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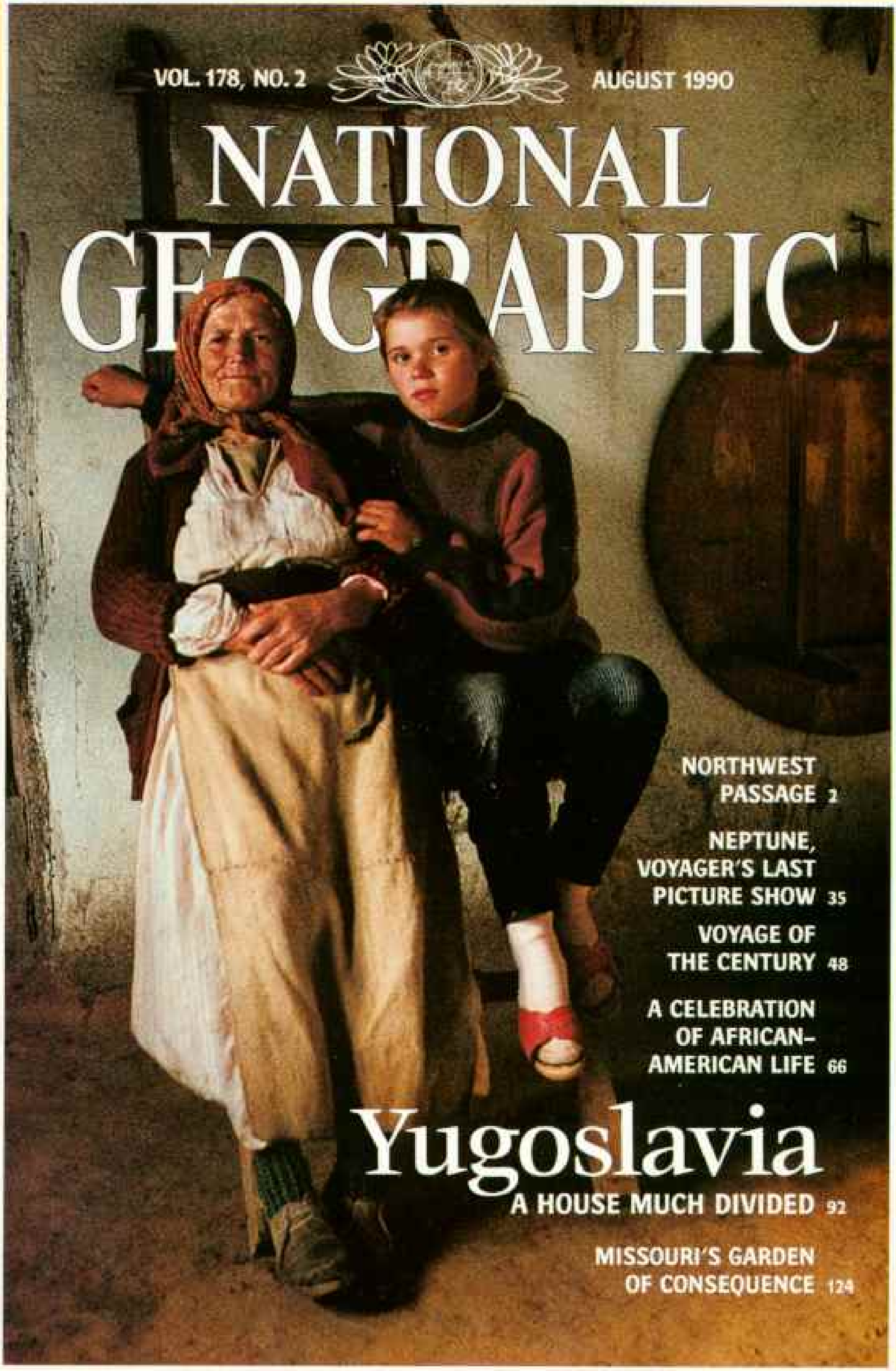

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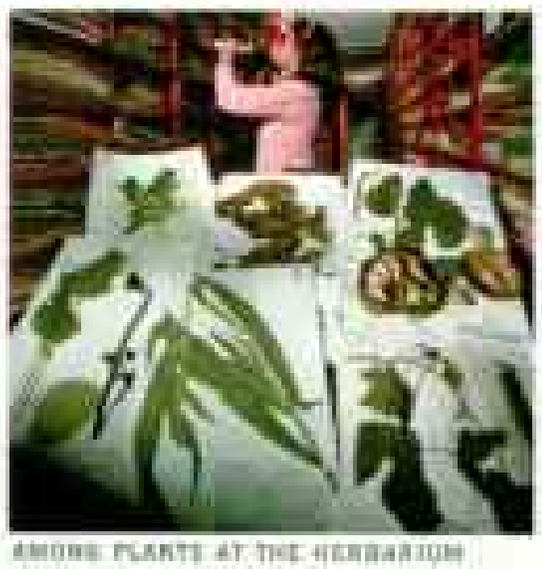
INUIT WOMAN

SURPRISINGLY STORMY NEPTUNE

CRAFTSMAN AT WORK

MACEDONIAN FARM COUPLE



AMONG PLANTS AT THE HERBARIUM

COVER: *An ethnic Albanian farm woman wears the* dimitë, *or culotte, that distinguishes Muslims in Macedonia, the southernmost republic of Yugoslavia. Her granddaughter chooses nontraditional dress. Photograph by Steve McCurry.*

Changing Images of the NORTHWEST

Inuit Jayko Ootoowak and Mikiseetee Komangapik hunt sought by explorers and threaded by few, modern technology

PASSAGE

By JOHN BOCKSTOCE

Photographs by
RICHARD OLSENIUS

narwhals off Baffin Island. Here along the Arctic route long in the pursuit of natural resources threatens a way of life.

The bold coast of Bylot Island, its snowy peaks cradling a glacier, witnessed the final leg of the author's six-year, 3,500-mile voyage through the Northwest Passage.

THE CRUNCH OF ICE along our steel hull snapped me awake. At the same moment crew member Craig George stuck his head through the cabin door.

"John, you'd better come topside," he said. "There's something weird on the radarscope—something really big, and it's dead ahead."

Groggily I pulled on my clothes and joined Craig and my old friend Sven Johansson, a veteran Arctic sailor, in the pilothouse of our 60-foot research vessel *Belvedere*. We were picking our way through heavy drift ice in the Beaufort Sea north of Alaska. For hours I had stood lookout at the masthead, but then fog set in and I went below to sleep.

Sven sat hunched over the radar set, his bearded face washed sickly green by light from the scope. The blip on the scope indicated an enormous object, seemingly the size of an aircraft carrier.

JOHN BOCKSTOCE, an Arctic ethnographer and explorer, is an authority on the 19th-century Arctic whaling industry. His book *Whales, Ice, and Men* is a classic reference work. Still and motion-picture photographer RICHARD OLSENIUS is based in northern Minnesota.

In a chill spring fog the brute strength of ice-breakers frees the Kulluk, *an offshore drilling vessel, from its icebound winter berth off Herschel Island. Now that oil and gas have been found in the Beaufort Sea, concern has grown over the potential for environmental damage.*

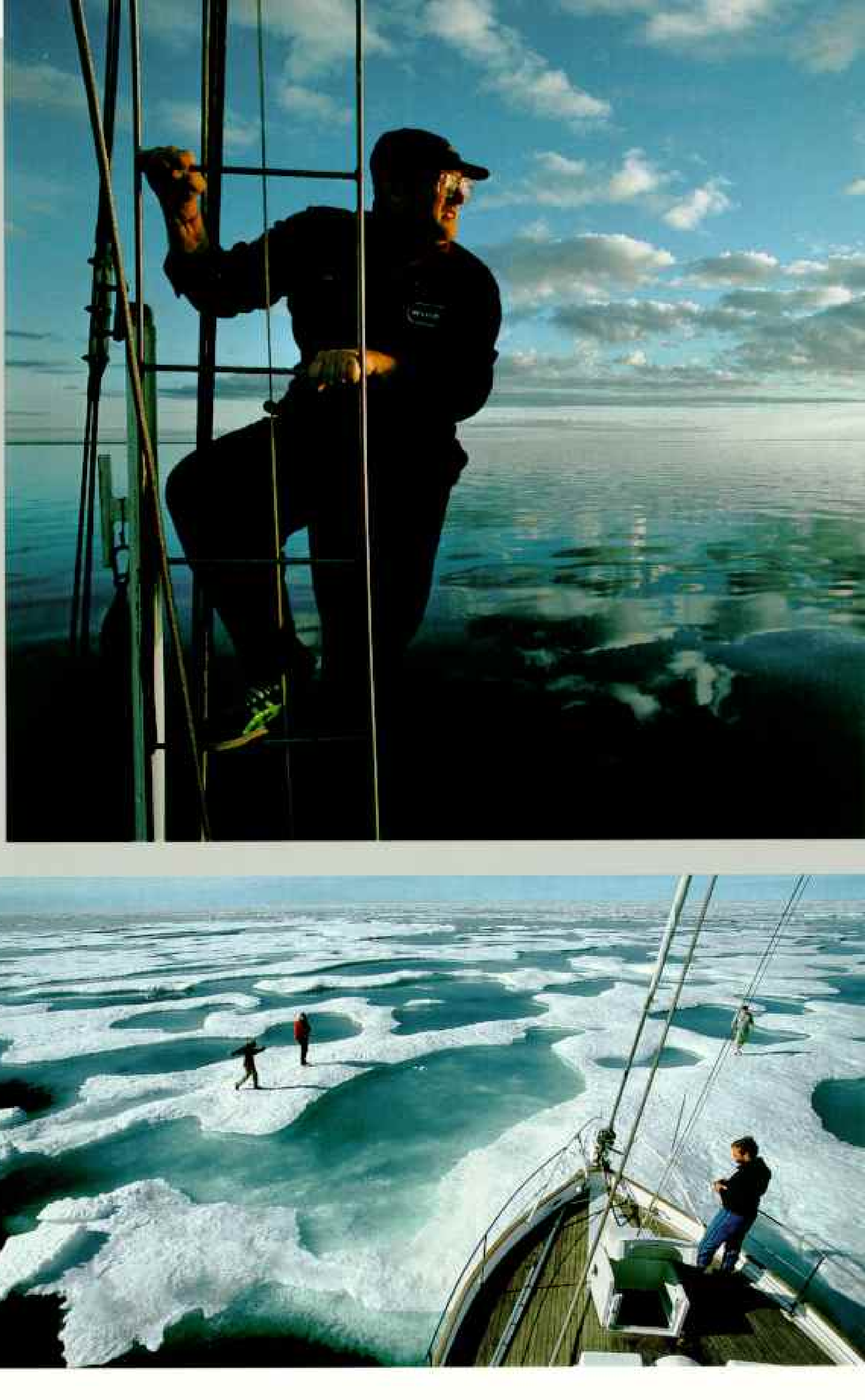
"A huge piece of drift ice?" I suggested.

"I don't think so, John," Sven answered. "The water's too shallow here. A piece that big would have grounded farther offshore in deep water, and so would a ship of any size."

I glanced at the chart on the navigation table. It only confirmed what I knew from sailing these waters years earlier: There was nothing here but empty sea.

Donning parkas, Craig and I made our way to the bow as Sven throttled back the engine. In the Arctic silence we could hear the ripple of water along the hull and somewhere to the north the great whooshing blast of a bowhead whale lazily blowing. Then from ahead came the faint clatter of machinery; the fog parted, and the "thing" materialized.

It was a man-made oil-drilling island, a great lens-shaped mass of gravel dredged from the floor of the Beaufort Sea and crowned with a maze of tanks, buildings,



Six years of persistence pays off

Time and again thick sheets of ice jammed between Arctic islands kept the 60-foot yacht Belvedere from making its way through the Northwest Passage. At last, during the warm summer of 1988, nature relented and it sailed through.

Leaving Tuktoyaktuk, Canada, the ship traveled 900 miles east to Gjoa Haven, where author John Bockstoce greeted an old friend, George Porter, amid welcoming villagers (below).

At James Ross Strait the crew explored the rotting ice that blocked the ship's progress (bottom left). "We knew this ice was going to move," John recalls, "but it held us up for about 48 hours before the wind blew it off the Boothia Peninsula and we were able to sneak up to Bellot Strait."

Western and eastern tides meet in dangerous 15-mile-long Bellot Strait, last obstacle to success. Once safely through, the crew sighted bowhead whales, which they recorded with a stamp in the log. Navigation dividers hold the page open.

From the rigging the author saw clear water ahead. Five days later, on September 3, he toasted arrival in Greenland.

Icy straits

TRAVERSED IN ITS ENTIRETY fewer than 50 times, the Northwest Passage has never become the shortcut across the Western Hemisphere that European explorers sought for centuries. During most of the year the thick, hard ice born of bitter cold makes the seas impenetrable. Long summer days of midnight sun loosen some of the ice and open a brief window for transit beginning in August. Smaller ships can sometimes sneak through the shallow southern route when melting ice breaks up and shifts aside. Larger vessels stick to the deeper northern route, where they must drive their way through much heavier ice. By November the passage has frozen shut once more. Ships powerful enough to use the waterway commercially could be built and operated with current technology but at a prohibitive cost.

machinery, piping, and the soaring drill rig itself. The entire scene was bathed in the eerie yellow glow of sodium-vapor lamps and punctuated here and there by the cold blue flicker of arc welders.

Craig shook his head and gave me a thin smile: "So much for the latest charts of the Northwest Passage."

THE INCIDENT occurred several years ago, and our charts were as up-to-date as any that could be found. Yet here was an immense new feature of the historic Arctic waterway that probably had not been there the season before.

In the months and years that followed as I traversed the Northwest Passage, I came to accept such surprises as commonplace. All along its rugged course the legendary polar route between the Atlantic and Pacific Oceans is undergoing profound and wrenching change.

Not only oil drilling but also mining, gas exploration, strategic military operations, tourism, shipping, and other industries are steadily invading the Arctic. The effect on native populations has been a confusing mix of benefits and drawbacks, including

SELECTED TRANSITS OF THE NORTHWEST PASSAGE

Year(s)	Name of ship	Registry	Type of ship
1903-06	*Gjoa*	Norway	herring sloop
1940-42	*St. Roch*	Canada	schooner
1954	*H.M.C.S. Labrador*	Canada	naval icebreaker
1960	*U.S.S. Seadragon*	U.S.A.	nuclear submarine
1969	*S/T Manhattan**	U.S.A.	icebreaking tanker
1977	*Willowe*	Netherlands	yacht
1984	*Lindblad Explorer*	Bahamas	passenger ship
1983-88	*Belvedere*	U.S.A.	yacht

*From Atlantic Ocean to Chukchi Sea and back.

Proceeding with diplomacy, Canadian icebreaker Sir John Franklin, *in the foreground, accompanies a U. S. counterpart,* Polar Star, *as it traverses the passage in August 1989. While the U. S. views the passage as an international waterway, Canada claims it as internal waters between its own islands. Under a 1988 agreement the U. S. asks Canada's consent for such transits but does not concede sovereignty.*

increased income and in many cases the drastic alteration of age-old cultures.

Meanwhile, disputes have arisen between Canada and the United States over national sovereignty in the Arctic, jurisdiction over military airspace, and free navigation through the Northwest Passage.

FOLLOWING COLUMBUS'S DISCOVERY of the New World in 1492, others soon realized that he had not reached the fabled Indies after all but had simply found a new continent. Almost at once the search was on for a way around it.

Charts of the passage feature the names of those who tried to find or to traverse the elusive waterway: Frobisher, Davis, Hudson, Baffin, Foxe, Parry—and the tragic name of Franklin.

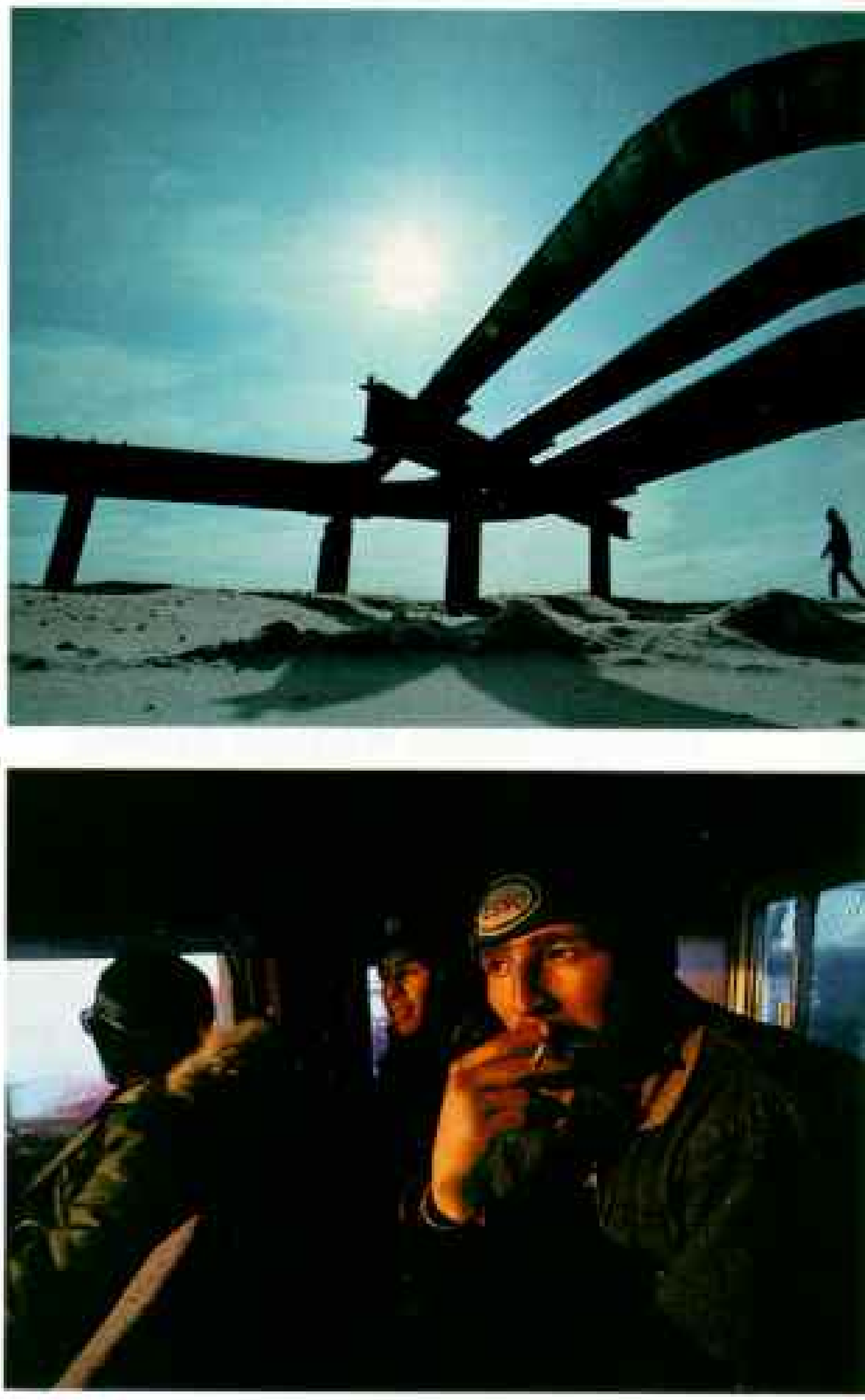
In 1845 Sir John Franklin left England with two ships, *Erebus* and *Terror*, to find and claim the Northwest Passage for Britain. The expedition vanished in the Arctic. Over the ensuing years a number of rescue parties explored and mapped previously unknown regions until a complete map of the Arctic could at last be drawn. Though the ships were never found, the searchers confirmed that Franklin and his 128 men had all perished. As one 19th-century chronicler wrote, "They forged the last link with their lives."

In fact, the last link was put in place by a Norwegian, Roald Amundsen, who later became the first man to reach the South Pole. Between 1903 and 1906 Amundsen and a crew of six threaded the Northwest Passage from east to west in a 70-foot herring sloop named *Gjoa*, proving that a navigable northern route existed between the Atlantic and Pacific Oceans.

Nearly four decades later, in 1942, a Royal Canadian Mounted Police sergeant named Henry Larsen and his crew completed the first west-to-east transit of the Northwest Passage in a 104-foot schooner, *St. Roch*. Two years later Larsen reversed course and became the first ever to traverse the passage in both directions.

My own traverse took six summers to complete, for as always in the Arctic everything depended on ice conditions. Besides, I was in no hurry. I had last sailed these waters in the 1970s by umiak, an Inuit open boat made of wood and walrus skin.* On both these transits I took the southern route through the passage rather than the northern one (map, pages 10-11).

During our initial season in 1983 we sailed *Belvedere* some 4,000 miles, from Seattle north through the Bering and Chukchi Seas, around Alaska's Point Barrow, and into the Beaufort Sea, where we had our encounter with the oil-drilling island. Soon afterward we brought *Belvedere* ashore for the winter at



***Conduits to the oil fields:** On a road of ice atop the Beaufort Sea, trucks haul supplies to Herschel Island for the early spring start of the drilling season. A pipeline from the Endicott field, tapped from an artificial island east of Prudhoe Bay, sends crude to Valdez, Alaska. In the Mackenzie River Delta a seismic crew waits for the next stage of a survey.*

*The author described his voyage in "Arctic Odyssey," NATIONAL GEOGRAPHIC, July 1983.

the Inuit village of Tuktoyaktuk, just east of the Mackenzie River Delta.

The following July my wife, Romayne, and eight-year-old son, Johnny, joined us at Tuktoyaktuk, known to Arctic hands simply as "Tuk." From there our first stop was Herschel Island, the major wintering-over site in the western Arctic for the 19th-century American whaling fleet. It is a place rich in history. During its heyday in the 1890s Herschel Island played host to as many as 15 ships and a thousand people at a time.

As a specialist on the Arctic whaling industry I had visited Herschel many times. It was a ghost settlement of empty shacks, rusting machinery, and lonely whalemen's graves interspersed with fields of wildflowers. Only the occasional cries of seabirds disturbed the silence.

But no longer. Well before we reached Herschel, our ship's radio began to crackle with an incessant barrage of voice traffic, all of it to do with oil—not whale oil but petroleum. When we arrived, we found the waters just outside the small harbor jammed with a fleet of dredges, barges, supply ships, and launches. Oil-company helicopters buzzed overhead like giant mosquitoes.

After several days spent completing a survey of old whaling sites, we left. For the first time I was glad to bid the island good-bye. "Never mind," said Romayne. "The place probably wasn't any quieter when those 19th-century whaling ships were jostling around the harbor!"

ON OUR WAY eastward from Herschel Island we stopped at King Point on the mainland coast. It was here that Amundsen and his men spent the winter of 1905-06 and here that a member of the crew, Gustav Wiik, died of an unknown disease.

Carrying a camera and a shotgun, Johnny and I took the ship's dinghy ashore. Johnny quickly spied a trail of fresh grizzly bear paw prints in the sand, and we followed them to the foot of a bluff a few yards from the beach. We clambered over a huge jumble of driftwood logs and scaled the bluff, which was eroding badly.

Johnny reached the top first, and I was entertaining uneasy thoughts about grizzlies when Johnny suddenly let out a whoop. I very nearly jumped out of my skin, but when I reached Johnny, he was merely holding a weathered board he had found at the edge of the bluff. The surface had been deeply inscribed with the name "Gustav Wiik."

Wiik's grave had eroded away with the bluff, and all that remained was the wooden marker. We moved the board 30 yards inland. Then after a bit more exploring, we returned to the ship. To my relief, though not to Johnny's, we never saw the grizzly.

The ice that had grudgingly let us pass in the summer of 1983 suddenly turned against us in 1984, blocking our way to the east. There was nothing to do but come ashore at Tuk and put *Belvedere* up for the winter.

Though *Belvedere* was immobilized, I was not, and I spent part of the following winter interviewing those who have helped bring major changes to the Northwest Passage. One of these is Vice Adm. George P. Steele, USN (Ret.), who as a young submariner in 1960 commanded the U.S.S. *Seadragon* on the historic first submerged transit of the passage. Like us, George Steele had had his problems with ice.

"We were entering Canada's Barrow Strait," he recalled at his home in Baltimore, Maryland. "In those days charts of the passage were quite inaccurate—some were actually based on exploration in the early 1800s.

"Just inside the strait our sonar picked up an uncharted shoal, and I admit I had some bad moments. We were in danger of being hemmed in by the pack ice above and the floor of the strait below, and I wasn't sure what lay on either side of us. If we got wedged between the ice and the sea bottom, we would probably become a permanent fixture in the Arctic.

"My stomach was in knots," he continued, "but as skipper I couldn't show it. For what seemed like an eternity we slowly followed the bottom contours, trying to maintain a ten-foot distance. Then to our relief the bottom began to recede.

"During less harrowing moments of our voyage I was fascinated by the view of the underside of the pack ice through the periscope. It was a wild, upside-down jumble of massive ice slabs, shaded in varying tones of blue and white—the most incredible scene I can ever recall."

Fortunately, *Seadragon* found its way through Barrow Strait, then proceeded through the passage, and eventually returned

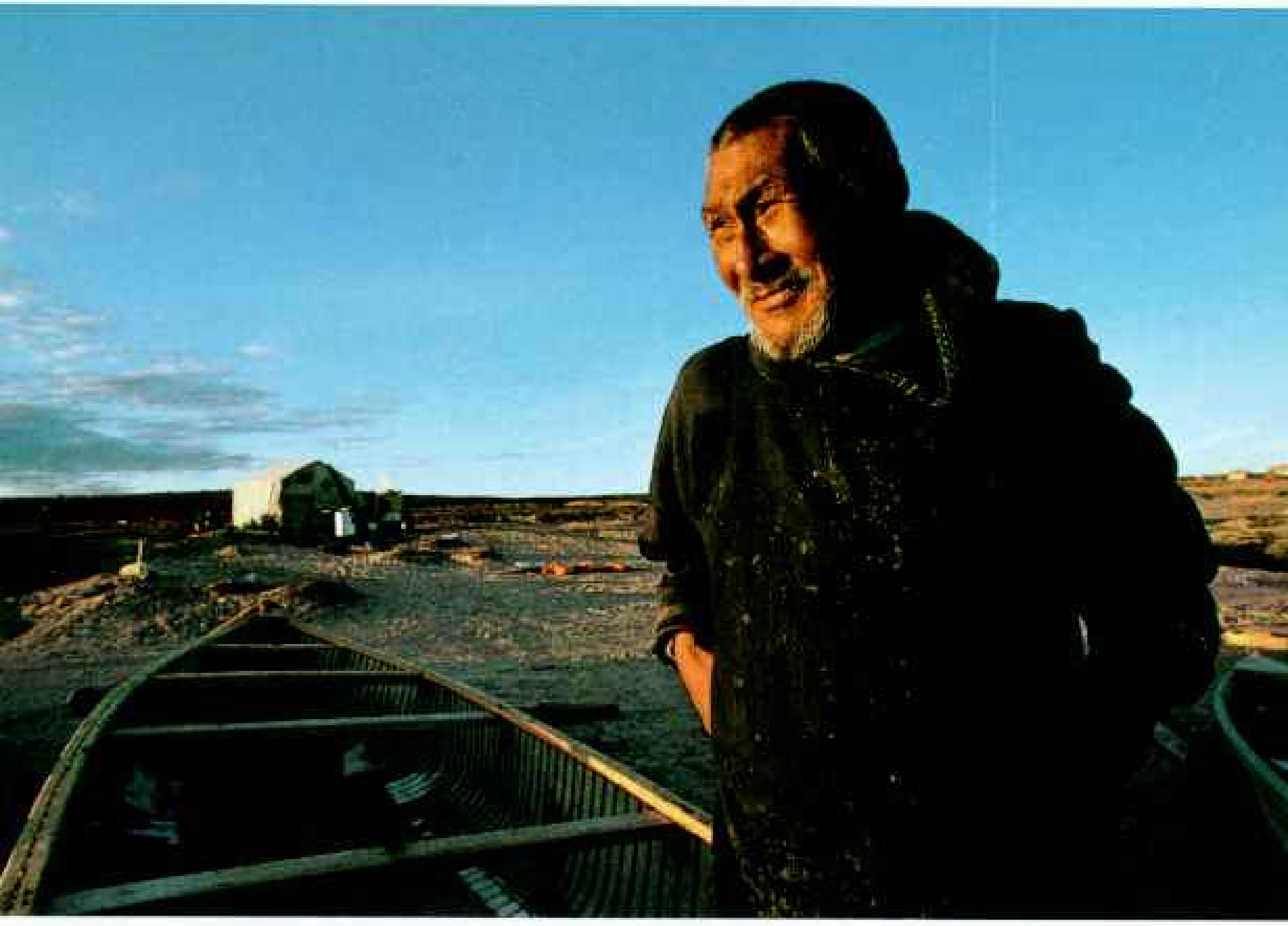
home via the Pole and Bering Strait. Two years earlier another U. S. submarine, U.S.S. *Nautilus*, had made history by completing the first undersea traverse of the North Pole. The following year U.S.S. *Skate* was first to surface there through the ice.* Such voyages helped transform the polar seas into a vast strategic amphitheater and ushered in an era of clandestine cat-and-mouse games beneath the ice that continues to this day.

