvers.

Unquenchable curiosity led the Colorado-born author to earn a degree in the history of science at Princeton. At the *Salida Mountain Mail* he embarked on a career as a writer. In our May 1985 issue he explained the inner workings of the atom, and in a 1985 book the theories of physicist Stephen Hawking.

Having followed the search for gravity's secrets from the Leaning Tower of Pisa to Perth, Australia, John finds that gravity still weighs on his mind, even while jogging near his home in Virginia. "It's a miracle that our legs can pump right along in earth's gravitational field," he says. He avoids introspection, though, when pursuing his real passion: downhill skiing.

Calling upon the last of their strength, author JEFF MACINNIS (right, at left) and photographer MIKE BEEDELL built a cairn on Baffin Bay to celebrate their navigation through the heart of the Northwest Passage. The first to make the journey by wind and muscle power alone, they sailed and hauled an 18-foot catamaran for 2,300 ice-choked miles. "We feel fortunate to have survived these treacherous waters," Jeff wrote on a note in the cairn.

Fortunate indeed. The passage has claimed many lives, including the 128 men who perished with Sir John Franklin on his 1845 expedition. Eight years later, while searching for survivors, the British bark *Breadalbane* was crushed by ice. Jeff helped his father locate and explore the wreck (July 1983 GEOGRAPHIC). That trip turned Jeff's fascination into determination.

Over three summers Jeff and Mike raced darkness and ice that annually lock up the Arctic. But then racing comes naturally to Jeff, a former member of Canada's national downhill ski team. "The Arctic teaches you to be incredibly adaptable," says the 26-year-old Toronto native. Recently outfitted with a business degree, Jeff now gives motivational lectures to corporate executives—when he's not planning his next expedition.

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