ABOVE THE SURFACE as well as beneath it the Northwest Passage has played a crucial role in the Arctic standoff between the United States and the Soviet Union. In the 1950s, when Soviet bombers developed the capability of striking American targets via polar routes, the United States and Canada built the Distant Early Warning (DEW) line—a chain of radar monitoring sites stretching from Alaska to Greenland. Most of the stations were built along the passage so that supply ships could reach them during ice-free periods or with the help of icebreakers.

Still, by 1968 only ten vessels of any type had ever managed to traverse the Northwest Passage. In that year a momentous, some say catastrophic, event occurred: Oil was discovered at Prudhoe Bay on Alaska's north coast. Overnight the passage took on vital significance as a possible route by which the world could tap Prudhoe Bay's estimated 11 billion barrels of oil reserves. Capt. Donald Graham helped prove the idea would work.

I called on him at *(Continued on page 20)*

*See "Submarine Through the North Pole," by William G. Lalor, Jr., GEOGRAPHIC, January 1959, and "Up Through the Ice of the North Pole," by James F. Calvert, GEOGRAPHIC, July 1959.



An old-time hunter and trapper, Nicholas Qayutinnuaq repairs his canoe on a summer evening near Gjoa Haven. In his 80-some years he has seen foreign life-styles and values intrude ever deeper and more permanently into the Arctic. Many Inuit fear that their culture cannot survive such pressure.

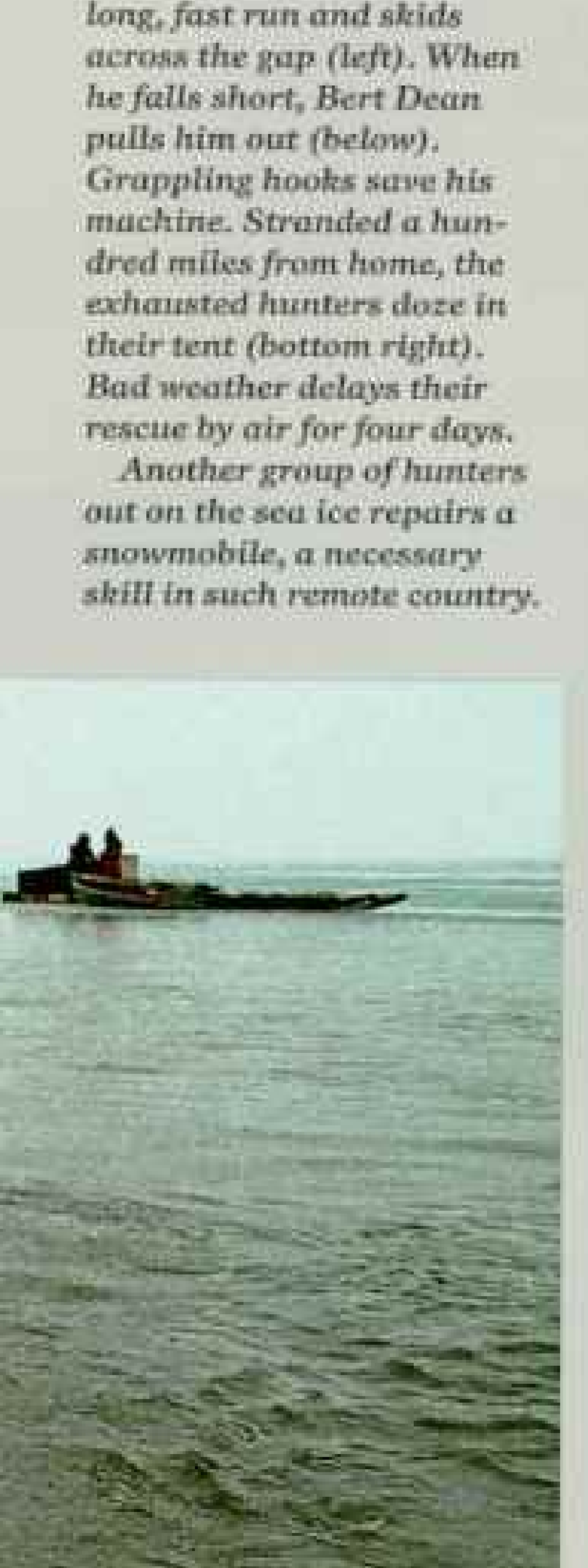
Skimming through shallow spring melt that pools on an expanse of sea ice, Inuit narwhal hunters ride a snowmobile and towed sled to open water.

There's not much room for error in the unforgiving Arctic wilderness, where hunters' lives depend on skill, experience, and a buddy's helping hand.

From the north of Baffin Island a hunting party has journeyed across the frozen sea to the floe edge, the line where landfast ice meets open water. But the round-the-clock sunshine of early summer has weakened the ice, which begins to break up and drift to sea before the hunters can land any narwhals. Safety now lies across a 70-foot stretch of

water that has opened between the ice and shore. Circling back on his snowmobile, Joe Koonoo takes a long, fast run and skids across the gap (left). When he falls short, Bert Dean pulls him out (below). Grappling hooks save his machine. Stranded a hundred miles from home, the exhausted hunters doze in their tent (bottom right). Bad weather delays their rescue by air for four days.

Another group of hunters out on the sea ice repairs a snowmobile, a necessary skill in such remote country.



his home in Falmouth, Massachusetts, where he is now retired after a lifelong career at sea in the U. S. merchant marine. He was one of three captains chosen to command *Manhattan*, the celebrated icebreaking tanker that made a round-trip between the Atlantic and Point Barrow in 1969.

"She was a real hybrid," Captain Graham said of the ship. "Humble Oil [now Exxon Corporation] chartered her, and she was the largest ship in the U. S. merchant fleet, with a length of 940 feet. But her hull had to be reinforced to withstand pack ice in the Northwest Passage, and she needed an icebreaking bow as well. To speed the job up, they cut her into four separate sections. Then they put her back together and launched her a second time. She had gained 65 feet in length, displaced 150,000 tons, and had a loaded draft of more than 52 feet."

Despite all the remodeling *Manhattan* was accompanied by U. S. and Canadian icebreakers. Even so, when she reached M'Clure Strait in the western part of the passage, she could go no farther.

"We came up against that great river of old polar ice that flows down into M'Clure Strait from the Arctic Ocean," he recounted. "As an experienced sailor in the passage yourself, you know what that's like: pack ice between 6 and 14 feet thick, jammed solid under pressure from wind and current both. And there we were—150,000 tons of ship, with the turbines cranking out 43,000 horsepower, and we couldn't move an inch. It took us two days just to get back out of M'Clure Strait."

Manhattan took an alternate route through neighboring Prince of Wales Strait and finally reached Point Barrow. The round-trip voyage was successful, but the idea of shipping Prudhoe oil through the Northwest Passage was abandoned in favor of a trans-Alaska pipeline.

Yet even with the pipeline, the oil still had to be shipped out of Valdez, a port in southern Alaska. Two decades after *Manhattan* made her historic voyage, the giant tanker *Exxon Valdez* made an even more memorable one: Twenty-eight miles southwest of Valdez the tanker struck a reef and spewed 11 million gallons of crude oil into the pristine waters of Prince William Sound.*

I thought of *Manhattan* many times during the brief summer season of 1985. The pack ice east of Tuktoyaktuk was so bad that we made only about 60 miles north along the coast before we finally gave up and sailed back to Tuk.

*See "Alaska's Big Spill," by Bryan Hodgson, GEOGRAPHIC, January 1990.

Curiosity brings a groggy two-year-old cub halfway to his feet during a polar bear census on Victoria Island. He and his still tranquilized brother have received lip tattoos and ear tags. Wildlife biologists examine their mother, who also will get a radio collar. Data will help determine hunting quotas.

The summer of 1986 was only slightly better, and I decided to detour north toward *Manhattan*'s old route through Prince of Wales Strait. For our pains we were hit by a 40-knot gale soon after we left Tuk.

We resorted to an old Arctic mariner's trick when there are no harbors around for refuge: We made for some nearby pack ice and secured the ship to the lee side of one of the larger floes. It was a curious sensation to be afloat in relatively placid water while the gale above ripped our masthead flags to shreds. Yet at the edge of the floe the wind was so calm that we stepped ashore and enjoyed a rather slippery game of Frisbee.

After the gale died, we continued north and entered Prince of Wales Strait. Along the shores on either side we spotted herds of musk-oxen grazing in valleys carpeted by the lush green of the brief Arctic summer. We went ashore at Jesse Harbour on Banks Island. As our dinghy scraped the gravel beach, one of the herds of musk-oxen bolted, long hair streaming behind and the muffled thunder of their hoofs echoing among the rocks. To seaward an occasional seal's head popped up through the calm waters, spreading rings of perfectly concentric ripples.

Our luck soon ran out again, for halfway through Prince of Wales Strait a solid wall of pack ice barred the way. We turned back, going ashore briefly on Victoria Island's Walker Bay.

In 1940-41 Henry Larsen and the crew of *St. Roch* wintered over in this beautiful, secure harbor ringed by limestone bluffs. We found a beehive-shaped cairn they had built to mark the spot. After a while we returned aboard *Belvedere*, set a course for the southwest, and sailed once more in frustration back to Tuk.

FOR YEARS Canada and the United States have disagreed about sovereignty over the Northwest Passage. Canada maintains that much of it consists of internal waterways subject to exclusive Canadian control. The U. S. recognizes Canadian sovereignty over the islands bordering the passage but insists that the passage itself is an international waterway open to ships of all nations.

Charges and countercharges have been leveled from both sides. Canadians accuse Americans of suffering from a "Mercator mind-set," referring to the old-fashioned Mercator map projection that greatly enlarges the polar regions and distorts the width of Arctic waterways.

"Mercator maps make the passage look very wide and very international," agrees Leonard Legault, the bluff and friendly number two man at the Canadian Embassy in Washington, D. C. "In fact," he told me cheerfully, "the National Geographic Society has done us a real favor by publishing its new

Research stations don't get much remoter. On a tiny island 90 miles north of Resolute, this cabin overlooks a polynya, an area of open water in the sea ice. Resident scientists study marine mammals that gather here.

Robinson projection map of the world. It puts Canada and the Northwest Passage into a smaller scale that more accurately depicts the region."

Canada and the United States finally agreed to disagree. Although both countries hold to their separate views of the Northwest Passage, U. S. merchant ships adhere strictly to Canadian regulations there. U. S. warships, meanwhile, are covered by bilateral defense agreements and NATO treaties allowing free passage, and icebreakers come under still another agreement. Before a U. S. icebreaker enters the Northwest Passage, the U. S. formally requests Canada's consent. It is promptly given, and both sides seem happy with the arrangement.

Prompted by *Manhattan*'s voyage, Canada took a major political and environmental step in 1970 by passing the Arctic Waters Pollution Prevention Act. The law extended Canada's territorial waters from 3 to 12 miles and established a pollution-prevention zone. The law also set standards for the types of vessels allowed into Arctic waters and requires progressively stronger hulls for areas of increasingly heavy ice conditions.

Ice isn't the only hazard that ships face while under way. Several summers ago I joined Capt. Patrick Toomey aboard *Pierre Radisson*, one of the Canadian Coast Guard's most modern *(Continued on page 31)*

Eskimos pull together for a whale harvest

It takes teamwork to haul in 50 tons of bowhead whale—friends, neighbors, and relatives pulling side by side until the great dark hulk slides onto the ice. So when the news crackles over the radio that Simeon Patkotak's crew has taken a whale on the Chukchi Sea, 150 Eskimos head out of Barrow, Alaska, on snowmobiles towing sleds and boats.

For more than three hours they drive toward the floe edge, guided by the dark band that open water reflects on the cloudy sky. Arriving around 9 p.m., they find the whale, marked with two buoys, floating just below the surface. Men take to their boats and clear a path so the team can move the whale to solid ice (left). A polypropylene line attached to a cargo strap brings the tail up first (top right). The flukes have been cut off to make towing easier and will be shared at a later ceremony.

"We need pullers," the whaling captain calls. "Come on, haul." As they lean back (top far right), others chime in, "Carry on back . . . keep pulling . . . haul away."

Suddenly a sound like a shotgun blast rings out, then the snapped line springs past. People sprawl on the snow (right), several holding up their badly burned hands.

Starting over, the group raises the whale far enough to attach a block and tackle. Several times as the huge mass inches forward, men kneel on the lines to prevent the whale from sliding backward while the purchase on the pulleys is changed (above).

A section of muktuk, the black skin lined with blubber, already has been cut away and boiled to make an oily snack enjoyed by all (right).

By 2 a.m. all 48 feet 3 inches of the whale lies on solid ice. Butchering begins immediately. Insulated by thick blubber, the warm meat will soon spoil, even though the outside temperature is well below freezing.

A collection of tents, boats, and snowmobiles converts the floe edge into a small town in a matter of hours. The people come alive in a way that they never do back in Barrow. It's a carnival filled with laughter. It means renewed friendships, strengthened community bonds, the reaffirmation of a people who have survived in the north for thousands of years.

Back by the whale, the hunters send up a loud cry. The female bowhead had been carrying an unborn calf, now cut free and left on the ice (left). It is sad, but the calf would not have survived without its mother. Whale-census coordinator Craig George will take it back to his laboratory in Barrow for study. "This is a rare opportunity to

look at a whole animal," he explains.

Nearly 12 hours after arrival, the whale carcass has been stripped and left for the polar bears. As tired families load up their share of meat and muktuk, I wonder just how long this tradition will continue.

—Richard Olsenius

(Continued from page 23) icebreakers. The ship was working out of Resolute in Canada's Arctic islands, escorting supply vessels to and from weather stations and other sites along the Northwest Passage.

Captain Toomey invited me to the bridge of *Pierre Radisson* during the run across Barrow Strait. As we crunched our way effortlessly through the closely packed ice floes, he told me a bit about escort duty.

"Of course, the heavier the ice," he said, "the closer you have to keep the ships behind you." He swept a hand in front of us. "This kind of stuff is nothing, but when you get into dense, thick ice that's several years old and you hit a big piece, it gets violent—feels like you've run aground at high speed.

"Then you have to look behind as well as ahead, because the real danger's that the ship astern won't be able to stop in time and will ram you." He smiled grimly. "In this business you look over your shoulder a lot."

Traditions can't compete with modern temptations in the heart of a child. Boys with a boombox play it cool at Inuvik's airport, while Victoria Island schoolgirls (above) eat snack food for lunch. Outside influences that have transformed Arctic life in little more than a generation put an added burden on young parents like Albert and Vera Ehaloak (top).

NOT EVERYONE along the passage welcomes the presence of icebreakers. I talked one day with an old friend, George Porter, an esteemed Inuit leader of the community of Gjoa Haven on King William Island in the central part of the passage. The village takes its name from Amundsen's sloop, which anchored there from 1903 to 1905.

George Porter's grandfather was a Yankee whaling captain who wintered many times at Herschel Island, and his father was both a fur trader and an Arctic seaman. I told George of my experience aboard *Pierre Radisson*, and his face turned grave.

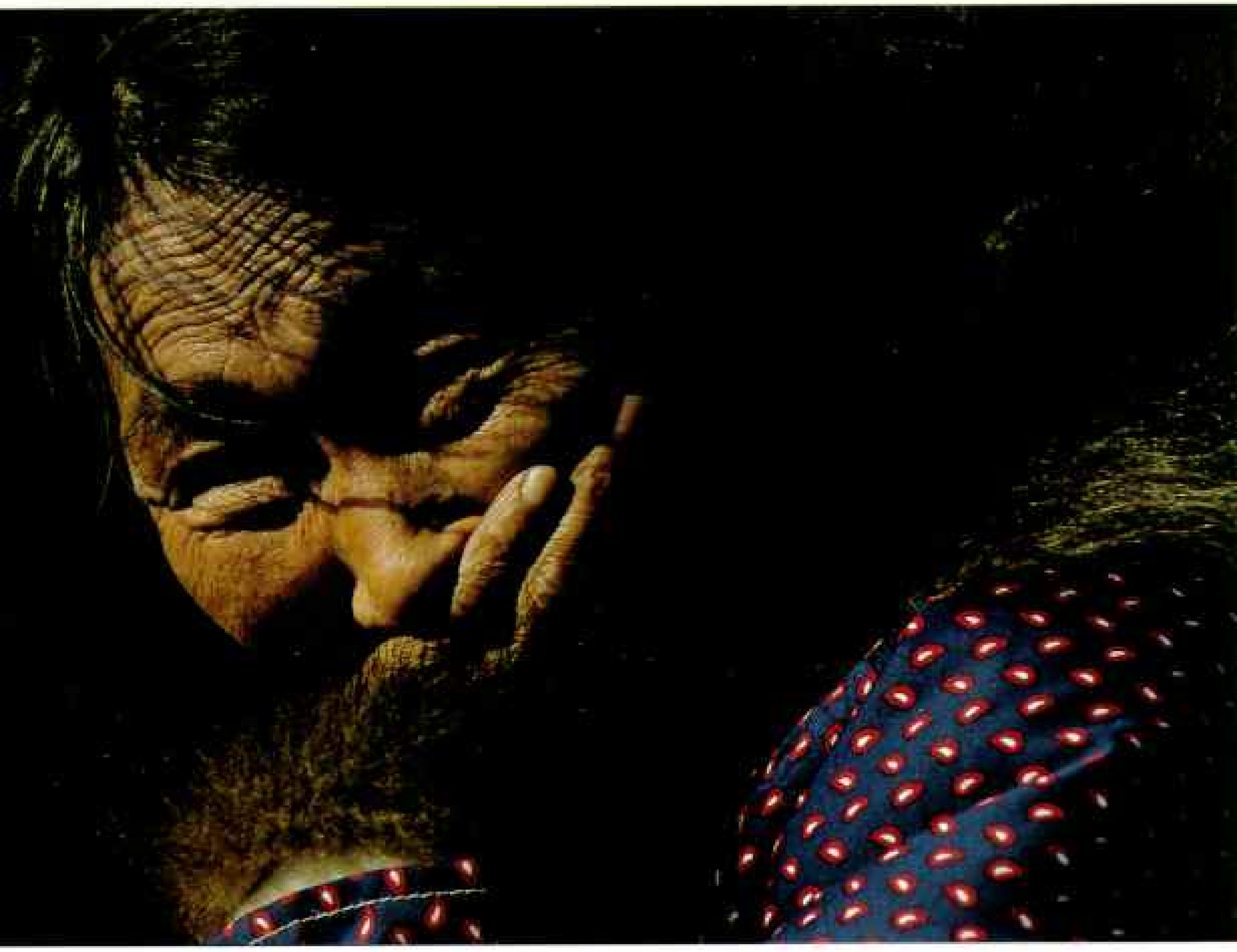
"You know, John," he said, "for Inuit people the land and the water are the same thing—here the sea is frozen over most of the year. So to us, driving a ship through the ice is like driving a bulldozer across a field with the blade down.

"A few years ago," he added, "a group of hunters from Arctic Bay to the north of here were out on the ice miles from home hunting seals. Without knowing they were there, a Canadian Coast Guard icebreaker cut a lane between them and the village. They were stranded for several days until the ice closed up again. If it hadn't, those men could have died."

What many native peoples fear most along the Northwest Passage today is the growing level of pollution. To them an oil spill such as the one caused by *Exxon Valdez* is not just an environmental disaster but a threat to life itself. Although oil has brought increased income and other material benefits, some like Luke Koonook consider the cost to be dangerously high.

A respected Eskimo leader in his village of Point Hope, Alaska, near the western entrance of the Northwest Passage, Luke is captain of an eight-man whaling crew that hunts bowhead whales each spring, when the great creatures come north to feed in the eastern Beaufort Sea.

Point Hope has 19 such crews, and they



The hard work and harsh weather of almost five decades are etched on the face of Alice Aglukkaq. She and her husband winter in their warm Gjoa Haven home and return to their seaside camp when the weather is mild, striking a comfortable balance between the best of the new and the best that their own heritage has to offer.

put to sea in sealskin boats with hunting gear little changed from that of the old Yankee whalers. The tradition of the bowhead hunt goes back a thousand years and forms a vital part of Point Hope's Eskimo culture.

For ten years I was a member of Luke Koonook's crew, and I visited him recently one spring during the hunt to see how things were going. I found him at the edge of the ice at his lookout station with his boat and crew nearby ready to launch at the sight of a bowhead. Several other boats were at sea pursuing whales already sighted. Luke greeted me with a grim question.

"John, what do you know about the tanker that's supposed to bring oil past here from Herschel Island?" I said I had seen the ship at Herschel, all 90,000 tons of it, and that I had heard the plan was going through. Luke shook his head.

"Those people just don't understand the ice the way we do, what it can do to any ship." He swept a hand seaward at the half dozen boats and crews amid the ice. "Just one accident and all this might go—and our way of life will go with it."

Farther north at villages such as Wainwright and Barrow, whalers say much the same thing, adding that the noise and vibration of offshore drilling and dredging have already scared away some of the bowheads.

Canada and the world at large have begun to listen to people like Luke Koonook and George Porter. The threat of pollution has been a significant factor in the five Inuit Circumpolar Conferences—pan-Arctic

gatherings first held in 1977 to discuss the future of Arctic peoples. Meanwhile, Canada has established regional planning groups with increasing local control over the use of land and other natural resources.

Here the Canadians had as a precedent the U. S. government's historic Alaska Native Claims Settlement Act of 1971, which gave Alaskans with at least one Native American grandparent partial rights to the oil-rich lands of the North Slope. Oil revenues make the Arctic Slope Regional Corporation one of the richest land-rights associations in the world today.

Two local Canadian Inuit land-use planning groups along the Northwest Passage have a major voice in development or exploitation of natural resources. One group, based in Lancaster Sound, oversees the eastern area of the passage, and the Beaufort Sea group controls the western area. No major step affecting the environment can be taken without one or the other group's approval.

None of these developments have come too soon. To date 240 oil wells have been drilled in Canada's Beaufort Sea and Mackenzie River Delta area alone. In Alaska's part of the Beaufort Sea, an artificial island known as the Mukluk Well reportedly cost more than a billion dollars to drill and came up a dry hole. Meanwhile oil companies have begun eyeing the Chukchi Sea, off Luke's village of Point Hope, and Lancaster Sound, in the eastern part of the passage, as likely spots for exploration. More ominous still, they hope to explore Alaska's Arctic National Wildlife Refuge for possible oil reserves.*

THE SUMMER OF 1987 turned out better than the previous three, but not quite good enough to get *Belvedere* through the Northwest Passage. We sailed more than a thousand miles to the east of Tuk, past Gjoa Haven, before pack ice in nearby James Ross Strait barred the way. We returned once more to Tuk, which I gloomily began to regard as *Belvedere*'s permanent home port, and hoped for better luck the following year.

We got it at last. The summer of 1988 proved to be the warmest in five straight years in the western Arctic. Breakup came early, and we left Tuk with high hopes of reaching our final destination, the northwest coast of Greenland, before the ice did.

The weather held as we threaded Amundsen Gulf, Dolphin and Union Strait, Queen Maud Gulf, and our nemesis of the year before, James Ross Strait. En route we anchored in Simpson Strait off King William Island, where many of Franklin's men died in the vain effort to walk south out of the Arctic to safety.

We went ashore to visit a group of cairns built in memory of Franklin's men by those who had searched for them. And when we left that sad and lonely spot, we flew our ensign in their honor, as Roald Amundsen had done 83 years before.

On August 25 we reached Bellot Strait, considered the fulcrum of the Northwest Passage, for it is here that the tides of the western Arctic meet those of the east. Some years earlier, during my umiak voyage, a fur-trader friend at Spence Bay, Ernie Lyall, had urged caution going through Bellot Strait.

"If there's ice around," Ernie warned, "the current can send the floes through the strait like bowling balls, and conditions can change fast."

Fortunately there was little ice in the strait on either occasion, and we ran it this time at slack tide without incident. As we left Bellot Strait behind and steered north for Lancaster Sound, little gray fulmars swooped around *Belvedere*, and we could see bowhead whales spouting ahead of us. They seemed a fitting welcome to the eastern Arctic.

The next day we entered Lancaster Sound, and a week later, after running down Baffin Bay, we reached Davis Strait, the end of the passage. Soon afterward we reached Greenland and the close of *Belvedere*'s odyssey.

It had taken us six summers to traverse the passage, and *Belvedere* was the first yacht ever to make the west-to-east transit. Even today no more than 50 vessels of any kind have traversed the waterway in either direction, and it can hardly be called a practical commercial route—yet.

I hope it never will be. The pace of change in the Arctic is already dizzying enough for residents and outsiders alike. A great maritime highway through that vast and haunting realm of land, sea, and shifting ice would forever change the character of the Northwest Passage and those who live along it.

The world would be the poorer. □

*See "Oil in the Wilderness: An Arctic Dilemma," by Douglas B. Lee, GEOGRAPHIC, December 1988.

NEPTUNE

Voyager's Last Picture Show

By RICK GORE ASSISTANT EDITOR

Images by NASA/JET PROPULSION LABORATORY

FOR THE VOYAGER 2 SPACECRAFT the visit to Neptune is both a first look and a final farewell. There was Jupiter in 1979. Saturn in 1981. Uranus in 1986. Now in June 1989, four billion kilometers from home, Voyager is approaching a mesmerizing blue planet. In a few weeks, cameras wide open, it will hurtle over the top of Neptune and scan the surface of its even more mysterious moon Triton. Then it will head for a silent death beyond the far ends of the solar system. To those of us who have followed Voyager since launch, the weeks ahead promise another euphoric high. But they are also tinged with melancholy. As veteran Voyager imaging scientist Rich Terrile puts it: "For a guy like me who explores worlds for a living, this is it. The last new world for a long time."

In June anticipation rules. At the observatory on Mauna Kea on Hawaii, a young astronomer, Heidi Hammel, focuses a huge telescope on the remote planet. In recent nights she has found a new white spot on images of Neptune. It is a cloud, a feature that Voyager is now also starting to see.

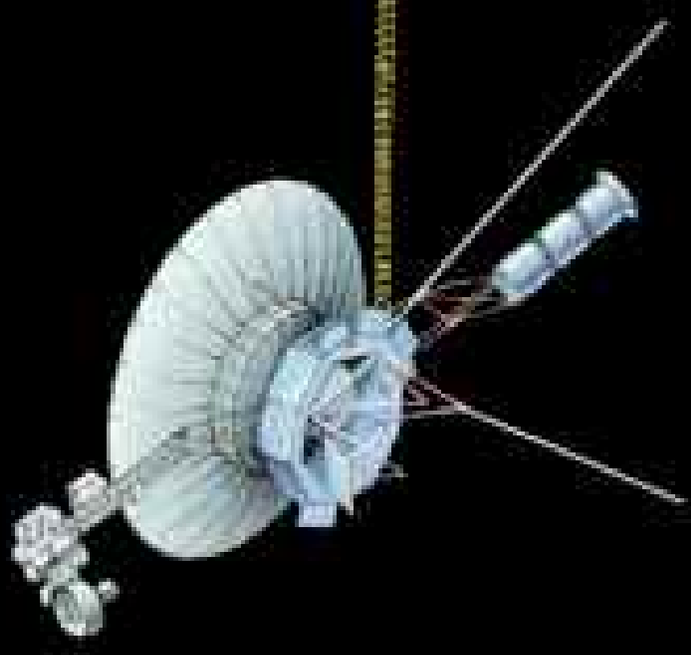
"Already we know that Neptune is not going to be another Uranus," says the excited Hammel. Uranus had disappointed scientists three and a half years earlier when Voyager could not see through the deep atmosphere that obscures its weather. It looked bland as a billiard ball.

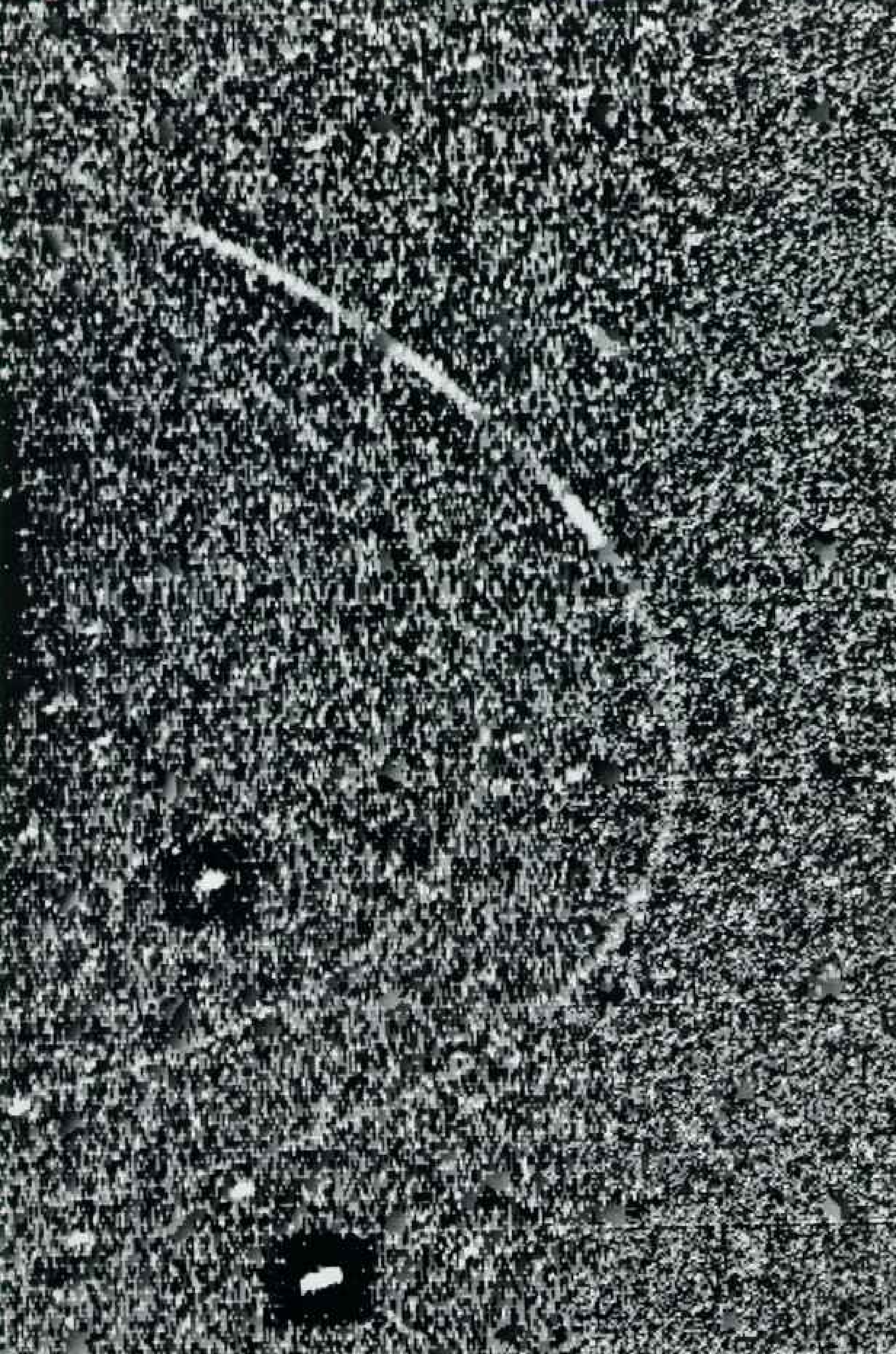
"We're calling this the Great Dark Spot," says Hammel as she points to a huge stormy vortex on a recent Voyager Neptune image. It recalls the gigantic, swirling Great Red Spot that dominates Jupiter's turbulent atmosphere. Wispy high clouds also streak Neptune's upper atmosphere.

Meanwhile, at another Mauna Kea telescope astronomers Dale Cruikshank and Robert Brown are measuring the infrared spectrum of the

Discovered as a speck of light in 1846, Neptune revealed its glory last August as Voyager 2 sped toward the edge of our solar system. Four times the diameter of Earth, this giant planet and its enigmatic moon Triton have scientists delighted and confused.

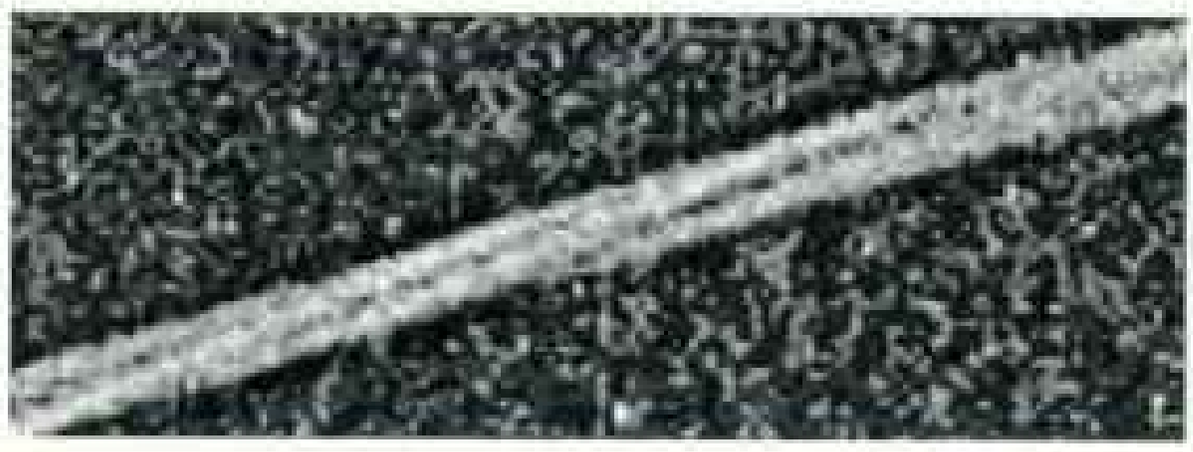
PAINTING BY STEPHEN BESHARA (RIGHT)





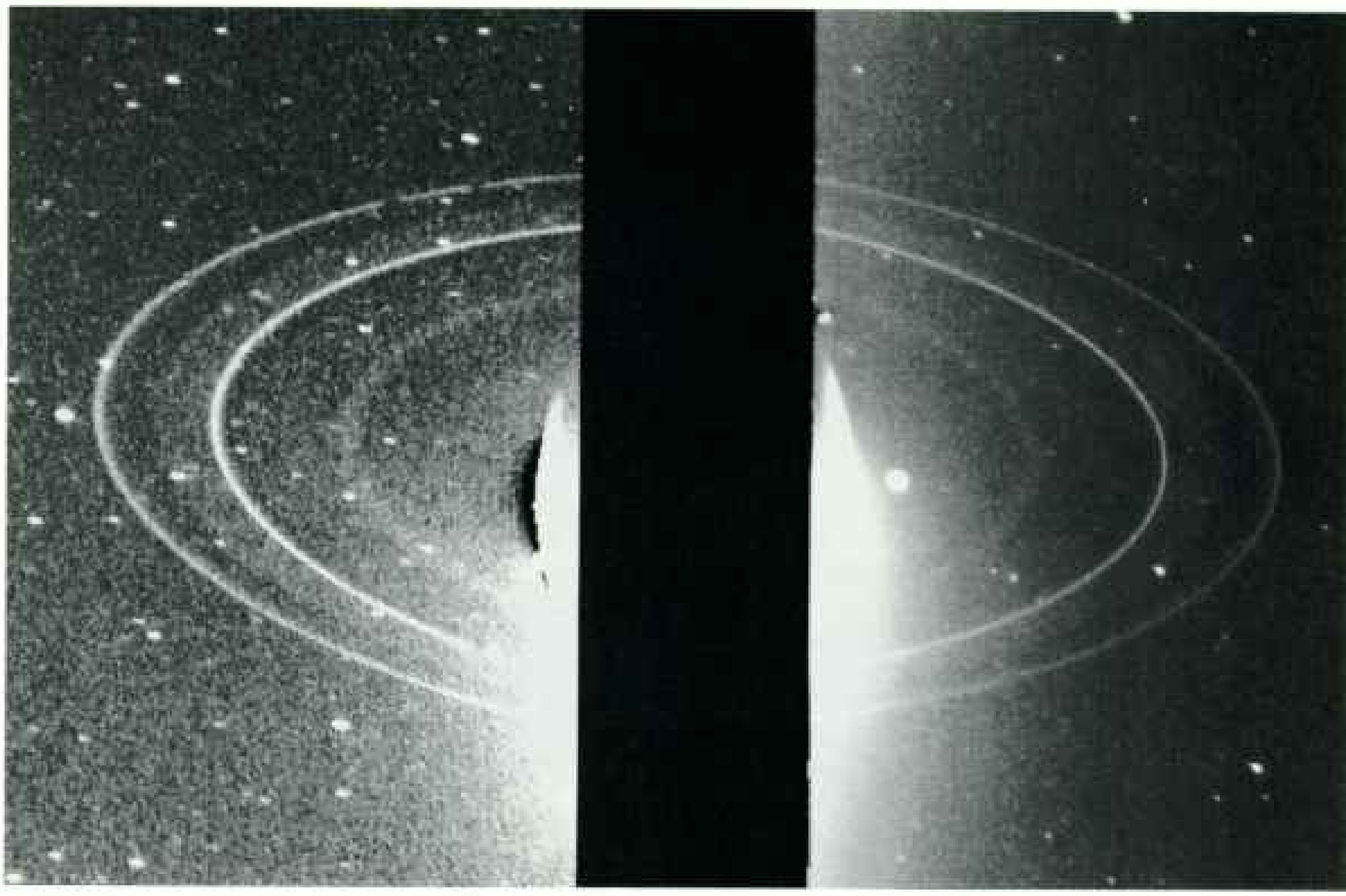
moon Triton. Six years earlier these two men—among the few interested in that distant speck of light—had detected methane and nitrogen on Triton's surface. At that time they suspected that Triton's frigid temperature might liquefy nitrogen but not be cold enough to freeze it. Thus they had predicted that Neptune's only big satellite—nearly the size of our moon—might be covered by an ocean of nitrogen, interspersed with continents of methane ice.

Recent Earth-based data have indicated Triton may be a bit too cold. Liquid seas would freeze. Still Cruikshank is hoping Voyager might find nitrogen lakes in local hot spots.



A more bizarre phenomenon intrigues astronomers at other telescopes. In the past few years several observing teams have detected blips in their data that indicate Neptune may have faint partial rings, called arcs. By the time mission scientists convene in August at the Jet Propulsion Laboratory in Pasadena, California, those arcs have actually been recorded. Preposterous apparitions, the arcs seem to defy the laws of physics as they dangle in space.

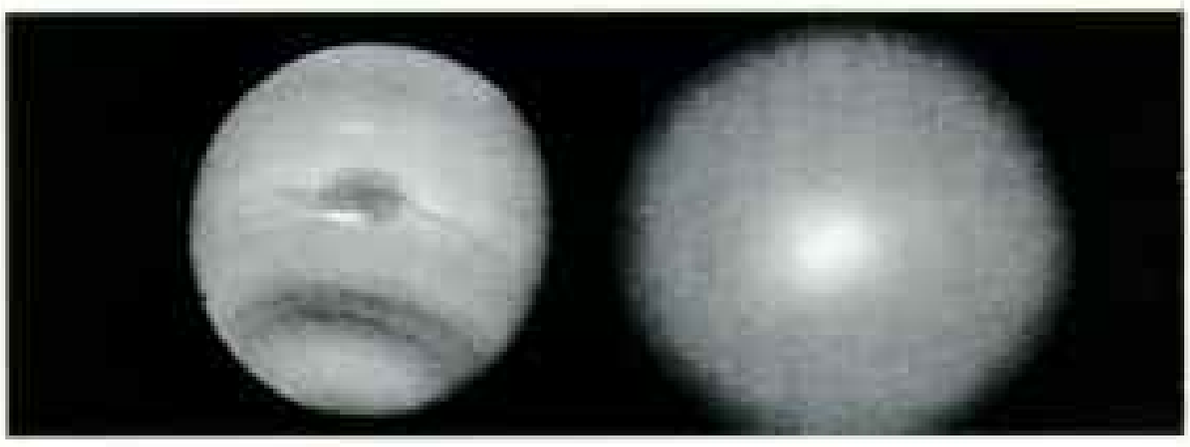
August 22. I arrive at JPL's press room. Familiar faces abound. Like Voyager, ten years ago all of us—scientists and reporters alike—had fewer miles on us. Then we used typewriters. Now everyone has laptop computers. Ten years



By looking back toward the sun (above), Voyager captured light being scattered by Neptune's tenuous, charcoal-dark rings. In the farthest ring (left), 63,000 kilometers (39,000 miles) out, material mysteriously clumps into three arcs, at lower left. The image includes one of Neptune's eight moons, at top, and a star. Ring movement smeared another image of one of the arcs (top), showing that they hold knots of accumulated particles.

ago we competed with the Soviet space program. Now three Soviet scientists sit as official members on the Voyager science teams.

Otherwise, the aura of chronic astonishment persists. Every day brings at least one discovery. Now only 3.5 million kilometers from Neptune, Voyager has already discovered four small moons. It has been tracking not just the Great Dark Spot but also a small dark spot called D2 and a fast-moving white spot nicknamed the Scooter. Early images of Triton look mottled. Are we seeing the surface? Or is it an obscuring haze?



The surprise of the day, however, is a faint new ring. Unlike the brighter arcs, this ring completely encircles the planet. Ring specialists are beginning to suspect that the arcs may simply be parts of a complete ring. The invisible sections would contain too few particles to reflect much light. But what causes the ring particles to clump into arcs?

At Saturn, scientists saw that rings were shepherded by small nearby moons whose gravity confined the rings. At Neptune, Voyager can find no confining moonlets. Could it be that the ring arcs formed quite recently? In the past few years could a comet have crashed into a small moon, creating debris that has not yet had time to organize into a smooth ring?

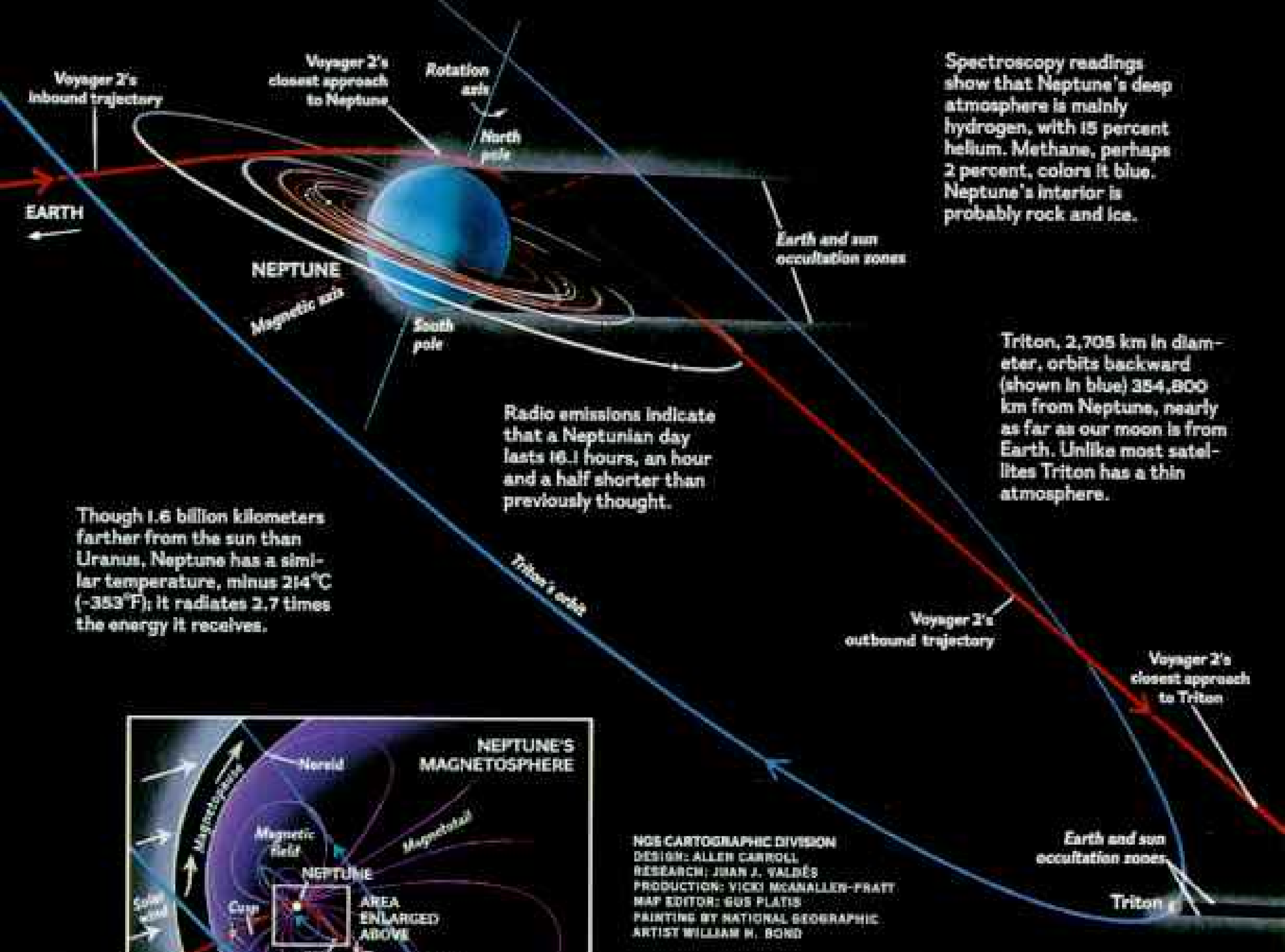
Although the scientists propose this idea, few like it. Imaging team leader Brad Smith expresses their skepticism: "That violates something called the cosmological principle, which says that it is unlikely that you happen to be at the right place at the right time to observe an event of cosmic significance."

Imaging Neptune's rings is a challenge. The ring particles are darker than charcoal. The spacecraft is moving fast enough to cross the U. S. in less than four minutes. There is about as much light out there as inside a cathedral on a cloudy day. "It's a photographer's nightmare," says one imaging expert.

Voyager's seasoned engineers have worked miracles. In order to steady the

HEIDI HAMMEL (TOP, RIGHT); JAMES A. SUGAR, BLACK STAR (ABOVE)

A good view of Neptune from Earth (top, at right), a near-infrared image, contrasts with an image recorded at the same time by Voyager from 1.5 million kilometers. International cooperation marked the Neptune encounter: Soviet scientists worked with NASA at the Jet Propulsion Laboratory in Pasadena, California.



DRAWING BASED ON MODEL DEVELOPED BY E. N. KRIMIGIS, RICE UNIVERSITY

Voyager's close encounter

PULLED by Neptune's gravity, the robot explorer accelerated from 60,000 to 98,000 kilometers an hour as it passed a daring 4,900 kilometers above the planet's north pole. The risky approach was essential to bend Voyager's course toward Triton.

Voyager discovered that Neptune's magnetic axis is tilted 47 degrees from the planet's rotation axis and that the magnetic center is located halfway to the surface. A similar case at Uranus has been attributed to a magnetic reversal or a catastrophic impact. "This is clearly not the case at Neptune," says principal magnetic-field investigator Norman Ness, "so we need new ideas."

Voyager found three prominent rings and added six small moon siblings to Triton and the nondescript Nereid. On other planets small moons seem to confine rings, but such shepherding is not yet obvious here.

spacecraft's cameras for long exposure times, they have reprogrammed onboard computers with new instructions.

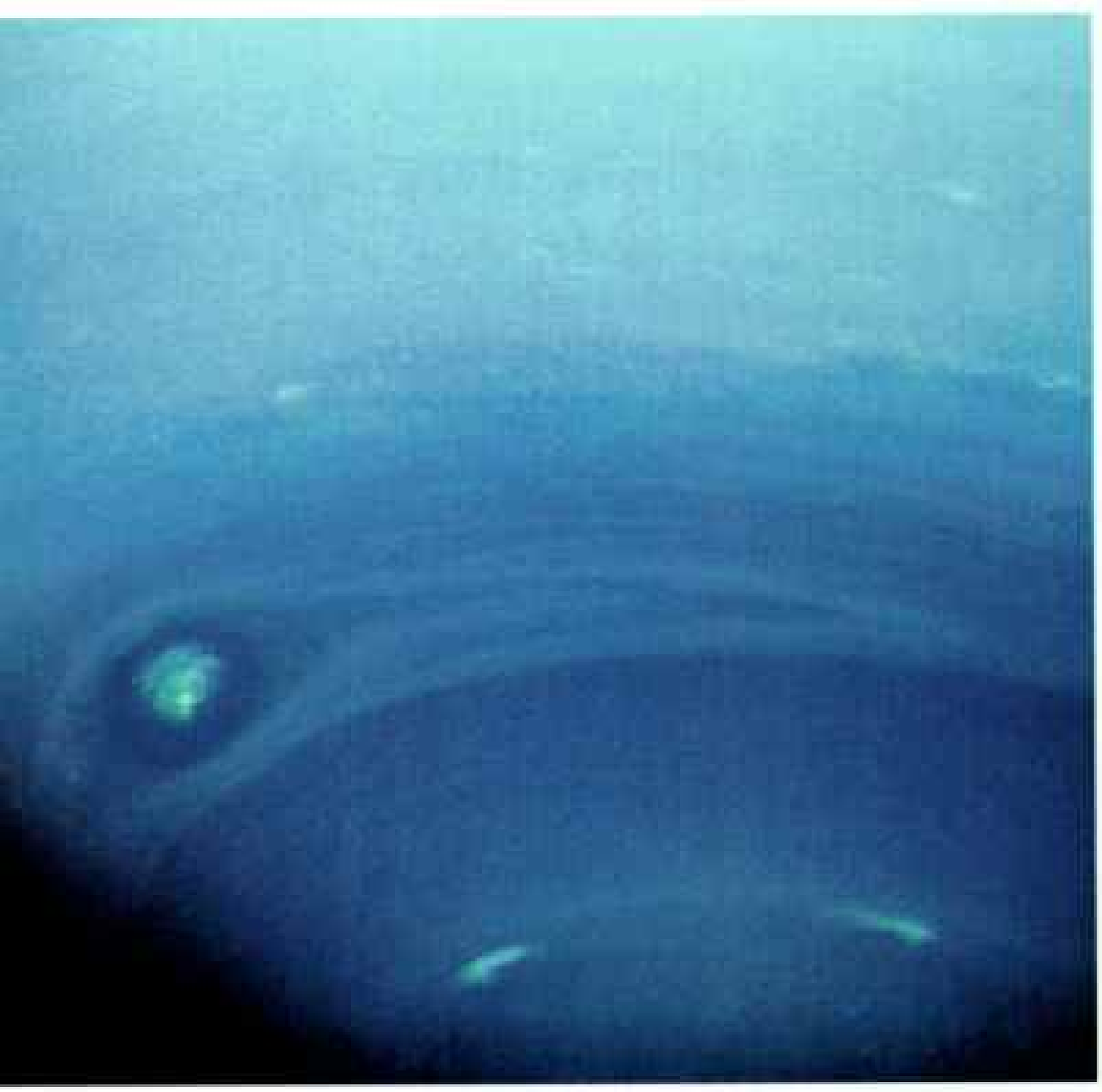
The engineers faced another problem. No one knew exactly where Neptune would be when Voyager arrived. Since its discovery in 1846 the planet has been observed for less than one full orbit.

"Our uncertainty over its precise location was as high as 5,000 kilometers," says navigation team chief Don Gray. "That was unacceptable. Everything we planned to observe at closest approach might be out of the field of view."

Here one of the newly discovered moons came into play. Images of it and Triton in relation to Neptune helped Gray's team steer Voyager to within 40 kilometers of where they wanted it. "It's like making a hole in one in London from Los Angeles," says Gray.

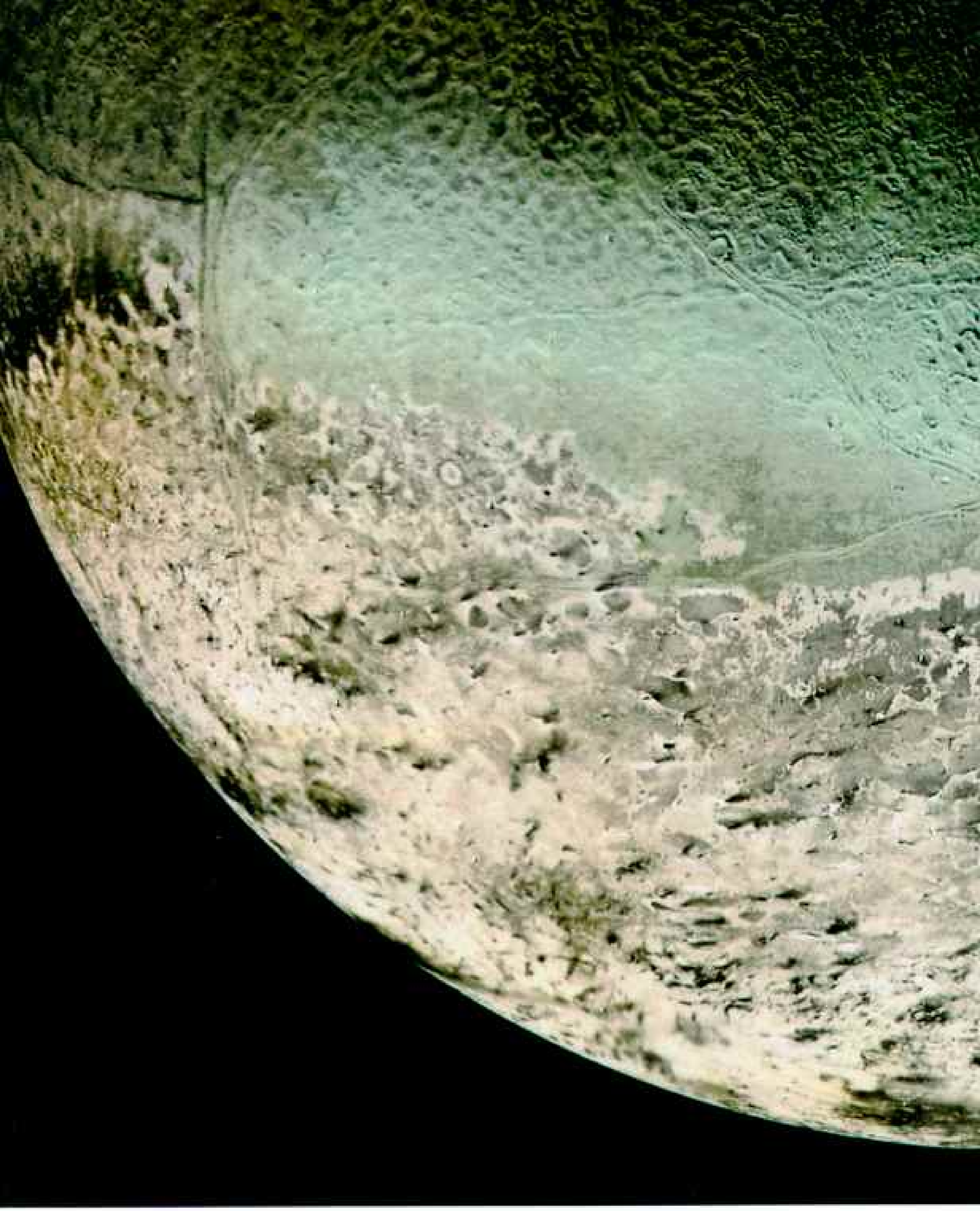
IN THE LATE HOURS of August 24 scientists cluster around monitors in the imaging area of Building 264 at JPL. Soon Voyager will cross through the plane of Neptune's rings. This dusty, debris-laden zone is the most perilous passage. Most of the ring dust is the size of cigarette-smoke particles. But even a BB-size particle met at Voyager's speed could be disabling.

Just before midnight, signals that have taken four hours to reach Earth indicate a barrage of impacts—as many as Voyager encountered at Saturn. Then, suddenly, there is abrupt radio silence. This shutdown is intentional, however. Voyager will soon skim Neptune at 4,900 kilometers and swing into a communications shadow behind the planet before its rendezvous with Triton. Its last encounter will be its most revealing. In the past few days Voyager has already told us that Triton is not swathed in clouds. Its atmosphere—if it exists—is thin and transparent. It also appears colder than expected—45 degrees C above absolute zero. Dale Cruikshank's *(Continued on page 45)*



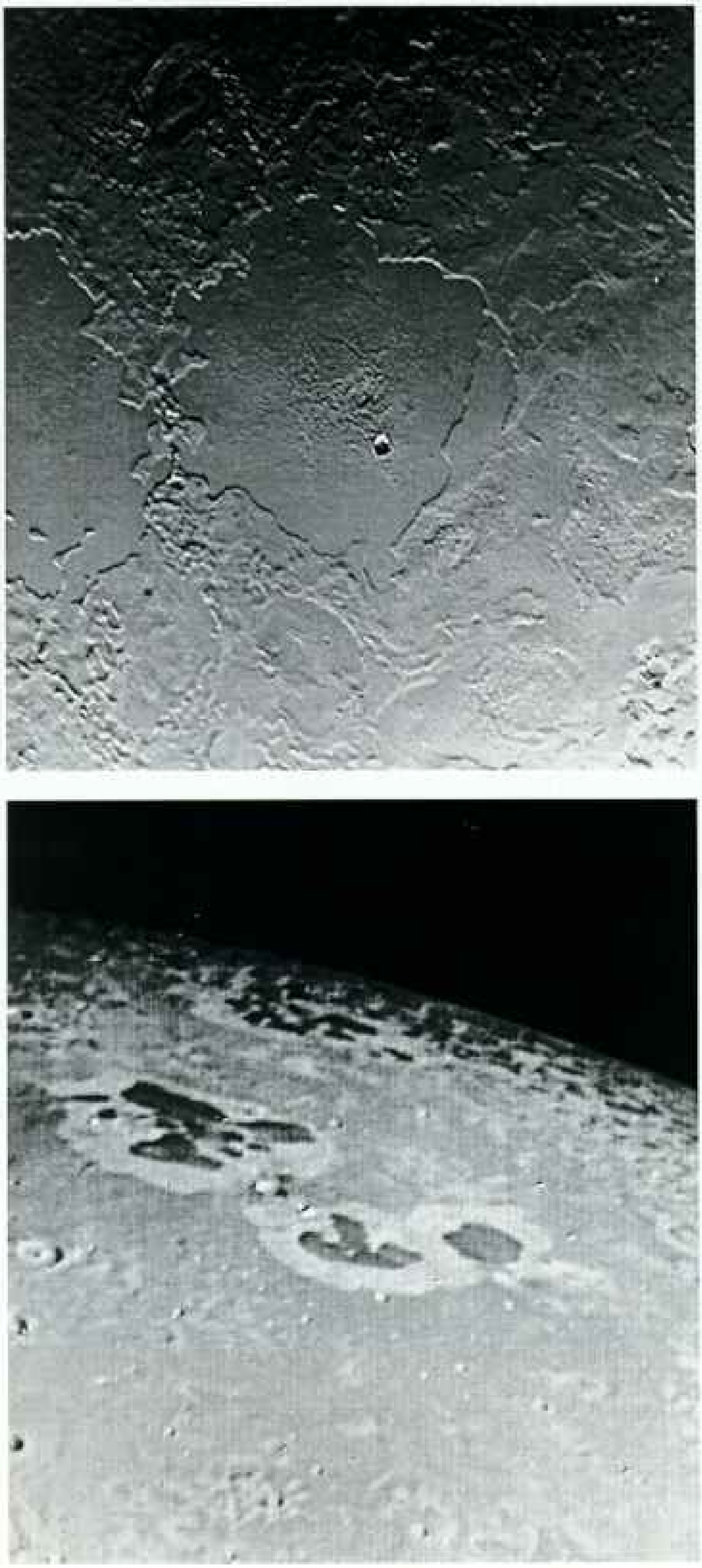
Violent weather came as a surprise on a planet so far from the sun. Neptune was known to have clouds, but no one expected winds of 2,000 kilometers an hour. A high-pressure system the size of Earth, the Great Dark Spot changes shape as it stretches and contracts. Winds racing around the planet are deflected upward by the storm, creating rapidly changing companion clouds—as seen in three images taken over a 36-hour period (right). Toward the south pole, a smaller storm called D2 (bottom left) often brightens with clouds brought up by convection from the deeper atmosphere. Wind speeds vary with latitude; D2 "changes lanes," rushing or slowing its journey around the planet.

North of the equator, white clouds of methane ice (below) cast blue shadows on the cloud deck 50 kilometers below.



"*The images returned this morning revealed a world unlike any we've ever seen.*" *Chief scientist Edward Stone expressed the team's astonishment as Triton came into view. Arriving during late spring in the satellite's southern hemisphere, Voyager found the coldest body in the solar system, minus 235°C (-391°F). At this temperature its water-ice crust is granite hard. Its steeply inclined orbit creates long seasons as Triton circles the sun with Neptune every 165 years. The south*

polar ice cap—mostly frozen nitrogen—will continue to evaporate and migrate to the north pole for 60 years. A retrograde orbit suggests Triton could have been a Pluto-like planet that was captured by Neptune. Tidal forces caused by gravity may have triggered eruptions of slushy ice into a network of faults on the "cantaloupe" terrain at upper left. Smooth plains at upper right were possibly flooded by similar material. The blue tint in this 22-image mosaic is exaggerated.



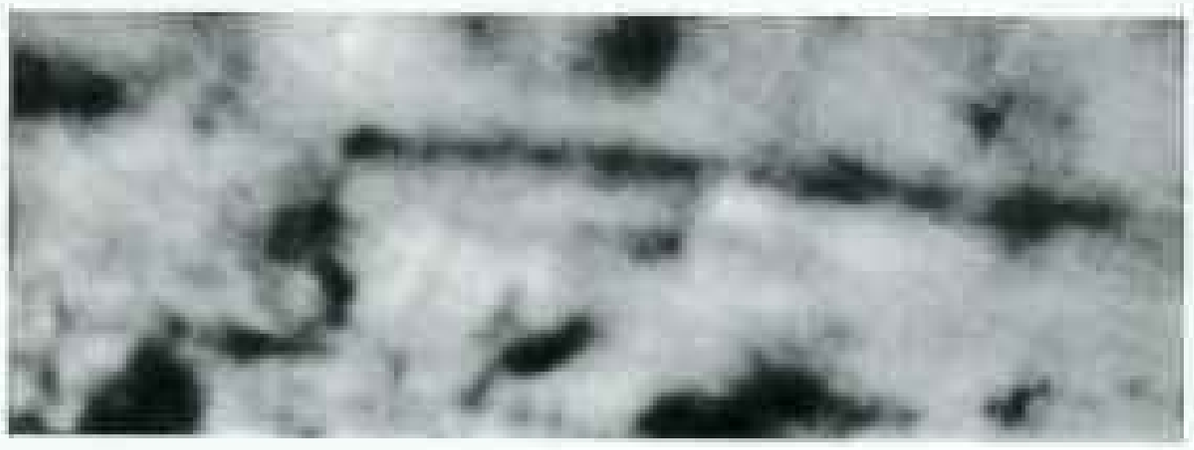
Scars of a tortured past mark Triton. Ice volcanism is the favored theory for its young, bright surface. "Lavas" of water ice, mixed perhaps with ammonia, likely flowed from caldera-like features (left). A computer-generated perspective of that scene (below) looks down 200 meters (650 feet) into a basin 200 kilometers across.

Proof of ongoing activity: A plume of nitrogen and dark particles (right) shoots eight kilometers high before winds carry it 150 kilometers. Wearing bright halos, dark shapes as wide as 100 kilometers (below left) appear to be recent, though they lie on Triton's oldest terrain.

hopes of seeing liquid nitrogen on the surface appear to be dashed.

Nearly four hours pass. Then the first Triton close-ups come in, and a collective gasp fills the press room: montages of perplexing icescapes. A craggy, faulted surface that in places looks like it was frozen while in a boil. Ridges and cracks that indicate a past of intense internal unrest.

A great ice cap covers most of the southern hemisphere. A blue zone along its edge implies fresh frost, indicating Triton has a dynamic atmosphere. Moreover, scientists see almost none of the impact craters so common on most satellites. What happened to them? The answer is almost instant: "Cryovolcanism," exclaims Steven Croft, one of the scientists watching the Triton images come over the monitors in the imaging team room. Cryovolcanism is a new buzzword. It means ice volcanism.



How can ice be volcanic? Consider that at Triton's temperatures water ice is as rigid as granite. Two of the gases we breathe on Earth—nitrogen and methane—become the glaciers and softer rocks of Triton. In this environment the ice within Triton—when warmed—melts to a slush, is forced to the surface,

Science for art's sake, Voyager transmitted a parting image of Neptune and smaller crescent Triton. "Voyager did wonders for our knowledge," wrote naturalist Stephen Jay Gould. "But it performed just as mightily in the service of wonder."

and flows much the way that lava flows on our planet. It then quickly refreezes.

Voyager has already proved that volcanism doesn't have to be based on molten silicate rock. It found sulfur volcanoes on Jupiter's moon Io. And it was on Ganymede, another of Jupiter's moons, that Voyager found the first hints of ice volcanism. Cryovolcanism helped explain odd features on moons of Saturn and Uranus as well. However, no satellite has shown the dramatic variety of ice volcanism now emerging on Triton.

Huge calderas indicate large-scale violent volcanism. Long cracks resemble great rift valleys. Odd dark patches a hundred kilometers across look like frozen-over lava lakes. "Cruik-lakes," they are dubbed.

Minutes later I find Dale Cruikshank in a coffee line. "What about those 'lakes,' " I ask. "They sure look like something you could skate on."

"We'll just have to see," he smiles. "What is clear is that this satellite has had a very tortured history."

This first glimpse of Triton supports the idea that Triton was once a small icy planet, perhaps similar to Pluto today. It passed catastrophically close to Neptune, striking a small moon. That collision slowed Triton enough to be captured by Neptune's gravity. Its orbit around Neptune was at first highly eccentric—and backward. Gradually over the next billion years, tidal forces from Neptune made that orbit nearly circular. Those tidal forces pumped enormous energy into the interior of the moon, melting its water-ice innards and creating a long period of volcanic turmoil.

Most of the cryovolcanics occurred in Triton's youth. But not all. Scientists puzzle over a series of strange dark streaks on Triton's southern ice cap. Within a few weeks deputy imaging team leader Larry Soderblom will find geyser-like eruptions. "There could be thousands of these," he says.

"Triton could be better than Yellowstone," adds Steven Croft. "Geysers going off somewhere any time of day."

What creates these eruptions? As seasons change, ice caps of nitrogen and methane snow form in alternate hemispheres. In spring the nitrogen evaporates more readily than methane. Over the years, suggests Robert Brown, cosmic rays convert the methane into a dark, freeze-dried organic dust, which becomes a permanent crust. With time a thick layer of nitrogen ice covers the crust and acts like a greenhouse. The dark layer beneath absorbs solar energy. Heat builds up, causing trapped frozen gases to warm and expand rapidly. When enough pressure builds, they explode through weak spots in the ice crust.

AUGUST 27. Voyager's exhausted team members celebrate at a gala party on the JPL plaza. Suddenly on the bandstand out pops a surprise guest, rock-and-roll singer Chuck Berry. To cheers and dancing, he breaks into a rousing "Johnny B. Goode," his 1958 hit song that was among the many souvenirs put on board the Voyager spacecraft.

And so, Voyager departs. But as Larry Soderblom says: "What a way to leave the solar system!" Still, as the spacecraft speeds off into the abyss, some team members can't quite let the explorer go.

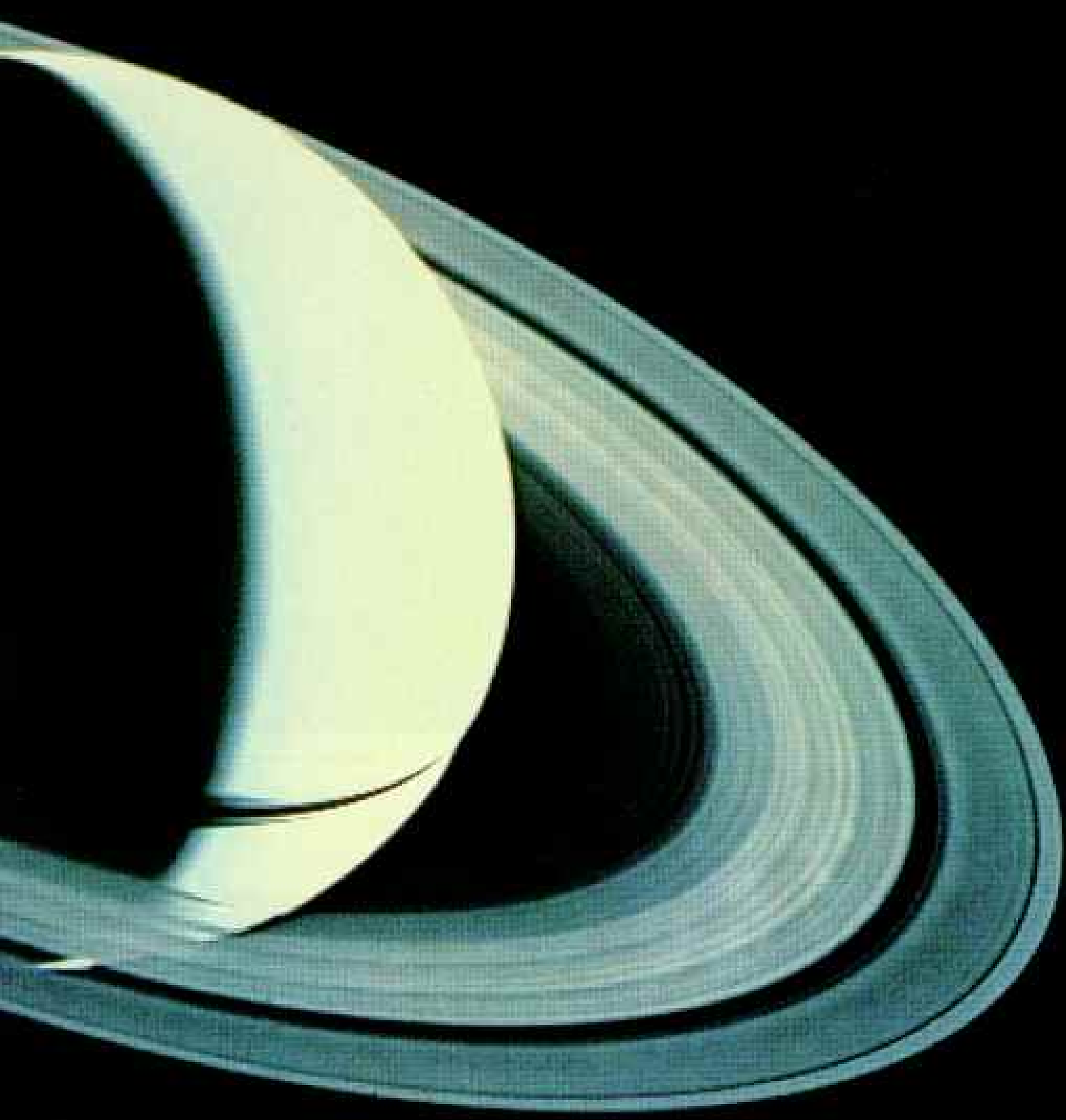
"I fully expect that Voyager will be picked up by a space-faring civilization one day," says an emotional Rich Terrile. "It will be placed in a museum and revered. I'm hoping that space-faring civilization will be our own. Or if not, we'll at least receive a message in 40,000 years or so from some distant solar system. And that message will say: 'Send More Chuck Berry.' " □

Voyage of the Century

Twin unmanned probes have set us on the distant shores of the outer solar system in a daring 12-year grand tour. Glancing back as it left Saturn in 1980, Voyager 1 showed us a sight impossible from Earth—the giant planet's full shadow across its rings. Images reprocessed and enhanced especially for this article reveal truer color and greater detail than ever before.

By BRADFORD A. SMITH

Images by NASA/JET PROPULSION LABORATORY



ENHANCED BY ALFRED S. McEWEN AND TAMMY L. BECKER, USGS, FLAGSTAFF, ARIZONA

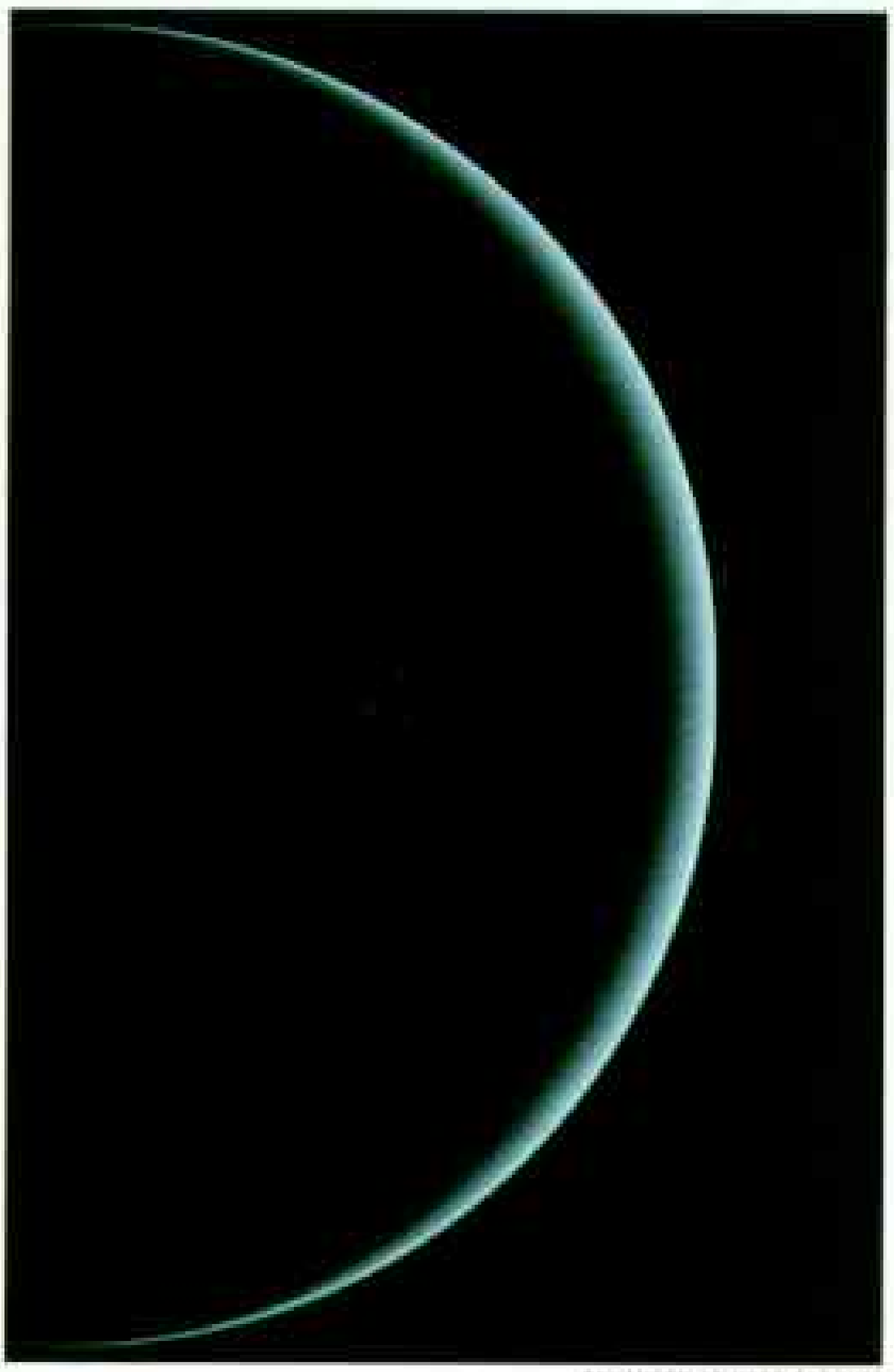
ENHANCED BY CHARLES C. AVIS, JAN B. YOSHIMIZU,
AND TIM J. PARKER, JPL, PASADENA, CALIFORNIA

Jupiter

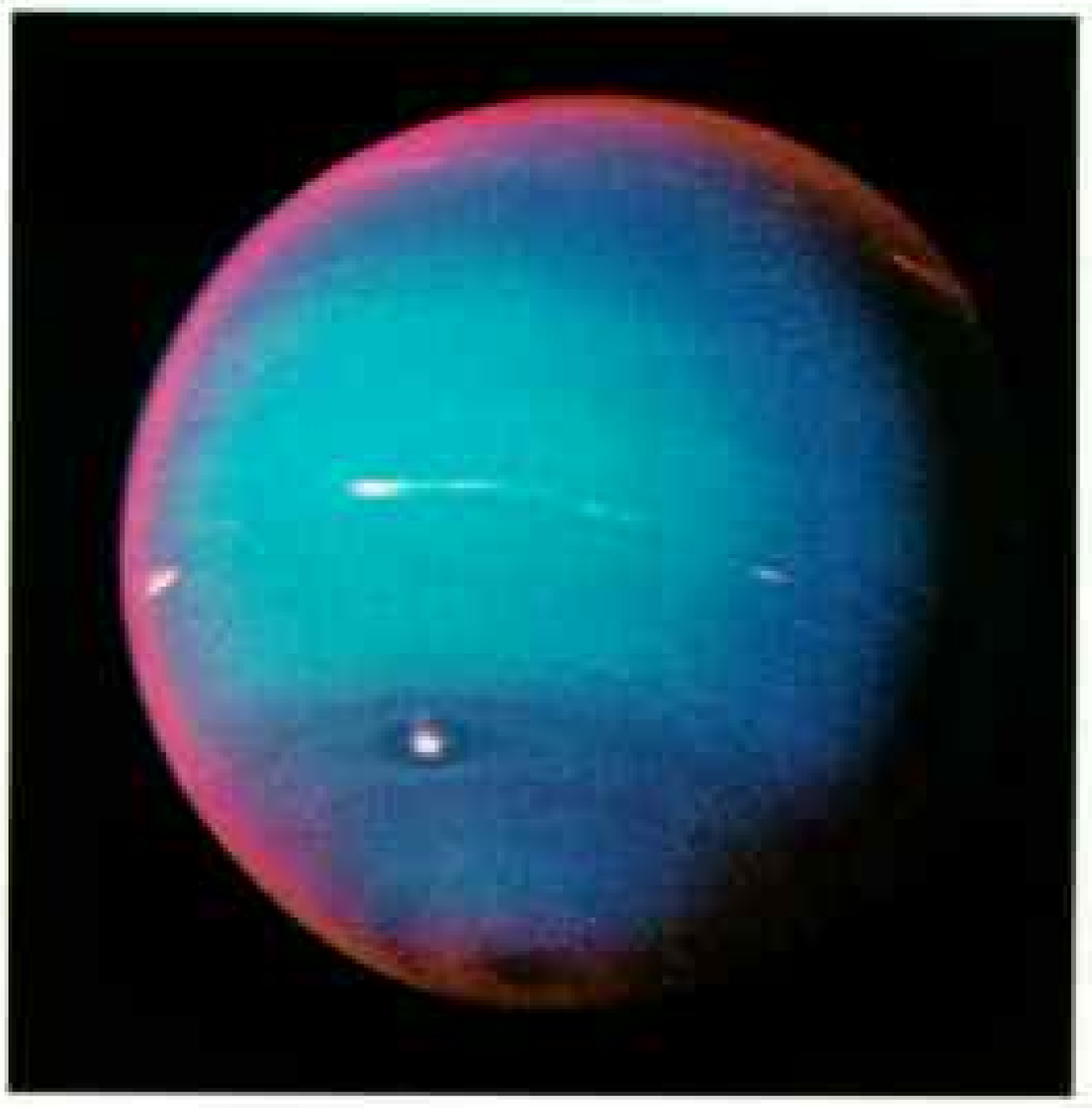
A RAGING GIANT, Jupiter in 1979 revealed atmospheric turbulence far beyond its famed Great Red Spot. First looks at the moons Io, at left, and Europa also stunned us all. We had expected ancient, cratered surfaces. A mottled blanket of debris from many active volcanoes gives Io the youngest surface in the solar system. Europa has the smoothest—most likely a thin ice crust over a global ocean.

Uranus

DAY WAS BREAKING across Uranus as Voyager 2 looked back in 1986 at a planet tipped on its side, probably by a colossal primordial collision. Uranus receives only one-fourth the sunlight Saturn does and hides its atmospheric features beneath a deep layer of hydrogen; the geology of its stunning moons stole the show.



ENHANCED AT 1000 (ABOVE)



Neptune

AGITATED despite the cold of minus 200°C, Neptune in 1989 showed Voyager storms like those on much warmer Jupiter. False color enhances a transparent haze, creating a red rim. White clouds and a circular storm form as convection shoots hydrocarbon gases up into colder regions, where they condense into bright ices. As with Jupiter and Saturn, internal heat drives Neptune's turbulence.

A MONTH HAD PASSED since Voyager 2 had soared past Neptune. Now the last of its electronic images—crescents of the planet and its great moon, Triton, suspended together in the emptiness of space—were coming up on our television monitors at the Jet Propulsion Laboratory (JPL). As usual Voyager's parting shots were among its best. Soon Voyager 2 would receive a command from Earth to turn its cameras off. The eyes that had shown us the wonders and mysteries of our outer solar system would close forever.

But for now there was still that haunting pair of crescents. They turned my thoughts back 12 years to another planet-moon image, and to a sunny August morning when I had stood watching the fiery spectacle of a giant rocket lifting the spacecraft from Cape Canaveral. Later that day, while driving to the airport, I had tried to imagine what Voyager would see as it sped swiftly away. Earth and moon. Together as a double planet. What a spectacular sight that would be.

The spacecraft's twin, Voyager 1, was scheduled for launch two weeks after Voyager 2. Perhaps we could program its onboard computer to show us that sight. I called the Voyager science office at JPL.

"At this late date? Impossible!" they replied. But a few days later, with an enthusiasm that would grow throughout the mission, they had figured out how to do it. And Voyager 1 gave us the first of many new perspectives that lay ahead (facing page). Such flexibility would become the key to Voyager's success.

Over the next 12 years the faces of Jupiter, Saturn, Uranus, Neptune, and their varied moons became familiar. Our scientific concepts of the remote and chemically primitive outer solar system changed dramatically. Voyager shattered the dogma that the worlds of the outer solar system had been shaped by similar, predictable, and rather uninteresting processes. It showed us that even the most remote icy moons insist on being individuals. That the processes that shaped them were often highly unlikely events. And that the solar system, let alone the universe, was diverse beyond comprehension. Voyager challenged the limits of our imagination.

From our post-Voyager perspective, it is truly astounding how very little we knew about the outer planets when we started. We were aware, of course, of such fundamental properties as their orbital periods and their approximate sizes and masses. Their densities suggested they were made up mostly of hydrogen and helium, but knowledge of their interior structure was scanty.

We knew that Uranus rolled along on its side, but we could only guess the length of its day and that of Neptune's. Methane had been detected in all of the atmospheres, and both hydrogen and ammonia had been found in Jupiter and Saturn. Jupiter alone was known to possess a magnetic field and to radiate more energy than it absorbed from the sun. Jupiter's Great Red Spot was recognized as an enormous anticyclone, but we had seen only a few cloud features in Saturn's atmosphere and none at all on Uranus and Neptune. We knew that Titan, a huge moon of Saturn, had an atmosphere containing methane. We mistakenly thought that the moons of Jupiter were nothing more than battered ice balls.

Only 30 of the 57 satellites known today had been found at that time. Saturn was the only planet known to have rings, and we had quite acceptable theories to explain why none of the other planets could have them.

THE STORY of Voyager began in the late 1960s with plans for a series of missions called the Outer Planets Grand Tours (OPGT). We knew that a future alignment of the outer planets would give any spacecraft launched toward Jupiter in 1977 the capability of continuing on past Saturn and Uranus all the way out to Neptune.

But OPGT was not to be. In 1972 funding problems forced NASA to scale down the mission. Called Mariner Jupiter/Saturn (MJS), it would visit only those two planets. But we knew nature was still on our side. The planets would still be aligned so that, once MJS was launched, we might cajole NASA into letting us continue the grand tour out to Neptune.

In late 1972 I was selected to head the imaging team—one of 11 MJS science groups. The NASA program manager told me not to contemplate "any changes

ENHANCED AT JPL

whatsoever" in the two MJS camera systems. One of my team's first decisions was to ignore this admonition.

NASA was interested mostly in the giant planets themselves. We quickly realized that their largely ignored satellites were at least as intriguing. Deputy team leader Larry Soderblom and team member Carl Sagan argued that the surfaces of these satellites, in their cratering history, would be a Rosetta stone for understanding the early years of the outer solar system. Much as the cratered surface of the moon helped us appreciate the forces that shaped the inner solar system, the outer satellites would hold much information in their presumably battered crusts. To understand those surfaces, we would need the best available optics on MJS's cameras. We would also need more geologists. In the beginning Soderblom stood alone.

We persuaded NASA to let us use spare higher-resolution optics from a Mariner mission to Venus and Mercury. Slowly I padded the team with geologists. One new team member, Geoff Briggs, devised options for trajectories that would let us fly breathtakingly close to as many satellites as possible.

Still, our trajectory selections were not without flaws. The best combinations all had a frustrating limitation. With only two spacecraft, and therefore only two trajectories, it was possible to get the very highest resolution imaging of just three—any three, but only three—of Jupiter's four Galilean satellites. One of these four moons had to be put at the bottom of our priority list. With only ground-based observations to guide us, we made our decision and relegated tiny Europa to relative obscurity. Much later, when Voyager arrived at Jupiter, we realized that only Io could have been a poorer choice.

We now know that Europa's surface is the smoothest of any in the solar system. A curious network of linear and arc-like cracks stretches across its icy surface. Beneath may be oceans of liquid water, oceans kept warmer by the insulating effect of the icy crust, oceans thought to be a possible abode for life elsewhere in our solar system.

WHILE we were still deliberating over trajectories, the world received a live report from a half billion kilometers away. On December 3, 1973, Pioneer 10 became the first spacecraft to reach Jupiter. Most of the news was exciting. Some of it was bad—very bad. Jupiter, we learned, is surrounded by an enormous belt of intense radiation, so strong that it nearly fried Pioneer 10 and promised to be even more menacing to Voyager—more sophisticated but also more vulnerable than its predecessor. Suddenly we had a whole set of new problems. Like many of Voyager's other instruments and subsystems, our cameras had to be modified. Optical

JAMES A. SUGAR, BLACK STAR, WITH KEVIN SCHUMACHER

VOYAGER TEAM MEMBERS (FROM LEFT): J. PIETER DE VRIES, EDWARD C. STONE, E. LEONARD TYLER, JAMES ISAAC, NORMAN R. HAYNES, ARTHUR L. LANE, PETER R. EDWARDS, RUDOLPH A. HAKEL, BARNEY J. CONRATH, BRADFORD A. SMITH, DONALD A. GURNETT, CHARLES F. KOHLHASE, S. M. KRIMIGIS, ELLIS D. MINER, NORMAN F. NESS

glasses and electronic components that could withstand intense radiation exposure had to be found.

In 1977 Mariner Jupiter/Saturn—renamed Voyager—was ready. Voyager 2, taking a longer and slower track out to Jupiter, was launched first.

Trouble began almost immediately. At first the spacecraft would not settle down. Then the radio receiver that listens for commands from Earth died. Then the backup receiver developed problems.

But with a cleverness that never ceased to amaze us, JPL's engineers rescued Voyager from each crisis.

BY THE TIME the spacecraft reached Jupiter, the crises were no longer engineering, but intellectual. We didn't know what to make of the sights Voyager was showing us. Eventually we got used to being surprised. But our first glimpses of the intricate, spaghetti-like cloud structure of Jupiter with its psychedelic storm systems threw us into a state alternating between ecstasy and despair. How could we ever hope to understand this turbulent, chaotic atmosphere?

At the same time, the innermost Galilean moon, Io, began to worry us. We had expected its surface to be heavily cratered and relatively undisturbed for four billion years. More than any other moon, Io's craters were going to provide us with the impact history of the early solar system. But Io was inexplicably covered with red sulfur dust and white sulfur dioxide. We couldn't find a single crater. Finally, to our astonishment, we realized that this little moon was volcanically alive. Snowfalls of sulfur settle down on it from explosive plumes. There isn't a square meter of Io's surface that is more than a thousand years old.

Just as we thought we were through with surprises, Voyager photographed a ring around Jupiter. We hadn't even thought it was worth wasting images to look for a ring. But two team members, Toby Owen and Candy Hansen, argued adamantly for taking one more shot—just in case. I had forgotten about it until someone came running in waving the image.

Rings confounded us again at Saturn. We thought the structure of its famous ring system would be simple. The gaps between the rings would be controlled by gravitational influences, called resonances, from Saturn's major moons. Since we felt we understood ring dynamics, we planned to take most of our ring pictures on the first Voyager flyby. Why waste time photographing the rings twice?

Saturn stunned us. What looked from Earth like empty gaps in the rings were filled with little rings. One gap, the Cassini Division, by itself had more

structure than the entire ring system we can see through the telescope.

Not all the surprises at Saturn were happy. I will never forget that dreadful phone call that awakened me just hours after we had celebrated Voyager 2's successful Saturn encounter. Just minutes after encounter the scan platform, which points our two cameras along with other critical instruments, began to freeze up. It finally stuck. Valuable Saturn data were being lost. Even more disturbing was the future. In order to get optimal scientific results at Saturn, we had chosen a trajectory for Voyager 1 that had flown it up and away from the solar system. Voyager 2, NASA had agreed, could go on to Uranus and Neptune. Now, the stuck scan platform was potentially fatal.

The flight team went into intensive sessions of computer analysis. Their virtuoso engineering and programming eventually jogged the stuck platform free, salvaging the mission. Then they outdid themselves as Voyager was en route to Uranus, where the light level is only one-fourth that at Saturn. Communicating with the on-board computers, they gave new instructions to prevent the blurring of long, light-gathering exposures taken at Voyager's high speed.

WE HAD HAD our share of disappointments. In what sometimes seemed like creeping dementia, an ever increasing portion of Voyager's computer memory became useless during its 12 years in space. We were unable to see enough on Saturn's moon Iapetus to really understand why that moon has one bright hemisphere and one dark. Clouds shrouded Titan's surface. Uranus astonished us with its blandness, earning the undisputed title of least photogenic planet in the entire solar system.

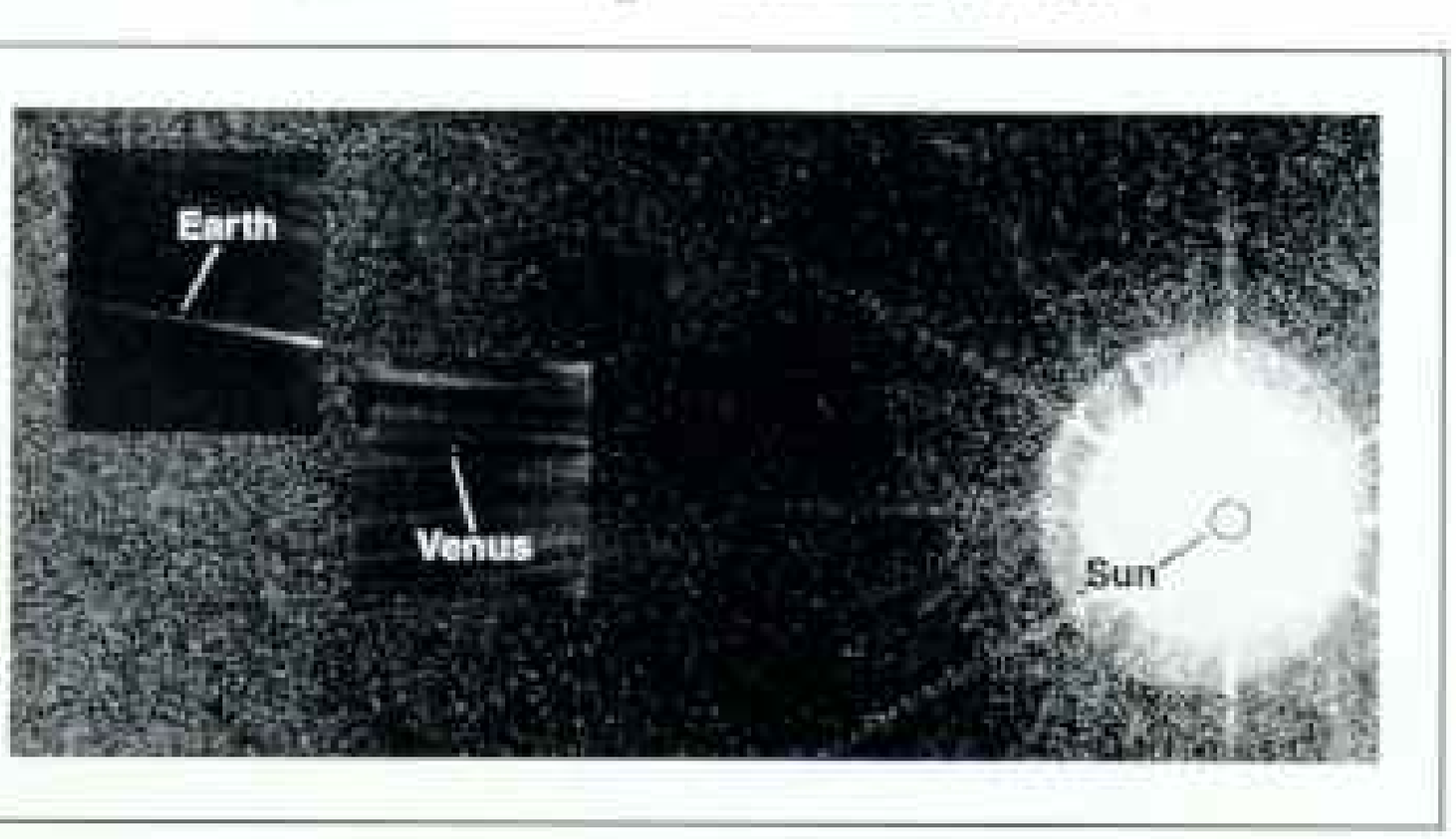
But excitement far surpassed boredom. So Uranus itself appeared a bit humdrum and monotonous. The unexpectedly weird terrain of its moon Miranda—a satellite that seems designed by committee—had us struggling to find ready explanations for an impatient assembly of journalists and television commentators, all of whom had deadlines to meet.

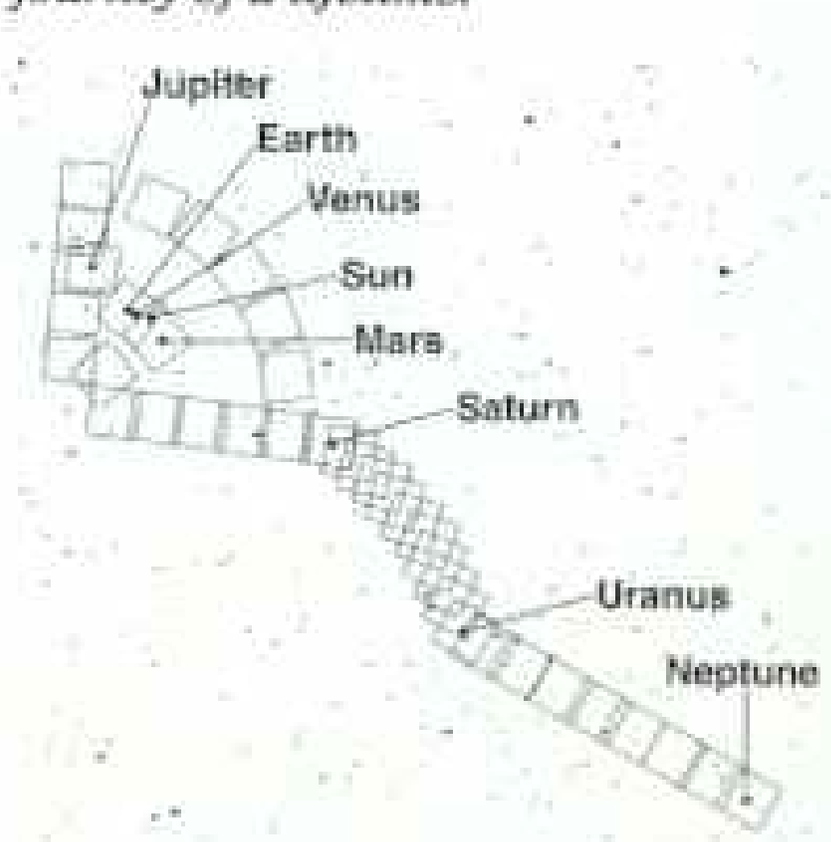
Instant science, we came to call it. In explaining the bizarre geology of novel landscapes, we gave the impression that we usually understood what we saw. I was happy if my instant science still held up the next day.

History will hold a special place for Voyager, as it always does for those very first adventurers who have led the way. But unlike most of history's great missions of discovery, Voyager took us along. Through its magical eyes, we were there.

A scattered family, the planets of our solar system were photographed February 14, 1990, as Voyager 1 looked back at the sun from six billion kilometers away. Earth and Venus appear as points within narrow-angle images—dark squares—set into one wide-angle frame. Mercury is lost in the sun's glare. To display the entire mosaic to scale using eight-inch-square prints would require a wall a hundred feet long.

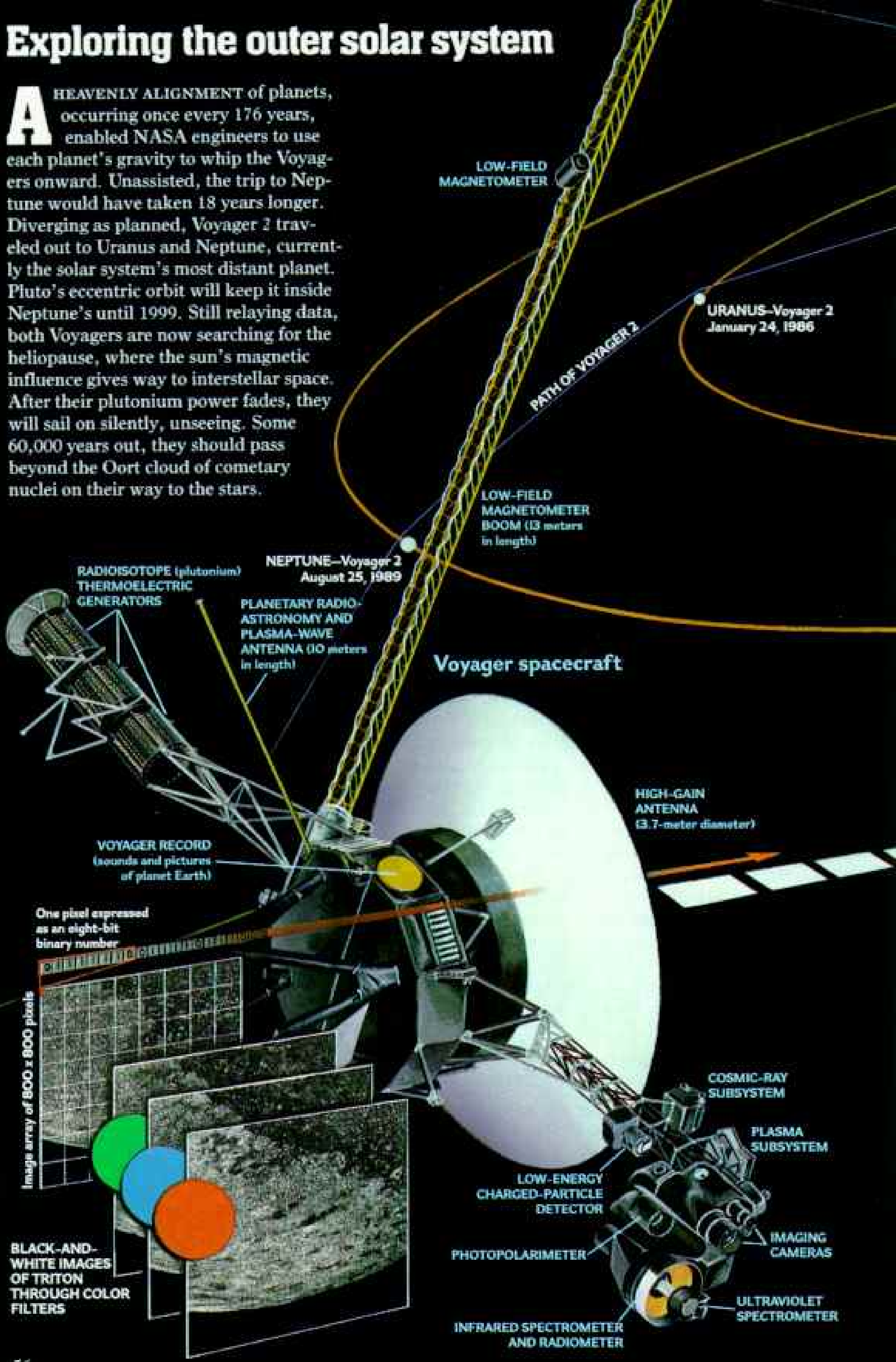
"An unprecedented decade of discovery," said Voyager project scientist Edward Stone (second from left) of the mission. "For all of us involved, it was the journey of a lifetime."

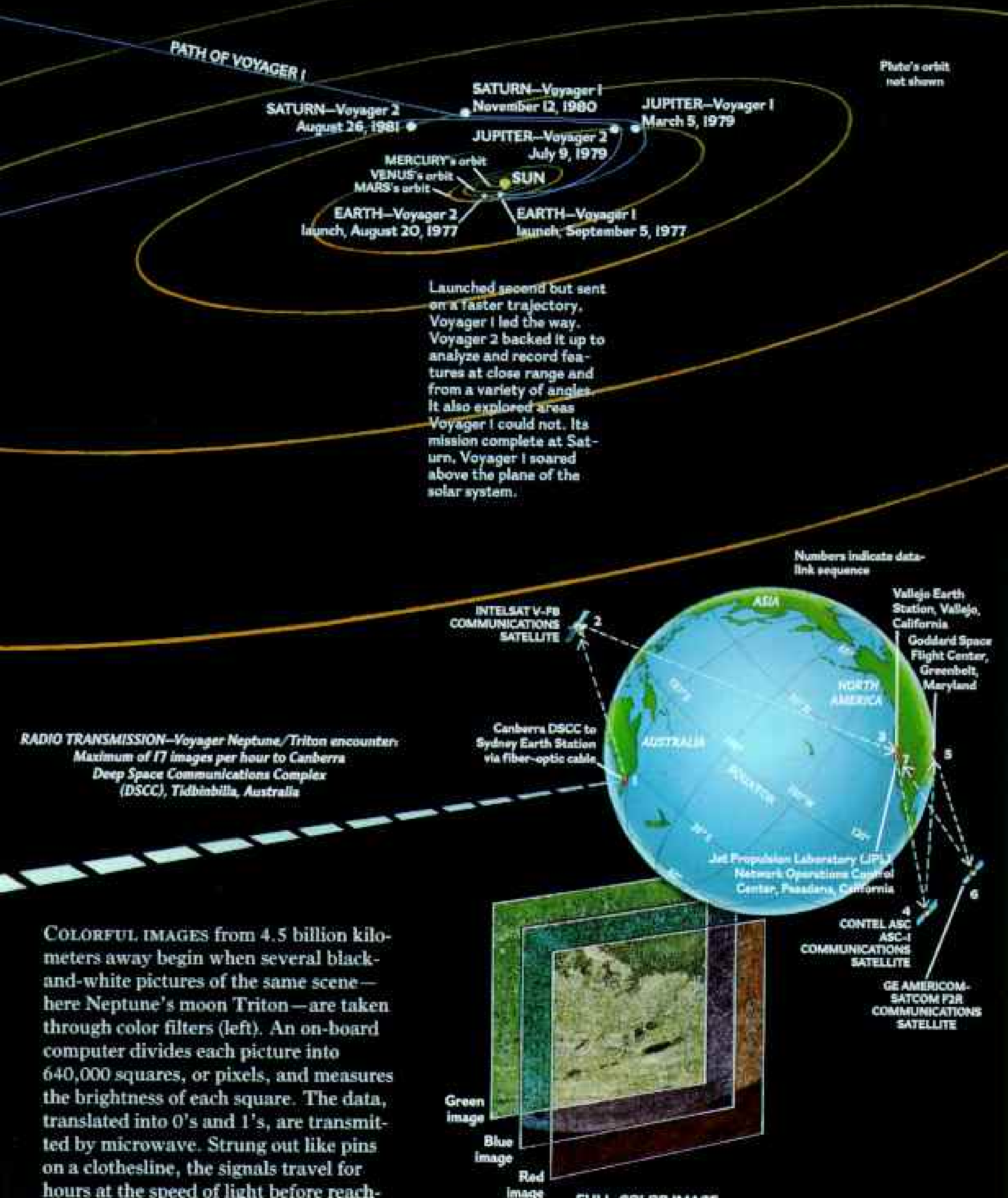




Exploring the outer solar system

A HEAVENLY ALIGNMENT of planets, occurring once every 176 years, enabled NASA engineers to use each planet's gravity to whip the Voyagers onward. Unassisted, the trip to Neptune would have taken 18 years longer. Diverging as planned, Voyager 2 traveled out to Uranus and Neptune, currently the solar system's most distant planet. Pluto's eccentric orbit will keep it inside Neptune's until 1999. Still relaying data, both Voyagers are now searching for the heliopause, where the sun's magnetic influence gives way to interstellar space. After their plutonium power fades, they will sail on silently, unseeing. Some 60,000 years out, they should pass beyond the Oort cloud of cometary nuclei on their way to the stars.





COLORFUL IMAGES from 4.5 billion kilometers away begin when several black-and-white pictures of the same scene—here Neptune's moon Triton—are taken through color filters (left). An on-board computer divides each picture into 640,000 squares, or pixels, and measures the brightness of each square. The data, translated into 0's and 1's, are transmitted by microwave. Strung out like pins on a clothesline, the signals travel for hours at the speed of light before reaching Earth. Received by huge dish antennas at one of three stations around the globe, the signals are boosted and relayed via satellite to the Jet Propulsion Laboratory in Pasadena, California. There they are converted back to pixels. Combining the color-filtered pictures creates full-color images.

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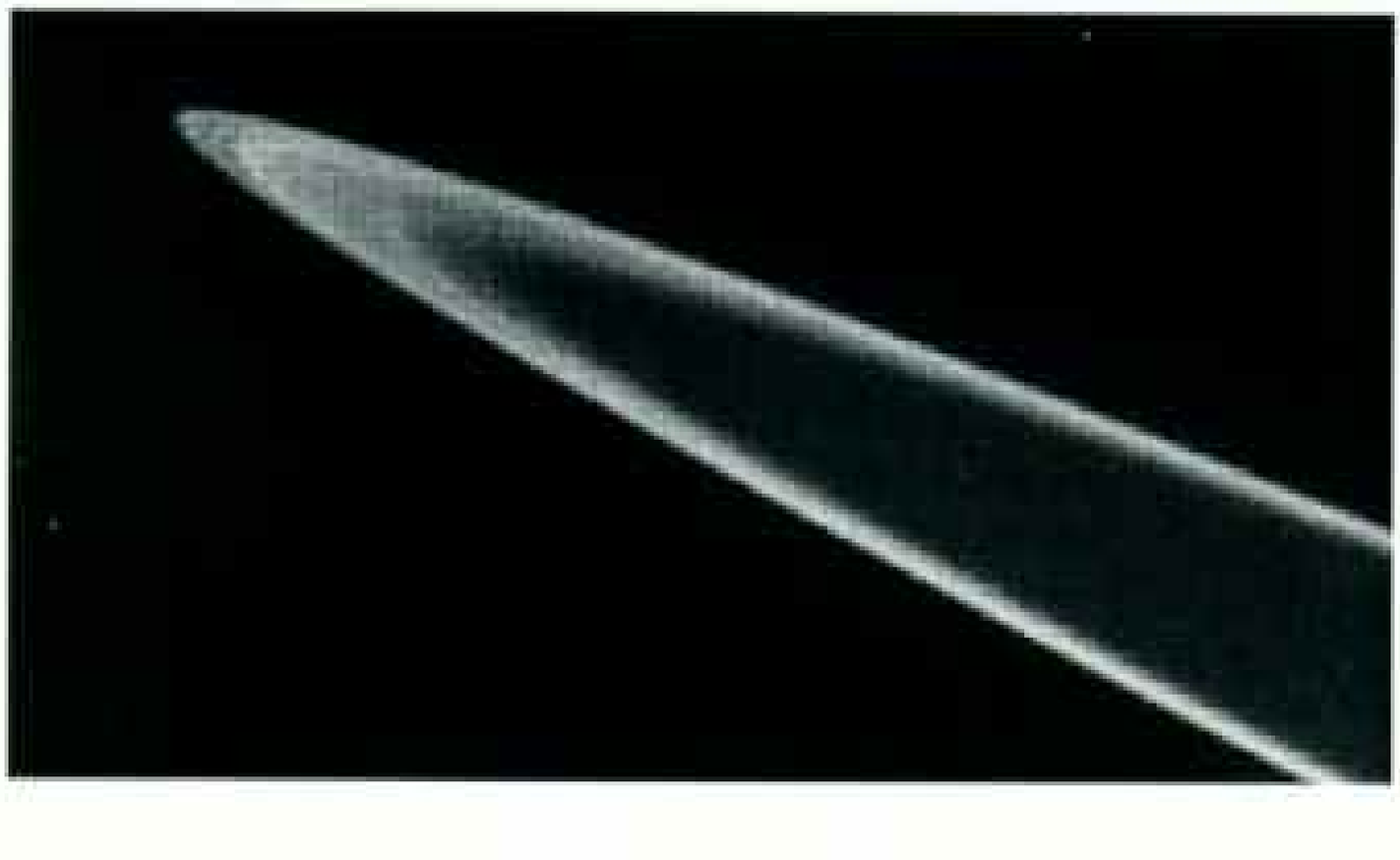
DESIGN: ALLEN CARROLL
RESEARCH: JUAN J. VALDÉS
PRODUCTION: RAMSEY MURRAY
MAP EDITOR: GUS PLATIS
PAINTING BY NATIONAL GEOGRAPHIC ARTIST WILLIAM H. BOND

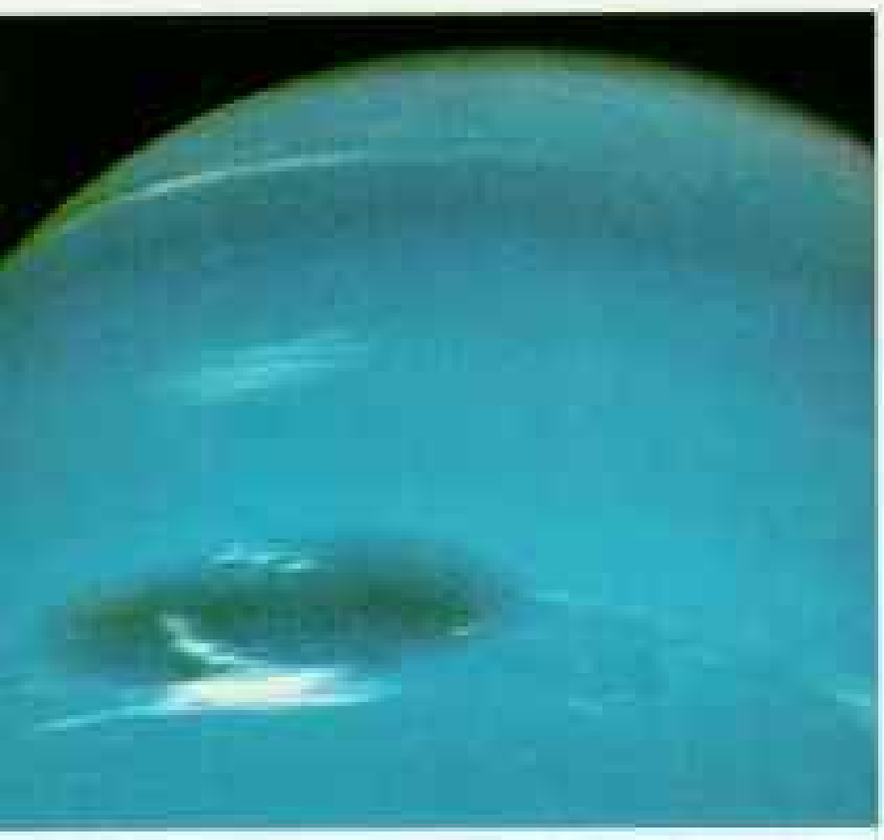
A panoply of rings

SURVEYING the outer solar system, Voyager confirmed that planets other than Saturn wear rings. Meteoriod bombardment of nearby moons may help feed Jupiter's ring (center), while dark particles, perhaps from a moonlet smashed by a comet, create rings around Uranus, seen here with star streaks (right). Why do Neptune's rings (far right) clump into arcs? No one knows.

The rings of Saturn—65,000 kilometers across and as few as ten meters thick—whirl in intricate choreography (above). So complex is their dance that whatever we see in the rings of other planets, we also see here.

ENHANCED AT JPL (ABOVE); ENHANCED AT USGS (BELOW)





ENHANCED AT JPL (ABOVE AND RIGHT)

Worlds of stormy weather

TRAVEL ADVISORY: Cloudy, with high-pressure storms lasting years to centuries on Jupiter, Saturn, and Neptune. On Uranus, no severe turbulence beyond local thunderheads.

Such detailed planetary weather reports are based on images like this of Jupiter's Great Red Spot (right) sent back by Voyager 1 in 1979. Until then the giant storm, visible by telescope for perhaps three centuries, seemed little more than what its name implied: a blotch amid smooth cloud bands.

Jupiter's atmosphere is enormously complex and dwarfs our own in scale. The Great Red Spot (whose color varies over time between red and brown) is large enough to swallow three Earths. Like a rock in a stream, it sends passing clouds spinning into short-lived eddies. The white oval passing below—a 50-year-old feature—is a similar high-pressure cell, although it lacks the chemical compounds that we think color the Great Red Spot. Jupiter, in fact, roils with tiny versions of the Great Red Spot. These vortices bring heat up from the interior, setting in motion the jet-stream bands.

And the other planets? Our best theory told us they would be increasingly less dynamic, each being farther from the sun and colder.

Saturn and Uranus fit that pattern, although Saturn did reveal winds three times as fast as

Jupiter's and convective storms, one of which (left, bottom) is as large as a Jovian white oval. Beneath its hydrocarbon haze Saturn remained the "quiet Jupiter." Uranus, hidden by its deep hydrogen atmosphere, displayed even less turbulence than Saturn.

In 1989 Neptune shattered our neat theory. Orbiting in a deep freeze within 60°C of absolute zero, Neptune nonetheless unleashes winds that may be the fastest in the solar system. The largest storm, an Earth-size vortex dubbed the Great Dark Spot (left, top), wears a scarf of bright clouds much as mountain peaks do on Earth.

We now know that all the giant planets but Uranus radiate more energy than they receive from the sun. So internal heat, along with solar energy, must drive their atmospheres. But how? And why is Uranus an exception to the rule? The debate, like the winds, continues to rage.

ENHANCED AT USGS (ABOVE)

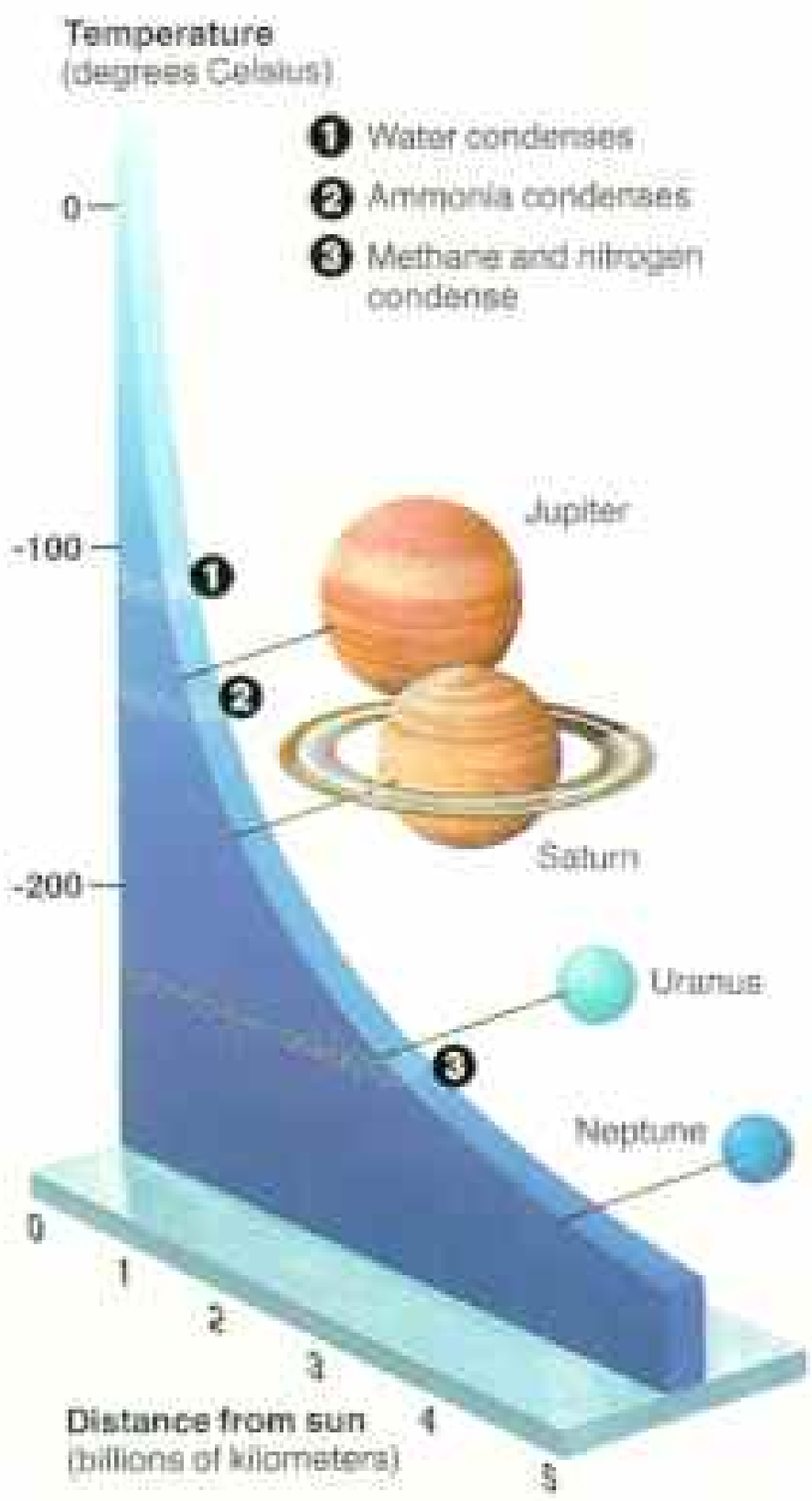


DIAGRAM BY NATIONAL GEOGRAPHIC ARTISTS WILLIAM H. BOND AND CHRISTOPHER A. KLEIN
CONSULTANT: JONATHAN I. LUNINE, UNIVERSITY OF ARIZONA

Alien moons

PEAS IN A POD they're not. The 57 satellites of the outer solar system have unique histories, although all were born under the constraints of temperature determined by distance from the sun (graph, left). Cataclysms and differing internal forces and orbits are part of their stories. We had expected chunks of ice and rock unchanged since they were battered four billion years ago by the same wild epoch of impacts that so cratered our own moon.

Jupiter condensed out of the dust and gas that became our solar system at a distance where water remains frozen. Thus water ice is a constituent of its moon Europa (above right). Heated internally by a gravitational tug of war with Jupiter—much as a paper clip heats up when it is repeatedly flexed—Europa may hold a global ocean between its silicate core and icy crust. Water or soft ice quickly fills in and darkens cracks, leaving Europa smooth as a cue ball.

Yet mysteries still surface a decade after encounter. What are those repeating ridges, the lines that look as though they were left by some double-jointed ice skater? No one knows.

At Saturn ammonia begins to condense out with water. The ice of Saturn's Mimas (left, center), perhaps tainted with ammonia, is nearly as rigid as granite and reacts similarly when struck. An impact not quite large enough to shatter it left a crater a hundred kilometers across.

Methane exists on Saturn's satellites only as a gas. Trapped in ice, it is converted by sunlight into other carbon-based compounds. This ubiquitous "black

National Geographic, August 1990

ENHANCED AT USGS (ABOVE AND BELOW)

gunk," similar to matter from which life may have formed on Earth, appears to cover much of Iapetus (left, top).

Even more striking is Uranus's moon Miranda (left). A patchwork of cratered terrain and younger, complex formations, Miranda may have been repeatedly shattered by collisions and reassembled by gravity. Ammonia and water ices, erupting as lava does on Earth, could have partly smoothed the surface. In addition to the images used in this mosaic, in 1986 Voyager 2 recorded close-ups of ice cliffs higher than the walls of our Grand Canyon.

Temperatures at Neptune are so low that Triton, its only major moon, revealed landscapes of nitrogen and methane ice. Triton held many surprises, but the type of ice was not one of them. That, at least, was anticipated.

Fire in ice

EXPLODING Earth's exclusive claim on active volcanism, Voyager in 1979 found the Jovian moon Io to be erupting continually (right). Heated by gravitational tugs from Jupiter and Europa, Io displays three types of plumes (diagram, below), based on interactions between its molten silicate interior (red), sulfurous mantle (magenta), and hard sulfur crust (brown).

Farther from the sun, water ice and other slushes—rather than silicates—make up "lavas." Such cryovolcanism probably occurred on Saturn's moon Enceladus (below right), where ices oozed through fissures. Dark streaks on Neptune's moon Triton (left) reveal recent eruptions of nitrogen ice and gas, laced with darker compounds. At least two such plumes have been found, rising 8 kilometers high and streaming 150 kilometers downwind.

What is the heat source that causes Triton's eruptions? Perhaps solar energy, say scientists. And, they quickly add, perhaps not. □

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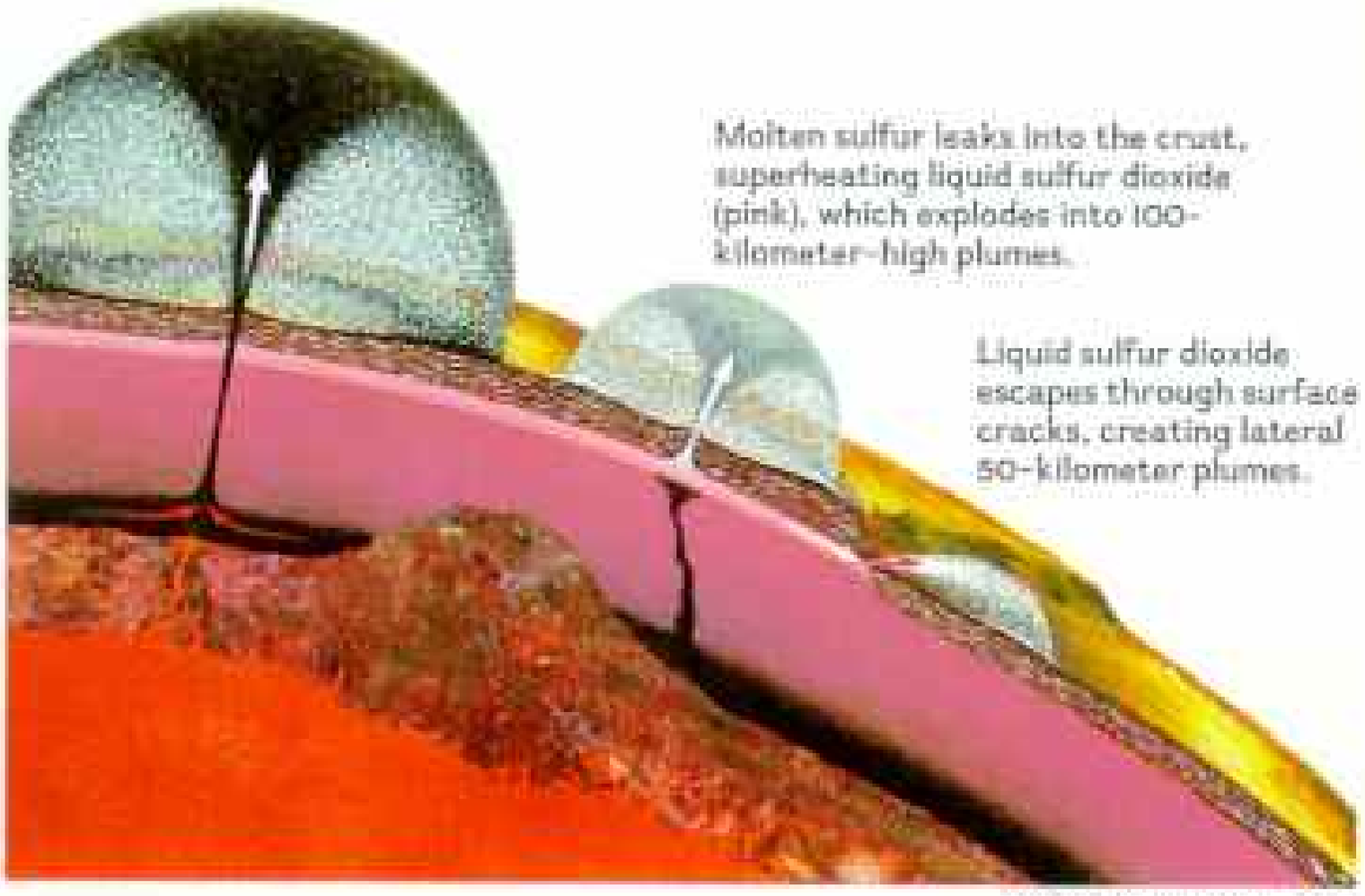


PAINTING BY WILLIAM K. HARTMANN

Philadelphia's African Americans

A Celebration of Life

The spirited expression of African American religion, music, and art thrives in black communities across the country. Documenting folk practices that migrated from the rural South to Philadelphia, Roland Freeman captures in photographs and reminiscences the heart of a people whose ancestors were snatched long ago from Mother Africa's shores. A tradition of family prayer came from Alabama with evangelist Sylvia Fletcher and her husband, Smiley (right), who gather their children each afternoon to talk to the God they know so well.

Photographs by
ROLAND L. FREEMAN

To celebrate their reunion in the sanctuary, members of the First Schwenkfelder Church in North Philadelphia march around the neighborhood. The original building, recently renovated, was being used for the first time in six months. This is the only African American congregation in the Schwenkfelder conference.

Many sections of North Philadelphia have been abandoned by the middle class, but this congregation is among those that have a commitment to continue worshiping in and working with the local community.

"The 1963 March on Washington inspired in me a commitment to explore African American culture," Freeman recalls. "I am still moved whenever we march together."

Mother Africa's Children

Twenty-seven years ago I set out to explore and photograph the richness and diversity of the African American experience. My quest continues, fulfilling me beyond my expectations—while forcing me to acknowledge some harsh realities.

Those realities are what millions of people see each day on television and read about in the newspapers. African American communities are represented as drug-infested, inner-city ghettos that spew bullet-ridden black bodies across the urban landscape. Such images turn all too many people away from knowing and associating with African Americans. And so, ignored are the masses of religious and hardworking people who love and care for their families and society and whose lives build upon generations of traditional culture and communal support.

Many of these strong qualities came with hundreds of thousands of African Americans along the dusty roads that brought them north from their homes in the South. Such qualities are rooted even deeper in time and place, perhaps in Central or South America or the Caribbean, ultimately in Mother Africa. These photographs show contemporary expressions of African American culture in Philadelphia. Traditional forms appear in music, speech, movement, dress, hair, religion, and crafts. Together they shape styles and manners that people of African descent have carried with them for generations, despite all the diverse influences in American life.

Expressions of black culture can be found in public spaces and neighborhood joints as well as in private homes and places of worship. Family gatherings, block parties, church convocations, and public holidays—such as the two-week, citywide Africamericas Festival, where everyone stopped to watch as the spiritual power of the drums took possession of Crystal Tett (right)—all celebrate the rich legacy of African American culture.

Working with folklorists Jerrilyn McGregory and Glenn Hinson, I directed this ethnographic project—cosponsored by the National Geographic Society and the Smithsonian Institution's Office of Folklife Programs. As always, one of my primary commitments when people permit me to photograph their intimate moments is to accept a moral obligation to present the fullness of the experience their openness has provided me, not just its most sensational images.

—Roland L. Freeman

"Fried chicken and down-home music: I felt right at home in this kitchen."

Alabama-born guitarist Chuck Mitchell joins in a late-night kitchen jam session with Robert "Washboard Slim" Young, a 90-year-old veteran of southern carnivals and medicine shows, whose washboard boasts an array of pots, pans, bells, and lamp bases.

"Watching Anthony play the spoons brought to mind my Uncle John, who played the bones with the same fervor."

Anthony "Spoons" Pough learned to play from his blind grandfather in South Carolina and from his near-legendary namesake, "Spoons" Williams, in South Philadelphia. "Now they're both gone," he says. "But I'm going to keep it going on."

"It was wonderful to witness the love, sharing, and unity through music that have helped bridge the generation gap for John Blake and his children."

Having grown up in a family of talented musicians himself, jazz violinist John Blake passes along his skills to his children, Johnathan, Beverly, and Jennifer.

"I was surprised to find that such young musicians rapped a message that showed a keen sense of what is going on in the world. It was poetic."

Drawing upon an African American tradition that makes eloquence the vehicle of wisdom, Ryan "R Rock" Johnson, at right, and fellow rapper Pernell "Nell Ski" Ghee fill their sharp-edged rhymes with political meaning.

"In my own religious upbringing I saw a lot of altars from different faiths. I was impressed that this one was so elaborate and large—it took up a third of the living-room floor space."

In celebration of her eighth anniversary as a high priestess of Haitian voodoo, Mambo Angèlà Novànyòn Idizol erected a seven-day altar in her home with offerings of honey, cakes, fruit, and champagne to honor *loa*, or saints, of her religion. These offerings will be presented to followers during services. A blending of beliefs and rites of African origin, mixed with some Roman Catholic practices, voodoo is attracting growing numbers of African American intellectuals who are searching for something more in tune with their ethos.

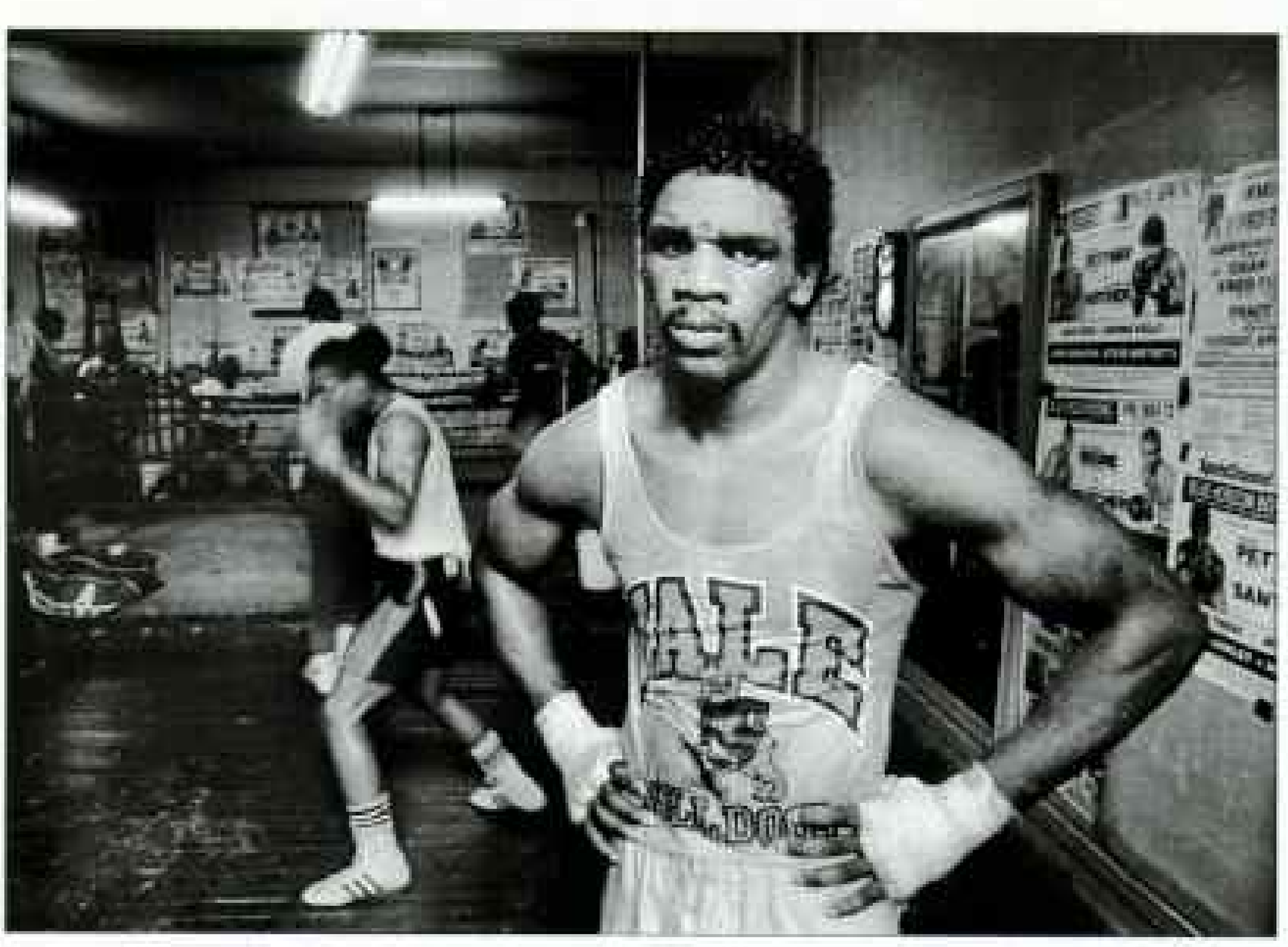
"I wondered if this man realized that he may be part of the last generation of skilled workers who rely on muscle power, before the robots take over."

"For 18 hours I watched this high priestess and others go in and out of possession. I was very moved and am still trying to fully understand what I witnessed."

"This work's not hard," says Prince Hyslop (top), a 17-year veteran of the H. G. Enderlein foundry in Philadelphia. "But you've got to keep your mind on what you're doing." Historically providing "bull labor" at foundries, blacks have moved into skilled positions at Enderlein.

Possessed by a voodoo loa, Mambo Angèlà Novànyòn Idizol takes on the voice and

"Bonnie's childhood dream was to own a horse, so last year she bought Sunshine for $800. She pampers the mare with special perfume and decorates her mane with ribbons. She is seldom far from Sunshine."



"He is vicious when he sets out to hurt an opponent in the ring, but outside it this boxer is one of the warmest, friendliest, most soft-spoken guys you could ever meet."

appearance of the saint she calls Erustie Freeda, the loa of love.

Bonnie Campbell (top) keeps her mare, Sunshine, at one of the many stables in Philadelphia owned by African Americans.

"Prince Charles" Williams, the current International Boxing Federation light heavyweight champion, trains at North Philadelphia's Champs Gym, among the city's oldest and most respected boxing establishments.

"The entire congregation stood as these singers slowly made their way to the front. In each face was a show of respect for two women who, as very young girls, gave their lives to the Lord."

"When I was saved, I told the Lord that I'd travel the highways and byways for him, singing wherever folks needed me," testifies Sister Janie Green (above, at left). "I've been singing since I was three years old, and I'm 71 now. And you know I ain't about to stop!" Appearing as the Philadelphia Gospel Singers, Sister Green and Sister Mary McNair are among hundreds of groups that have earned Philadelphia the title Gospel Capital of the World.

Gathering around a feast of roast turkey with all the trimmings—including corn pudding, an old family recipe—the children and grandchildren of Barbara and Sinclair Whiteman enjoy a bit of good-natured bantering at their Sunday dinner table.

As the faithful experience the washing away of their sins during the annual convocation and baptism at the United House of Prayer for All People, four brass "shout bands" play songs of praise with exuberant, improvisational brilliance. "When you walk out of the water, don't take your problems out of the water with you," preaches Bishop Walter McCollough, heir to church founder Daddy C. M. Grace and proclaimed steward of the keys to heaven. On their way to the pool, believers stream past Bishop McCollough, who lays his hands on each and every person.

"The long line of worshipers moved solemnly toward the baptismal. They went into the water humble, but they came out shouting praises to God for taking their sins away."

"I first noticed Denise in church, when her hat fell off as she was moved by the spirit and started 'shouting.'. . . These bridesmaids in their ruffled gowns made me think of orchids."

Style—whether captured in an elegant hat, an eloquent phrase, a sophisticated step, or a smooth move—lies at the very heart of African American culture.

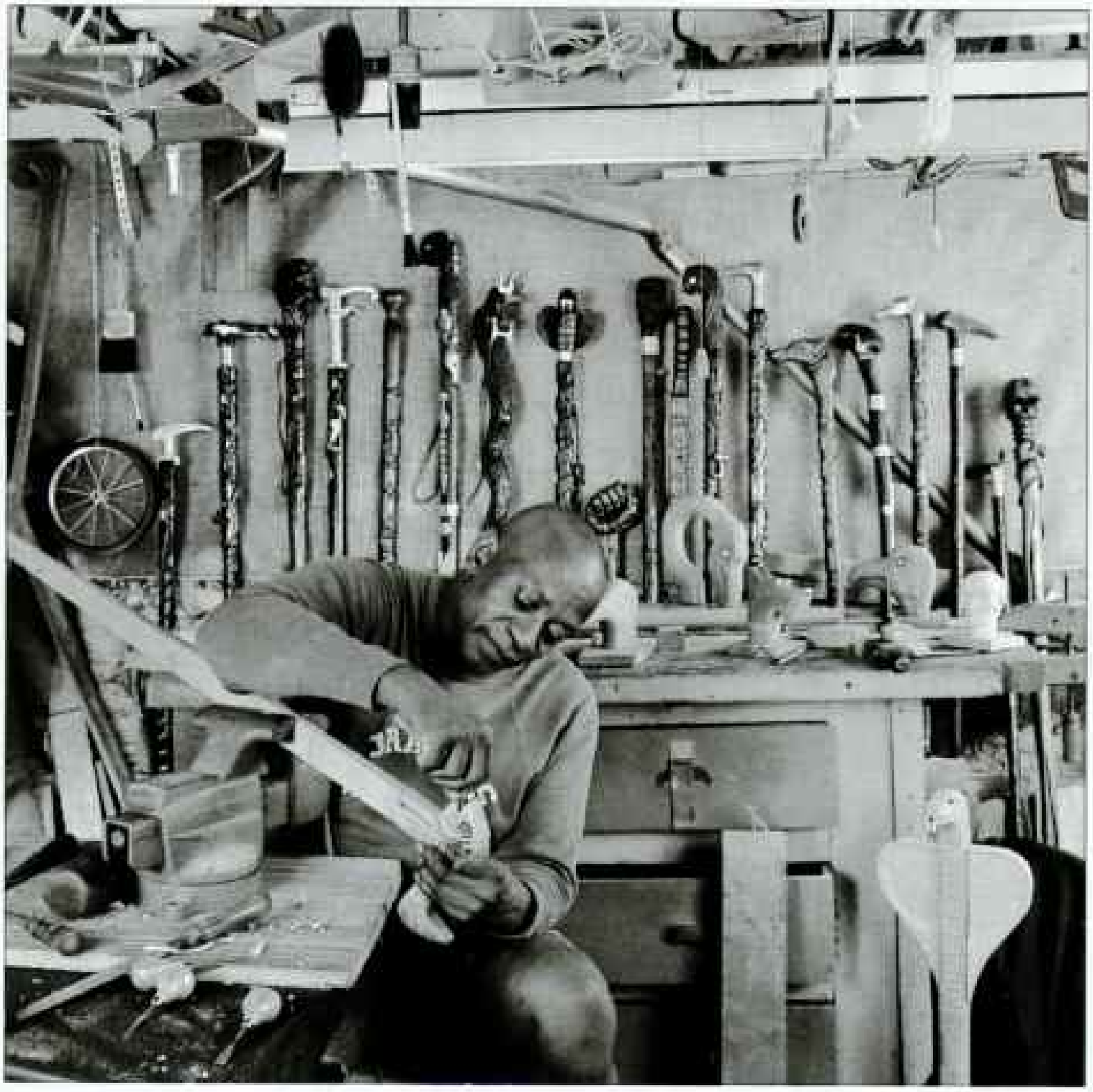
"A hat shouts out a person's inner self, their personality, their

aura, their spirit," says Denise Lowney, who tries out her creation on her sister-in-law, Carla Horton, as her daughters, Lahtesha, at left, and Nataya, look on.

Bridesmaids cluster like a bouquet while awaiting the hansom cab that will convey the bride and groom to their nuptial rite. On Saturdays the historic area of Philadelphia often becomes jammed with all manner of vehicles as bridal parties assemble for tableau portraits.

"Mrs. Mahan will only give her quilts to someone she loves and respects. She never sells them. For her it's not about money. She simply loves what she does."

Putting the finishing touches on a masterpiece, Lorraine Mahan gathers onto her lap a quilt of 176 panels, one for every verse of the 119th Psalm—the Bible's longest. She has also produced quilts representing the Lord's Prayer, the Ten Commandments, the Beatitudes, and the 23rd Psalm. Declining to sell her work, she has presented quilts as gifts to President Jimmy Carter and Philadelphia Mayor W. Wilson Goode, as well as to homeless children, family members, and friends.



"The pride Milton feels when carving his walking sticks comes through when you see how he handles them. He works each one meticulously, wraps it carefully, and puts it away. He maintains a private collection as a legacy for his family."

"I see something in the wood before I ever start carving. The wood tells you what's in there. That's right, it tells you!" says master craftsman Milton Oliver Jews, who has been carving elegant walking sticks in his South Philadelphia basement for more than 20 years.

Most of these pieces began as scrap wood scavenged from trash piles, construction sites, and city parks. Yet generations of black Philadelphians have carried the finished sticks with pride.

"This single mother makes a conscious effort to expose her children to African traditions. When they are older, her sons will choose to keep or shed their dreadlocks in a rite of passage."

Surrounded by her daughter and six sons—clockwise from Cetawayo, on her lap, they are Kehinde, Atiba, Hesaam, Sibongile, Obatala, and Taiwo—Kemba Sonnebeyatta explains the significance of her children's African names: Hesaam means brave, generous, and kind; Obatala means king of peace and love; Cetawayo is the name of a Zulu king; Atiba means one of understanding; and Sibongile means we are thankful. Taiwo, signifying the first born, and Kehinde, second born, are twins.

Barbara and Sinclair Whiteman (left) consider their dolls part of their own extended family. Barbara has been collecting black dolls for about five years and recently founded the Philadelphia Doll Museum. Her collection, entitled "Dark Images," includes more than 400 dolls, from antiques to folk dolls made of grass, cornhusks, walnuts, pecans, or baby-bottle nipples. Gathered from all over the world, they reflect how people of African heritage have been perceived through history.


WOODE'S

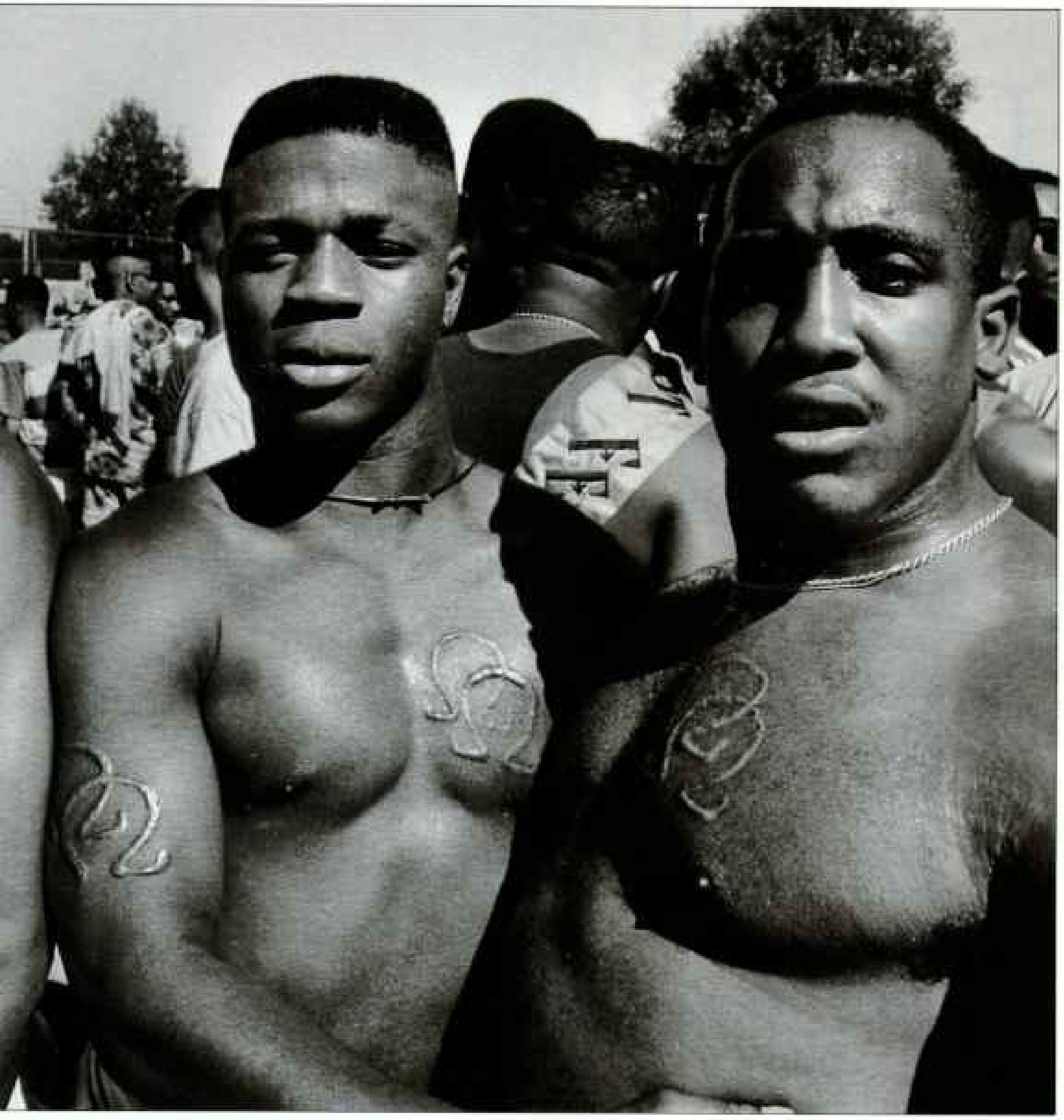
"I knew I was close to finding this barbecue stand when I caught its aroma from a few blocks away. With ten grills, Florida Boy's is at the top of the barbecue business in Philadelphia."

"Folks here in Philly may be living up North," says a customer at a streetside barbecue stand, "but they're still eating like they're down South." Among the oldest and the largest stands, Florida Boy's Barbecue (above) fires up ten cookers at a time, serving a steady walk-up trade until the wee hours of the morning. Dozens of such stands dot the city, filling African American neighborhoods with the sweet smell of barbecuing pork.

On the other side of town, white-frocked members of the Evangel Temple Church of Deliverance have used the proceeds from six years of suppers—offering fried chicken, pig's feet, oxtails and gravy, ribs, greens, potato salad, steamed cabbage, and sweet-potato pudding—to move from a cramped storefront church into a spacious, newly built sanctuary.

"When I saw Greek letters branded on these young men, I was reminded of the African concept of beauty through scarification."

Showing off symbols of their brotherhood, members of Omega Psi Phi fraternity are among 100,000 African American men and women who descend upon Philadelphia on the second



Saturday of July for the annual Black Greek Picnic.

To spiritualist Imani Zen-Ra (left) each aspect of her look symbolizes inner qualities: A nose ring reflects the infinite life force; a diamond stands for light; the strands of her headpiece represent higher and lower selves. Dreadlocks absorb cosmic energy.

Finding ways to express the spirit—thus do African Americans keep their heritage alive. □

A House Much Divided

Long before becoming one country, the land known as Yugoslavia was infamous for tribal vendettas. Now, as it struggles to cast off its one-party straitjacket, this country with its myriad ethnic groups must also struggle to resolve ancient antagonisms—especially in Kosovo Province, where Serbs, like Milijana Vukmirović and her neighbor, are locked in acrimony with an ethnic Albanian majority.

By KENNETH C. DANFORTH
NATIONAL GEOGRAPHIC STAFF

Photographs by STEVE McCURRY
MAGNUM

YUGOS

LAVIA

A twilight moon rises above the Kamniške mountains and Slovenia's Sava River Valley. Early in the seventh century, during great migrations of peoples across Europe, Slavic tribes from the northeast began

to colonize this valley and the rugged Balkan Peninsula to the south. Their descendants are the Slavic "nations" that make up modern Yugoslavia, including the Slovenes, one of Europe's smallest ethnic groups.

In its 20th-century coliseum, built for the 1979 Mediterranean Games, the Croatian city of Split hosts a soccer match with Zagreb. In the old city, at upper right, stand walls of the palace of Diocletian, a Roman

emperor who was born on this coast when it was a Roman province. Many of the cities and roads in what is now Yugoslavia are a legacy of Greek colonization and Roman rule in the eastern Adriatic.

The timeless ways of the medieval Balkans still hold in western Macedonia, where Stojan Slaveski enjoys a smoke while his wife, Duha, sorts beans grown in their small private plot. Mostly old folk remain

in the small village of Brežani, surviving on their own crops and the occasional sale of a sheep. Much of the younger generation moves to the cities or joins the ranks of Yugoslavs working abroad.

THE JACKDAWS came at *korzo* time in Priština, capital of Kosovo Province in Yugoslavia. Cawing and squawking over the main street, they whirled down in a black mass, then flapped out toward the reddening sky only to swoop back again. It took them an hour to settle on the bare branches of the trees, and their social adjustments as night descended kept the racket going almost until curfew.

The korzo is the traditional evening stroll that people—laughing, chatting, flirting—make in every town in this Balkan country. But in Priština it had a somber air. Joy had forsaken the town; no bands played; the cry of the jackdaws was the only sound I heard.

Families ambled under the grit-filtered glare of streetlamps, and if they talked, it was in a murmur, fearful they would be overheard. For in a street closed to all vehicles except police cars and armored vans with machine-gun turrets, they walked under the sullen scrutiny of steel-helmeted militia with bulletproof aprons and submachine guns. These citizens of Kosovo, a self-governing province of the Republic of Serbia, could be bludgeoned and jailed just for saying "Republic of Kosovo."

Serbia had wiped out their autonomy with tanks, troops, tear gas, and terror. Though not many Serbs live in Kosovo, they consider it the sacred heart of medieval Serbia. They cannot stand the thought of losing it to a non-Slavic, non-Orthodox populace whom they call "overbreeding defilers."

Ethnic Albanians, mainly Muslim and Europe's fastest growing population, form 90 percent of Kosovo's inhabitants. They claim descent from the Illyrians, whose homeland this was for centuries before Serbs and other Slavs swept out of the north. Finding "autonomous province" an empty phrase, Kosovo Albanians clamor for their own republic in the Yugoslav federation, coequal with Serbia.

From this confrontation comes violence. Rioting Albanians have stoned and beaten outnumbered Serbs. The state, reacting with brute force, has shot Kosovo Albanians, killing more than 35 since the first of the year.

"Some were just kids, only making the V for victory sign or chanting *Lavdi!*, which means 'glory,' or *Demokraci!*" I was told in a backstreet café.

"Police go into people's houses and shoot them, branding them secessionists and terrorists" was another charge.

Curfew came at nine o'clock, but I had been advised to be indoors before eight. After that, one is viewed with increasing suspicion. I lingered until 15 minutes before curfew, by then sharing the street only with scowling militia and the man who seemed to come and go from the hotel whenever I did. Everyone else had hurried home, and the jackdaws slept at last.

To understand the emotions Kosovo stirs in the Serbs, you have to go back to 1389, to the Battle of Kosovo Polje—the Field of Blackbirds—one of the largest battles ever fought in medieval Europe. I drove out from Priština. Thick smoke from a coal-fired power plant blew across the frozen fields, pitch-black earth dusted with snow. Here a Christian alliance tried to block the northward advance of the invading Ottoman Turks.

Losses on both sides were appalling; legend says that birds tore at the corpses for weeks. The battle spelled the end of the once powerful Serbian empire, though more fierce battles lay ahead and the Turks did not occupy the land for 70 more years.

The leaders of both armies were killed. Strikingly different monuments to each stand near the hamlet of Gazimestan. A centuries-old mulberry shelters the mausoleum built where Sultan Murad I died in his tent.

No one knows where Serbian Prince Lazar fell, but a stone tower honors him and the other "heroes of Kosovo." In the summer of 1989 on the 600th anniversary of the battle a million Serbs came to this hilltop. They were there to wrest victory from an old defeat, saying in effect that a charter of perpetual suzerainty was written in the blood Serbs had spilled there. And they came to celebrate tough new measures under which Serbia was dismantling whatever remained of Kosovo's autonomy.

Kosovo's Albanians stayed away.

Now, months later, I was alone at the monument. A bitter wind swirled snow around the base and stung my eyes. Beyond the cleared area, stuck on a ring of bare shrubs, hung plastic trash left behind by the celebrators.

Under the spires of Zagreb's great cathedral a sprawling produce market prepares for the morning rush. Though Yugoslavia has large socially owned farms, private farmers make up a quarter of the working population and account for 75 percent of food production.

Driving back to Priština, I was stopped by policemen so that three big buses crammed with soldiers could pull into a military compound. Scores of tanks were parked there, poised for a five-minute dash into Priština.

Military authorities had closed the airport, so to get to Priština the day before I had flown to Skopje, in the neighboring republic of Macedonia. At the car-rental agency I had insisted on license plates with an "LJ" prefix—to imply that I was from Ljubljana, in Slovenia far to the north, not Belgrade, capital of Serbia as well as of Yugoslavia. I was following one of two suggestions for traveling in Kosovo. The other was, if an Albanian crowd seemed threatening, to hold up two fingers in a V sign.

WHAT KIND OF LAND is this, where you must be ready with a signal that, with luck, will save your skin? Where you need to make sure your car isn't from the wrong part of the country?

This is Yugoslavia: 24 million people of 24 ethnic groups and three major religions, writing in both the Latin alphabet and Cyrillic,

divided into six republics—six bows drawn tight. The bowstrings sing of hatred, group against group. Civil war is discussed daily in every republic—in Serbia, Croatia, Slovenia, Bosnia and Hercegovina, Macedonia, and Montenegro. Slovenia and Croatia, the most prosperous republics, threaten to secede but fear an army takeover if they try.

Geographically, Yugoslavia encompasses the diversity of all Europe. On the plains of Vojvodina waves of yellow wheat sweep northward from the Sava and Danube Rivers toward the Great Hungarian Plain. The crystalline Adriatic washes a deeply indented 3,800-mile-long coast including 725 islands.

But it is the mountains that dominate the land—70 percent of it. The Dinaric Alps lumber fiercely from north to south like a stone stegosaurus, until in Montenegro they lose all semblance of order and rear up in a fearsome immensity of peaks. To go from one side to the other has always been as daunting, in its way, as a journey from the Catholic north and west, facing Austria and Italy, to the Muslim and Eastern Orthodox south, bordered by Bulgaria, Greece, and Albania.

"We're all supposed to be Yugoslavs," Zdeslav Bošković, a lawyer from the Croatian port of Split said. "But scratch one of us and you'll find a Serb or Croat or something else." And you don't need to scratch very much.

I have traveled in Yugoslavia in all seasons, seen every part of the country, and the more I talk to people the more difficult it becomes for me to imagine a Yugoslav. I have learned to take them on their own terms, which means ethnic family yes, country maybe. Diplomatic codes that allow Yugoslavia to get along with the rest of the world do not apply within Yugoslavia.

Flags talk in southern Yugoslavia, where ethnic origins are freighted with politics. In the troubled province of Kosovo, a wedding party flies the national flag of Albania modified by the Communist star. In the Republic of Montenegro, a house painted like the Yugoslav flag (below) expresses patriotic support for the Yugoslav state, a sympathy shared by most Serbs and their ethnic kin, the Montenegrins.

YUGOSLAVIA, under President Tito, embarked on *perestroika* and *glasnost* long before anyone outside the U.S.S.R. had heard of Mikhail Gorbachev. Breaking free from Stalin's Eastern bloc in 1948, Yugoslavia became the most progressive communist country. Now it is struggling.

For decades the West supported Yugoslavia as a bulwark against Soviet expansion. Easy credit fueled the economy. Yugoslavs had plenty of money for holidays. Their country was a model for nonaligned nations in Africa, Asia, and Latin America.

Today Yugoslavs spend 80 percent of their wages—which average $212 a month—on food and household expenses. Their standard of living has sunk to the level of the mid-1960s. Unemployment nears 20 percent. The government is saddled with a foreign debt of 16 billion dollars. Leaders fret over low productivity while offices slam shut at 2 p.m. You learn to recognize the sound, the drowsy hum of a whole country shutting down.

Students say they have no future.

Each ethnic group blames Yugoslavia's problems on another group, and they coddle

GEORGES MERILLON, GAMMA LIAISON

Flash point of ancient rivalries, Kosovo was stained with blood this past January when ethnic Albanians rioted in Podujevo (above) and other towns to demand more autonomy from the Serbs, who view the province as the cradle of their culture. Several days of violence left 28 dead. An important part of Yugoslavia's polyglot population, Albanians outnumber Serbs in Kosovo nine to one.

Land of the South Slavs

On the Balkan Peninsula, between the Black and Adriatic Seas, a band of tribes had arrived by A.D. 600. These South, or "Yugo," Slavs—like their kin the Czechs and Poles—migrated from a homeland still occupied by other Slavs, the Russians and Ukrainians. Under foreign domination for centuries, the Serbs, the Croats, and the Slovenes decided to join together in a kingdom after the carnage of World War I. Today such Pan-Slavic nationalism is on the wane in Yugoslavia's six republics and two provinces, as eight major and a score of minor ethnic groups flounder in a leadership vacuum left by the death of President Tito in 1980.

AREA: 255,804 sq km (98,766 sq mi). **POPULATION:** 23,701,000. **CAPITAL:** Belgrade, pop. 1,087,900. **RELIGION:** Eastern Orthodox, Roman Catholic, Muslim. **LANGUAGE:** Serbo-Croatian, Slovenian, Macedonian, Albanian. **LITERACY:** 90%. **LIFE EXPECTANCY:** 71 yrs. **ECONOMY:** Food processing, machinery, textiles, nonferrous metals, chemicals.

The kingdom of Serbia reached the height of its power under Stefan Dušan, self-proclaimed emperor of Serbs and Greeks (1346–1355), while Hungary, Venice, and the Habsburgs vied for control of the Croats and the Slovenes. The Byzantine Empire, encroached on by the Bulgarians to the north and the Turks to the east, had shrunk to a remnant.

The Ottoman Turks achieved a strategic victory in Europe by defeating the Serbs at Kosovo Field in 1389. In 1453 they took Constantinople, ending the Byzantine millennium.

By 1529, when they laid siege to Vienna, the Ottomans controlled most of southeastern Europe. Slavs, Albanians, and other groups maintained strong national identities.

GERMANY

SLOVENIA

One of the "peasant nations" of the Habsburg empire, Slovenia emerged in 1918 from six centuries of Austrian rule as Yugoslavia's most westernized republic. Through the centuries its cities were outposts of German culture. That the Slovenian language was preserved is a tribute to continued use by the peasant population and Roman Catholic clerics.

ITALY

Rome

Tyrrhenian Sea

CZECHOSLOVAKIA

U.S.S.R.

AUSTRIA

HUNGARY

ROMANIA

BULGARIA

ALBANIA

GREECE

Adriatic Sea

CROATIA

Incorporating the ancient Roman province of Dalmatia, with its Latin-speaking inhabitants, the kingdom of Croatia flourished in the 10th and 11th centuries, after which it was dominated by the Hungarian kingdom. In the 1400s Venice gained control of Dalmatia and ruled it for four centuries.

VOJVODINA

(Province)

To dilute Serbian hegemony, President Tito (1953 to 1980) promoted greater self-rule for the provinces of Vojvodina and Kosovo, although they remained subordinate to the Republic of Serbia. Though Serbs are the largest group in Vojvodina, ethnic Hungarians constitute a large minority.

SERBIA

Serbs make up 40 percent of Yugoslavia's population. Determined to maintain national unity and Serbian primacy, Serbs revere the memory of their 14th-century emperor, Stefan Dušan, who extended Serbian rule in the Balkans. Fierce fighters, the Serbs defied Turkish control and preserved the Serbian Orthodox faith through centuries of occupation.

KOSOVO

(Province)

The heartland of medieval Serbia—dirt poor but mineral rich—Kosovo is home to some 1.7 million ethnic Albanians. Predominately Islamic in faith, they are Yugoslavia's fastest growing population and a source of enmity to Serbian nationalists who view Kosovo as a kind of Serbian Palestine.

BOSNIA and HERCEGOVINA

Religious mavericks, Bosnians once incurred the wrath of popes by following a heretical sect known as Bogomils. Later they and the people of Hercegovina provided the largest number of Slavic converts to Islam during Ottoman rule. Muslims were recognized as an ethnic nationality in 1969. Today the republic is 40 percent Islamic.

MONTENEGRO

Once a part of the Serbian empire, this isolated mountainous kingdom gained fame as a sanctuary for Serbian freedom fighters after the Battle of Kosovo Field. For centuries a theocracy ruled by bishops, Montenegro maintained its autonomy during the Ottoman period.

MACEDONIA

In this Balkan brew of Slavs, Albanians, Turks, Gypsies, and Greeks, Macedonians are the majority and have their own language. Early in the century this ancient land of Alexander the Great was torn by the bloody Balkan Wars, finally resolved by partition between Greece, Serbia, and Bulgaria. Serbian Macedonia became a republic when the modern Yugoslav state was formed in 1946.

By 1878 only Macedonia and Kosovo remained under Turkish control. In 1908 a fuse was set for World War I when Austria-Hungary annexed the Bosnia and Hercegovina region. The fuse was lit in 1914 when a Serbian nationalist assassinated Austrian Archduke Franz Ferdinand in Sarajevo.

0 100 km

0 100 mi

NGS CARTOGRAPHIC DIVISION
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- Serbs
- Croats
- Albanians
- Muslims
- Slovenes
- Macedonians
- Montenegrins
- Hungarians
- No predominant ethnic group

SERBS Additional ethnic concentration

Colors represent areas where an ethnic nationality constitutes 50% or more of the population.

Favored by the sailing set, Croatia's Kornati archipelago (below) is protected as a national park. Little polluted by the wastes that plague much of the Mediterranean, hundreds of miles of island-studded coast make Yugoslavia a prime destination for tourists. Rebuilt from the rubble of a 1979 earthquake, the walled Montenegrin city of Kotor (opposite) occupies a narrow shelf of land on the Gulf of Kotor.

their right to hate as if it were the primordial gift of fire. The Yugoslav ideal—that historically contentious peoples, including non-Slavs, could band together peaceably after centuries of bloodshed—has become lost in a blinding sandstorm of nationalism.

After more than 40 years in which Yugoslavs managed to subordinate their tribal passions, a former bank president stepped forward to tap those passions and put them to his own use. Slobodan Milošević, President of Serbia, has gone from obscurity to dictatorship, purging party and press along the way, on the strength of one issue—persecution of Serbs in Kosovo.

Belgrade shopwindows feature portraits of Milošević. His jowly visage glares from displays of television sets and women's shoes. Milošević professes to disdain his personality cult—popularity based not on improved living standards, health care, or education but on hammering Albanians and threatening to colonize Kosovo with hundreds of thousands of Serbian settlers.

In Yugoslavia, with its powerful oral tradition, it isn't the truth that's operative, it's what people *think* is the truth. In Belgrade, with its rigidly controlled press and no one to tell them that Albanians are not raping Serbian women every week, people believe the most gruesome accounts. Consequently, the Serbian-controlled militia wreaks vengeance in Kosovo, as if acting out a time-honored Balkan vendetta.

Kenneth Anderson is an investigator with the Helsinki Watch Committee, a human-rights organization that monitors compliance with the 1975 Helsinki accords. His recent report describes the situation in Kosovo as "a frightening example of the power of a one-party dictatorship, the full weight of a police state controlled by one ethnic minority unleashed against another. . . ."

As the tragedy of Kosovo unfolds, other republics watch uneasily; the Slovenes and Croats say that Serbia's mailed fist in Kosovo may be parting the curtain on a scheme for the rest of the country. The Serbs respond angrily that they have special historical rights in Kosovo, where the Albanians are a majority only because they have frightened the Serbs away, and that Serbs just want equality.

In this country even "equality" is a loaded word. The federation is based on equality among the republics. What Serbian nationalists want is "one man, one vote," which is fair enough for most countries. But, since ethnic Serbs are 40 percent of the Yugoslav population and Slovenes, for example, are only 8 percent, equality of individual voters means that Serbia takes over.

WHEN THE TURKS grudgingly drew back to Constantinople after severe losses in the Balkan Wars of 1912-13, their 500-year reign in southeastern Europe left a cultural and economic rift across what is now Yugoslavia.

The Serbs, nearly doubling their territory, also wanted Bosnia and Hercegovina. But Austria-Hungary had annexed the province in 1908, and kept it. When Archduke Franz Ferdinand, the Habsburg heir, visited his

subjects in the provincial capital of Sarajevo in 1914, he was shot dead by a young Bosnian Serb nationalist. The Austrians invaded Serbia; World War I was under way.

As the war was fought, plans were made for a Slavic union, the Kingdom of Serbs, Croats, and Slovenes. Formed in 1918, it included Montenegro (ethnic Serbs) as well as Bosnia and Hercegovina (ethnic Serbs and Croats).

Unity hardly led to comity, as the new country was ruled by Serbia's King Alexander, whose despotism soon alienated the Croats and Slovenes. Perhaps his only lasting decree was to change the country's name in 1929 to Yugoslavia, "Land of the South Slavs." A Croatian separatist assassinated him in Marseille in 1934. The kingdom started a disintegration that didn't end until a Croatian guerrilla leader, Josip Broz, emerged from the ashes of World War II as Marshal Tito, the only man who has ever been able to make these hostile peoples be civil to each other.

The sufferings and triumphs of Tito's communist Partisans provided one of the most heroic chapters of the war and made him an epic figure who could get what he wanted at home and abroad. Tito silenced dissent by sending at least 7,000 critics to living hell on Goli Otok, a barren island in the Adriatic.

To prevent Serbian domination of the entire country, Tito gave greater autonomy to Vojvodina (with its large Hungarian population) and Kosovo (with its Albanian majority). That is why Serbs burn Tito's picture in mass demonstrations today and shout for the removal of his remains (he died in 1980) from Belgrade.

TO TASTE LIFE in the Kosovo countryside, one day I took off my shoes at the top of a stone staircase and entered the parlor of a large Muslim Albanian family farm. I smelled wood burning in an iron stove and surveyed the array of woolen cushions and blankets around all four walls.

With its 170-year-old water mill, cattle and

poultry, and good crops of wheat, corn, peppers, and cabbage, the clan, about 250 strong, is virtually self-sufficient.

One of the boys spread a tablecloth on the floor, then helped two others bring in a huge ten-inch-high wooden table to set upon it. We sat cross-legged around it and pulled the cloth over our knees. The younger men brought in platters and bowls of grilled beef chunks, yogurt with onions, salami, boiled eggs, cabbage, thick cornmeal polenta, and a pudding-like cheese. Each of us had a tablespoon and fork but no plate.

There were 18 men and boys at that meal—but no women. I had met the women in other rooms and on a tour of the farm, but they had been excluded from that chamber since time immemorial. I asked how old a boy had to be to sit with the men.

"Tradition says a boy can join us when he's ten," I was told. "But now that's changing in some houses." A child of three burst through the door and rushed over to nestle beside his father, an engineering student playing a two-stringed *çiftelí*. Heeding a whisper, he thrust two small fingers toward me in a V.

"Before, we never talked politics in this room," said one of the younger men. "So far we have not fought back. But now we Albanians are like cats pushed into a corner. We have nothing else to lose."

"We will get democracy or get killed," said another. "They accuse us of wanting to join Albania. That is stupid. We want to stay in Yugoslavia. But in *Serbo*slavia? Never!"

Many Kosovars are turning to Ibrahim Rugova, a 44-year-old Albanian professor, to lead them out of the pit. His Democratic League claims 350,000 members, while communist ranks have fallen to 80,000. "We're growing by hundreds every day," he told me. "Not only Albanians. Turks and even some Serbs too. The only end to this foreign occupation can be if we start a dialogue. But they say they will deal only with 'progressives.' That is the Stalinist line: Everybody who doesn't agree with you is not progressive."

To the south, in Macedonia, I found more ethnic turmoil. This seemed out of tune with the polyglot mélange—Macedonians, Albanians, Turks, Gypsies, Bulgarians, Greeks—I saw mingling and bartering on the winding streets of old Skopje. In this lively bazaar, razor blades and panties from Turkey sell as fast as a smuggler can open his valise, and men in fezzes buy tea to smuggle back to Turkey. In the thick of it all, Macedonians, who form the Slavic majority, and Albanians outwardly get along.

Yet as the birthrate pushes Albanian numbers toward a fourth of Macedonia's population, clashes are increasing.

Bogomil Gjuzel, a poet and repertory director who helped organize the League for Democracy, the first of ten alternative movements in Macedonia, told me, "The Serbs want to colonize not only Kosovo but also Macedonia. Milošević says the Serbs must reclaim land taken from them after World War I and given to Macedonian peasants. But

Worth the struggle, the cheese that Dinko Steponoski and other Macedonian highlanders make from their sheep's milk is a much sought-after delicacy. With their wattle fences and stone farm buildings, the rugged farmers of this mountainous land seem little affected by Yugoslavia's 40 years of socialist planning.

these people have been tilling the land ever since, and nobody's going to take it away."

Sašo Ordanoski, 26, deputy editor of *Mlad Borec*, or *Young Fighter*, a liberal biweekly Macedonian magazine, was optimistic. "If the official newspapers print lies, they know we'll expose them," he said. "We are heading toward free elections. If we can develop a good economy and a good life, we won't need to look around for enemies."

UP IN BELGRADE people worry me worrying about their enemies, but I like the city anyway. Settled for millennia, destroyed many times, like the Serbs it keeps its pride. To me a day in Belgrade is incomplete without a walk through the dark shade of Kalemegdan park's big chestnuts to the ramparts of the mighty fortress overlooking the strategic confluence of the Sava and the Danube. Or a visit to the Skadarlija quarter. Carryout stalls do a big business there. People buy snacks, then stroll or sit on stone walls to munch. Biting meat from wooden skewers, smartly clothed women teeter uphill, their spike heels trembling on the cobblestones.

But politics is never long out of mind. I once told an old Serbian friend, one of the gentlest men I've ever known, about secessionist sentiments I'd heard in Slovenia.

"Let them secede!" he roared. "Tomorrow won't be a minute too soon. We'd rather go it alone. We don't need the Slovenes and Croats. The Serbs have taken enough!"

Across the Sava the towering government buildings and apartments of Novi Beograd (New Belgrade) rise like hackles from reclaimed marshland. Sidewalks exist, but they are usually empty.

Lost in this immensity of pavement and concrete boxes sits the Palace of the Federation, a pile of breathtaking sterility. The president (the position revolves annually among the country's six republics and two provinces) and the prime minister have grand offices at the head of marble staircases. But ceremonial trappings belie their relative impotence. Power resides in the republics.

Seven months ago Prime Minister Ante Marković, a Croat, attacked Yugoslavia's 2,600 percent inflation rate by making the dinar convertible to Western currencies and lopping off four zeros. The million-dinar note shrank to a hundred dinars. At 100,000 dinars to the dollar, the stacks of paper needed for simple transactions had become ridiculous; people were losing their multimillion-dinar shirts.

Marković coolly concentrates on monetary reform while treating human-rights abuses as an irritant. Supporters defend his program as pragmatic: Give people security and maybe they'll calm down; bread will still their cries for circuses. Except for vigorous economic initiatives, the federal government is largely ineffective. Elsewhere in Belgrade, leaders

The Croatian capital of Zagreb bursts with life during rush hour. Centuries of rule by Hungary and the Habsburg empire have lent Yugoslavia's most industrial city a central European air. In the older and larger federal capital of Belgrade, residents take their ease and other pleasures in leafy Kalemegdan park.


KRALJEVO

of the Republic of Serbia hold to their dictum: Kosovo is our own internal affair.

In the Belgrade station I joined passengers traveling not so much with suitcases as with taped bundles, into which they delved for boiled eggs and salami. A woman in a blue scarf gnawed a cold lamb's shank clutched in one hand and wiped the fat from her lips with black bread held in the other.

Twenty bleary-eyed young men were toxic with slivovitz, lurching, shoving one another along, braying lyrics as they piled aboard. As the train pulled out, one lighted a large firecracker and threw it out to explode among waving, laughing friends. A young soldier hung out of a still open door, swinging an enormous black radio as the quickening train bore us southward.

The railroad from Belgrade to Bar on the Adriatic coast negotiates 234 bridges and 254 tunnels in its tortuous 295-mile route. The line is an engineering achievement in which the Yugoslavs justly take pride. Climbing through cornfields and plum orchards to Kolašin, crawling along a sheer wall of Montenegro's Morača gorge, the train descends to Titograd, then crosses the marshy north end of Lake Scutari and a cypress-slashed plain to run along the sea to Bar.

They have built a magnificent railroad only to run a squalid train on it, with little consideration for the passengers. The corridors hold as many people as the compartments. A trip to the *bife*, or buffet car, is more of a climb than a walk, with people sprawled in every space, cigarette smoke streaming from their mouths.

The day I rode the train about 75 men crowded the bife, guzzling and bellowing. Those who found room sat on the floor, littered with wrappers and the remnants of bread and cheese. I squirmed to within shouting distance of the counter, exchanging dinars and beer over other passengers' heads. I retreated to a window to let in some mountain air; the window wouldn't budge. But the bartender opened his and threw out a large box. It sailed across a waterfall, strewing trash.

THE COAST can be the most relaxing or the most nerve-racking section of Yugoslavia, depending on whether you are on a beach or driving to one.

The Adriatic Highway convolutes 643 spectacular miles from the Albanian border to Italy. It affords little margin of error on its lanes, which typically trace the edge of a precipice with no guardrail between one's tires and a long drop into the sea. But it takes one to the walled city of Dubrovnik, a magnificence of glowing white stone, and to storied ports where the Lion of St. Mark carved on gateways recalls the imperial heyday of Venice.

A fanfare for the uninhibited marks founders' day celebrations at Camp Koversada—one of the largest naturist resorts in the world—located on the Istrian Peninsula. Facilities for nude campers or hotel guests dot the entire Adriatic coast. Elsewhere, even traditional beaches can be topless.

I would rather travel the coast on Yugoslavia's excellent ferry service, Jadrolinija, which annually carries 6.3 million passengers and a million vehicles. Its 120 ports of call include places as small as Drvenik, population about 150. The service is punctual, clean, and inexpensive. Without it, many of the Adriatic coast's 66 inhabited islands would be isolated.

One day I boarded a ferry for Hvar. The island's green hills shelter tidy ports with fine Renaissance architecture and a pleasing climate where the Venetian fleet used to winter and repair its ships. Among its blessings, Hvar, like the other islands, is free of ethnic strife. And the dependable sunshine favors *lavanda*—whose oil is used in perfume, aftershave, medicines, and washing powders.

Jakov Dulčić, a lavender farmer, showed me his fields. For centuries peasants had scrabbled away the stones and heaped them into whalelike hillocks to make room for the lavender. The plants were flowering, a purple mist against the green. The afternoon waned. People were riding home on donkeys.

In the nearby village of Brusje, we went to Jakov's *konoba*, or wine cellar. He drew amber wine from a 450-gallon cask and lifted a loaf of goat cheese from a vat of olive oil. In a walled garden Jakov placed the pitcher on a weathered table. Neighbors arrived.

A living museum of 16th- and 17th-century architecture, the walled city of Dubrovnik was for centuries capital of the tiny yet prosperous republic of Ragusa,

self-governing until the 19th century. From the city ramparts, Franciscan nuns enjoy a view of the lovingly preserved old quarter.

Celebrating All Saints' Day, the devout light candles in Zagreb's Mirogoj Cemetery. Croats, along with Slovenes, compose the bulk of Yugoslavia's Roman Catholics. Catholicism is now enjoying a resurgence throughout Yugoslavia, which over the years has provided a more secure climate for religion than most Eastern European states.

"There's an old Brusje tradition," he said. "Nobody pours wine in your glass. You pour what you want. If someone pours it for you, you might not want that much. *Živili!*"

Then everybody started talking about village feasts, open doors, the korzo, the need for everyone to have a boat and *veze*, or connections; you could count on your friends. Love for the old ways poured out—a powerful unifying factor in a society that, with its state-imposed afflictions, could have sunk into sterile, modernistic despair.

The slanting sun played on their faces and the garden wall with a mellow saffron light, and a breeze moving down the hill stirred the roses and geraniums and rustled dry ivy against the stones. Darkness fell. Still they talked. They talked so much they lost interest in pouring wine, and no one went for candles.

I sailed farther out in the Adriatic to Vis, an island that had entered history as Issa, a Greek colony with its own Adriatic outposts. From its beautiful cup-shaped harbor I set out in a downpour to see the cave from which Marshal Tito directed the Resistance in 1944. British and American forces joined the Partisans on Vis, and their collaboration changed history: Attacking and tying down German divisions on the mainland, they helped win Allied victory in southern Europe and international recognition of Tito's leadership.

Munching huge figs I'd plucked at roadside, I climbed a rain-soaked mountain path through rosemary and sage to the fortified entrance to Tito's cave. In his "bedroom" water dripped from many fissures in the limestone ceiling, and the floor was all puddles.

When Tito wanted fighters, he didn't ask where they came from. His system of ethnic balances was explained by a man in Budva: "If consensus didn't work, there was Tito. Now we are left only with consensus, and it doesn't work."

The islands are part of the Republic of Croatia, which is so divided by mountain ranges that it maintains its unity chiefly on the strength of ethnic cohesion. The maritime portion is sun-toasted villages and easy wine. Over the Dinaric Alps lies continental Croatia, with its brisk central European outlook. For long periods Venice ruled the coast, the Habsburg empire the interior, and the differences are still obvious.

ZAGREB, capital of Croatia, is Yugoslavia's economic and industrial leader. With its green parks, baroque 17th- and 18th-century buildings, and imposing boulevards rattling with streetcars, it smacks of yesteryear's Vienna.

Last winter when Croatia announced its first free elections in 50 years, some 30 parties rushed into the fray. As students of Balkan history might have predicted, the most formidable opposition (winning a sweeping victory in this spring's voting) was led by a man who had been imprisoned for Croatian nationalism.

Franjo Tudjman, 68, historian, author, and former Partisan general, ran his campaign out of a one-story wooden building beside Zagreb's railroad tracks. I had to ask in several of the 15 small rooms before I found him.

"My earlier books led to a charge of espionage in 1972," he said. "The judge wanted to

put me in prison for 20 years, but Tito reduced it to two. He knew I was working against Serbian hegemony. Tito forbade all talk of 'Great Serbia,' but now it has become flagrant again. We have to do something about it or get out of Yugoslavia. We aren't *yet* asking for independence. We want to try confederation; only with looser ties can we continue to live in Yugoslavia."

In the mountainous heart of Yugoslavia hundreds of schoolchildren were walking long distances along the highway while their elders herded sheep and cattle. Several families creaked along in heavy wooden wagons, their horses plodding as if each lift of a hoof might be the last. The road climbed through thick forests and along rushing rivers. Every few miles a lamb turning on a spit outside advertised a *gostionica*, or roadhouse.

When I first began to travel in Yugoslavia, I was amazed by the number of unfinished houses. Then I came to accept them along with mosques, minarets, castles, and campaniles as part of the architectural landscape. Some are four stories high, as if their owners hope someday to shelter several generations and tourists too. Construction may go on for years, and many builders, despairing of ever completing them, put up a door and a few windows and move into only one part.

This is called *divlja gradnja* (wild building). Built without permits, officially these homes do not exist. Since the graft to get permits can cost more than materials, people go ahead, undeterred by the lack of streets and utilities. From time to time the police blow up a few of the places. Work soon resumes.

The dark themes expressed in his "Sarajevo Chronicles" and other paintings by Mersad Berber reflect a deep strain of pessimism that also colors much Yugoslav literature. Seen in his Sarajevo studio, the acclaimed artist draws heavily on local Islamic lore for his work. He is one of some four million Yugoslavs who practice Islam, about half of whom live in his native republic, Bosnia and Hercegovina.

NOWADAYS ROMAN CATHOLICS, at least, have a refuge that has little to do with race or politics. Seaward from Sarajevo, up in the scraggy hills not far from the historic town of Mostar, lies the phenomenon called Medjugorje.

A decade ago you'd have been lucky if anyone 20 miles away could have told you how to get there. No hotel bed was to be found in the entire village. Nobody would have sold you a meal, although they might have given you one, figuring you must be lost if you were in Medjugorje.

Then, on June 24, 1981, six teenagers came down from the hill where they had been tending goats. Excitedly they told of seeing the Virgin Mary. She soon promised to deliver ten secrets and other messages.

Word spread rapidly. Snack bars popped up. Local people found corners for extra beds. The establishment frowned and had the visionaries examined by a psychiatrist. The Vatican remained skeptical.

Still the legend grew. Mary continued to appear every day. She said she wanted peace on earth, and wept because she saw so little of it. Now there are 12,000 tourist beds in Medjugorje, where ten times as many taxis line up as you can find at the Belgrade airport.

The trail to the top of Apparition Hill begins beside the Podbrdo Pizzeria. The first 30 yards are lined with shops selling crucifixes, plastic images, and holy portraits on polyester.

The sun was low, so I hurried up the steep trail, past small white goats that nibbled

Used by champions, Elan skis are prepared for shipment at a factory near Slovenia's Austrian border.

At Iskra Telekom near Ljubljana, workers inspect circuit boards for the company's highly competitive communications systems.

Nearly two-thirds of Yugoslavia's industry and most of its exports to the West are produced in Slovenia and Croatia, whose standards of living are highest. Disparities in income between the republics have become a major cause of political contention.

Though struggling to reform, a great many socially owned industries, like Serbia's huge MKS steelworks (left), remain money losers. Launched with an advertising blitz in the U. S. market in 1985, the diminutive Yugo has been an export failure. But it is popular at home, where some 250,000 a year roll off the assembly line at Kragujevac, Serbia, under the gaze of Yugoslavia's "great unifier," President Tito.

Freedom was in the air this spring, when millionaire philosopher Ivan Kramberger stumped the countryside on a platform of Slovenian independence and social welfare. Though he lost his bid for the republic's presidency to communist reformer Milan Kučan, opposition candidates swept the elections in both Slovenia and Croatia.

Aided by other European Greens, fledgling environmental parties in Yugoslavia protest the country's only operating nuclear power plant at Krško.

at the thornbushes. Two boys sat amid the maquis, selling white candles.

Crosses studded the hilltop. The largest rose from a pile of stones on which about 50 candles burned. Black from smoke, and with wax smoldering, the stones looked aflame.

Few stones small enough to carry remain at the site. People were scooping sand into envelopes. A group of Germans stood before the largest cross singing softly, "Maria." As the sun melted behind the mountains and the faraway church towers glowed, 10,000 people were kneeling in worship.

I drove northward into the Alpine heights of Slovenia, the most westernized region in Yugoslavia. The Slovenes recently dropped "Socialist" from their name, to become simply the Republic of Slovenia. And the Slovenian communists decided they couldn't tolerate the federal party and pulled out.

REFRESHINGLY, the most popular plaza in Ljubljana was named for a poet, a sometimes bawdy one. A statue of France Prešeren beams down on Prešeren Square, hard by three interlocked bridges that span the willow-shaded Ljubljanica River. Rustic stalls and bright cafés radiate in all directions.

Amid Ljubljana's air of solid accomplishment few enjoy playing rich uncle to poor relatives in the south. Rudi Tavčar, 31, with the Slovenian Chamber of the Economy, told me why he scorns the national economic system: "With only 8 percent of the population, Slovenia makes 20 percent of Yugoslavia's gross national product and a third of its exports to the West. But we have been forced to turn over to the federation most of the hard currency we earn, with no control over how it is used. We provide 27 percent of the federal budget—just 'floating money down the Sava.' "

Slovenia's bad relations with Serbia came to a head last winter. Riled because Slovenes didn't seem to understand their actions in Kosovo, the Serbs and their brothers in Montenegro organized caravans of thousands to go to Ljubljana and "educate" the Slovenes. The Slovenian leadership, fearing street battles and a coup d'état, set up roadblocks. Serbs then backed down, calling the blockade violent, uncivilized, and "aggression against basic human rights and freedoms." Two Yugoslav republics were behaving like foreign belligerents.

A Serbian boycott against Slovenian companies and products followed with more than 500 orders and contracts canceled. The boycott, harming many companies, proved convenient for others: Serbian firms reneged on 225 million dollars owed to Slovenian manufacturers; Slovenes retaliated by canceling 48 million in unpaid debts to Serbs.

One of the most successful companies in Slovenia is Adria Airways, which has broken the old communist mold and challenged JAT, the national airline. "We have made a profit for 20 years by being better than the competition," said Janez Kocijančič, the president of Adria. Technically his airline is "socially owned," but it operates on a free-enterprise standard of service.

Kocijančič is, remarkably, not only a businessman but also a high-ranking Communist Party official. As Slovenia approached its most important election day ever—Yugoslavia's first free multiparty elections since World War II—Kocijančič explained why his party, which today appears enthusiastically noncommunist, decided to keep its old name, "League of Communists of Slovenia," while adding a mollifier, "Party for Democratic Renewal," and a new slogan, "Europe Now!"

"We didn't want to avoid our responsibility for the past," he said. "We know communism has a bad image today, especially after China's Tiananmen Square massacre, Romania's Timişoara, and incidents here in Yugoslavia, and that it is identified with Stalinism. We don't want people to say we cheated to win."

They didn't cheat, and they didn't win. Voters in April elected a democratic parliament, while awarding the largely ceremonial office of president to a maverick communist, Milan Kučan.

"Yugoslavia today is undemocratic and on the brink of civil war," said Kučan, one of Yugoslavia's most liberal politicians and a man who courageously fostered an atmosphere of freedom in Slovenia. "We are out of line with developments in Europe. We need to join the European Community, but that's impossible as long as the Serbian policy in Kosovo persists. Kosovo is the touchstone that will mark Yugoslavia's readiness to be a modern, progressive, democratic state. Only

Serbian Orthodox clergy, like these monks living along Serbia's Crna River, have proved a resilient lot. During World War II and its aftermath some 700 were killed, and nearly a quarter of their 4,400 churches and monasteries were destroyed. With little outside help the church has made a stubborn comeback.

if we cannot achieve democracy would Slovenia consider secession."

It struck me that many of the people I met in Yugoslavia had spent time in prison for airing their opinions. One circulated a petition asking amnesty for political prisoners and thereby joined their ranks. Another wrote about the long-gone monarchy in such a way that present leaders saw a reflection of their own shortcomings.

Jože Pučnik, chairman of the Democratic Opposition of Slovenia (DEMOS), was jailed seven years for writing psychological literature with a political twist. Returning from 23 years of teaching in West Germany to test the newly opened political process in Slovenia, he soon emerged as leader of a six-party coalition.

"People don't want to hear anything more about communism," he said. "It doesn't work. It isn't compatible with freedom. But this year, after years of stealing from the people, the communists suddenly embraced free elections!"

Pučnik explained the empty shelves in his two-room party headquarters in a run-down apartment building: "We just moved here from a cellar." Yet, from such a humble base, his DEMOS mounted a successful challenge to the tax-supported establishment.

"We are for confederation, the only possibility for Yugoslavia," Pučnik told me a few weeks before DEMOS swept most of the communists out of parliament. "People are afraid of military intervention. If it comes, Yugoslavia is dead! The army can occupy our homes, but they can never make an economy. They can never make a life for us."

ONE OF THE FEW ROADS across the Julian Alps winds upward through a forest of larch and over Vršič Pass at 5,285 feet. I climbed through melting snow, with high peaks all around, to the tiny tavern called Poštarski Dom. I sat outside on a split-log bench and felt the sun on my back. After months of trying to cram a beautiful and bewildering country into small notebooks, I was ready for pensive distance.

I looked across a chasm to pockets of snow on the cliffs. Around me, in sunny spots where knobs of limestone held the heat, patches of short grass had emerged. I listened to the breeze blowing through knee-high conifers. It was glorious up here. I wished such tranquillity could flow down across the plains and span the abyss that divides these troubled but likable peoples.

As I turned to leave, I noticed on a promontory above me a concrete bunker with gun slits. The Italian border was just over the peaks. The South Slavs no longer have to worry about foreigners. Their demons dwell within. As do their hopes. □

A PORTRAIT OF THE MISSOURI

THE PLANT

BOTANICAL GARDEN HUNTERS

By BOYD GIBBONS

Photographs by
JAMES P. BLAIR
BOTH NATIONAL GEOGRAPHIC STAFF

DRIED SPECIMEN OF DICLIPTERA DODSONII (EXTINCT) FROM CENTRAL ECUADOR

Called to the front lines in the war to save tropical rain forests, the Missouri Botanical Garden has grown beyond its four walls to become one of the world's leading research institutions of its kind. Spearheading the garden's efforts in Ecuador, David Neill (left) collects plant specimens from the tops of trees felled by road builders.

WELL BEFORE DAWN Peter Raven walks out the back door of his house in St. Louis and up a path to a low, modern building faced in glass that in daylight reflects the surrounding grounds of the oldest institution of its kind in the United States. For the past 19 years Raven has been director of the Missouri Botanical Garden, which he has transformed into a landscape of exceptional beauty. His alarm at what is happening to tropical rain forests, however, has caused the garden to transcend aesthetics and become one of the world's leading centers for tropical botanical research.

At least two-thirds of all species live in the profuse rain forests of the tropics. Yet, as Raven points out, these forests are being rapidly cleared and burned, extinguishing species and the genes of evolution. This also accelerates climatic warming by loading more carbon dioxide into the atmosphere through burning and by removing trees, which, by photosynthesis, absorb carbon dioxide. In something less than geologic time, the corn belt may become the dust bowl.

Raven leans forward in a loping gait, a tall, somewhat jowly man of 54 in a blue pinstriped suit. He unlocks the entrance door and heads for his office, on occasion startling the bejesus out of some poor graduate student working overnight in the herbarium.

The herbarium, below Raven's office, is a repository of nearly four million specimens of pressed, dried plants, which have been carefully mounted on acid-free paper, labeled, and stored on open shelves in movable orange bins. Among them are collections from Captain James Cook and Charles Darwin. Each year the collection expands by 120,000 more specimens shipped in from around the world. Smelling faintly of dead grass, the herbarium is the botanists' encyclopedia—a palpable record of what grows where on earth and what is rapidly disappearing.

"Think of it," Raven said to me. "All this deforestation is destroying each year an area roughly the size of Illinois. About one-quarter of all biological diversity in the world—more than a million species—will likely vanish in the next quarter century. No extinction episode of this magnitude has occurred during the past 65 million years. The great majority of these species—and their potential for humanity—will disappear unknown. That's one reason we are dedicated to the collection and identification of plants."

One needn't have a lifelong affection for plants to appreciate how our survival depends on photosynthesis, and how much of what we eat is plants, or burgers or chops derived from grass, and that the aspirin we take for headaches originated with willow bark. Roughly 25 percent of all prescription medicines in the United States are derived from plants, including alkaloids from the rosy periwinkle of Madagascar that have arrested childhood leukemia and Hodgkin's disease. As the garden's botanists document what is still growing in the tropics, they are, by no stretch of metaphor, in a profound race against the clock.

DAVID NEILL and Cal Dodson are among ten of the garden's 39 Ph.D. botanists spread across the tropics, living where they collect specimens. In the brilliant light and thin air of the high Andes the two men leave their apartments in Quito, Ecuador (map, page 129). Cal, a world expert on orchids, heads toward the Andean cloud forests. David drives east toward the Oriente, the Ecuadorian portion of the Amazon basin. He studies tropical trees.

David, 37, lanky, russet-bearded, steers down the east face of the Andes in a dilapidated Chevy Suburban, passing torrents of Amazon drainage and cows perched on slopes that would alarm a goat. Six hours later in the humid lowlands, the darkness accented by beeping frogs, we pull up to a small sign reading ESTACION BIOLOGICA JATUN SACHA.

Jatun Sacha—"big forest" in Quechua—consists of a few hundred acres of virgin rain forest that David has helped preserve with his own savings. His research shows that more species of trees may exist in a few dozen acres at Jatun Sacha than in all the United States east of the *(Continued on page 130)*

Nature girl Katie Raven, eight, helps her father, Peter Raven, collect plants on weekends at the family farm outside St. Louis. "Collecting brings out the kid in me too," says Raven, director of the Missouri Botanical Garden, who took up botany at Katie's age and published his first scientific paper at 14.

A

PETER GOLDBLATT

The garden's global mission

"THE VARIETY OF PLANTS in Madagascar is just phenomenal," says botanist Jim Miller (below, at top), who spends half his year in St. Louis and the rest in the rain forest taking inventory for the Missouri Botanical Garden. He cites the tree he's climbing as a good example.

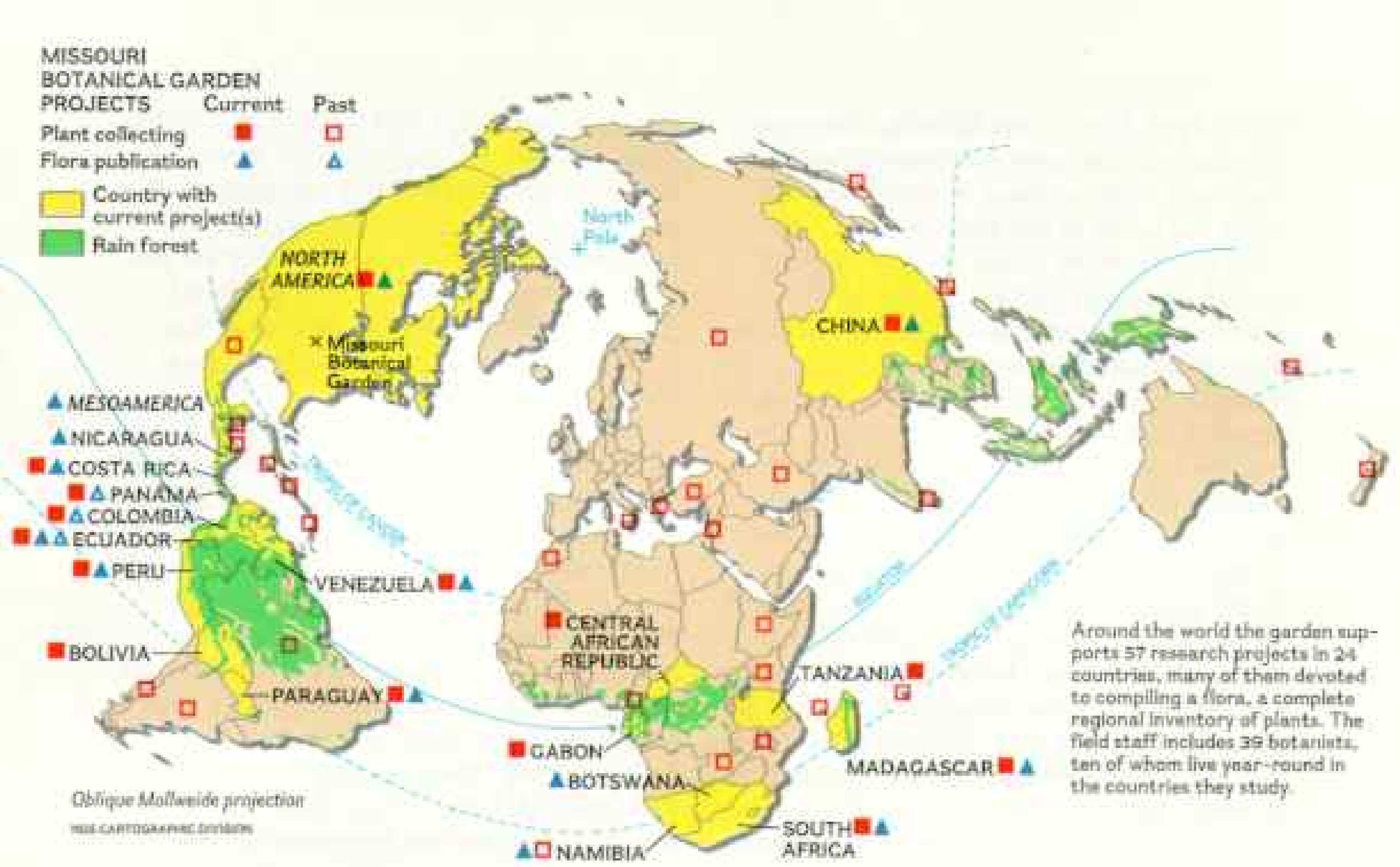
"It's a member of the genus *Symphonia*, which has one species in Latin America and Africa. So far in Madagascar we've found 17 species—including this one, *nectarifera*. We may find 20 more species before we're through."

"That kind of diversity gives our work great urgency," says Peter Raven. "Population on Madagascar will double by the year 2020. Unless something changes, the world will watch as people, in their efforts to survive, destroy the very environment that supports them. The remaining forests of Madagascar will disappear in our lifetime."

Worldwide the situation is not much better. Half of earth's rain forests have already been cleared, and experts predict that most of what's left will be gone

B

C



Around the world the garden supports 57 research projects in 24 countries, many of them devoted to compiling a flora, a complete regional inventory of plants. The field staff includes 39 botanists, ten of whom live year-round in the countries they study.

D KAY YATSKIEVYCH

E BARRY HAMMEL

in 50 years. With them will vanish a quarter of all life-forms—including, perhaps, a plant that could provide a cure for cancer or help end world hunger.

RACING AGAINST THE CLOCK of extinction, the garden's field botanists work with local governments to preserve tracts of rain forest, scour the landscape for unique plant life, and send specimens home to Missouri for identification and further study. Flowing in from tropical field sites around the world, these specimens contribute to the 120,000 received each year.

What follows is a sampling of endangered plants recently collected by garden botanists:

(A) *Moraea neopavonia*, a South African wildflower threatened by wheat farming; (B) *Barringtonia butonica*, a member of the Brazil nut family from Madagascar; (C) blossom of Madagascar's *Symphonia nectarifera* tree; (D) *Iliamna remota*, found only in Virginia, Indiana, and on an island in the Kankakee River in Illinois; (E) *Symbolanthus pulcherrimus*, a member of the gentian family native to Central America; (F) *Gloxinia dodsonii*, discovered in Ecuador by Cal Dodson; (G) *Lindmania holstii*, named for Bruce Holst, who found it on a mesa in Venezuela.

F BRUCE HOLST (BELOW)

G

Mississippi. Here in the Oriente, where oil drilling since the early 1970s has brought roads and settlers, about a third of the rain forest has fallen to the chain saw.

To get into parts of the Oriente he can't reach by canoe or Suburban, David hitches rides in oil-company helicopters. Stuffing his cuttings into plastic bags, he moves on, eventually kneeling in the forest to fold each specimen in a page of newspaper, recording the species, if he knows it, and where and when he collected it. A cluster of grape red flowers goes into the comics of Quito's *El Comercio*.

When the stack is precipitously tipping, David puts it in his plant press—two latticed frames of hardwood cinched with nylon straps. Back at camp he places the cuttings in a tublike plant dryer, lights the kerosene, and dries them for 24 hours. Shipped to St. Louis, they will be labeled and checked by other taxonomists and mounted for storage.

David unloads his gear from the Suburban, heaves a coiled rope and sections of a 42-foot aluminum pruning pole onto his shoulder, and hikes up a forest trail to the station. In a clearing stand four bunkhouses, a kitchen/field office, a caretaker's house, and an outhouse for four (with view). In equatorial Ecuador, days and nights are almost the same length, and the sun goes down early. We eat and go to bed.

The next day we walk into the rain forest—uniformly green, dim, quite passable, the air emphatically still. In the distance a chain saw is groaning. Tripping over a fallen limb, I fall flat on my face, confirming that tropical soils have all the organic cushion of macadam. With no winters to kill insects and with ample heat and humidity to encourage them, organic matter decomposes so quickly that only a thin layer of fallen leaves and twigs covers the soil. The luxuriant forest feeds on itself through fungi, which draw nutrients from this detritus into the roots—a closed

FRANS LANTING

Losing ground in their effort to grow rice, farmers in Madagascar survey erosion on hills cleared of rain forest. Farming further depletes the soil, and in turn new land must be cleared. Slash-and-burn farming destroys 50 acres of rain forest an hour worldwide.

system of nutrition that virtually bypasses the heavily leached soils.

Clear a temperate forest and it comes back quickly. Log a rain forest and the sterile soil becomes hot pavement. Centuries may pass before there is rain forest again. Many species will have vanished forever.

To identify a species, botanists prefer to collect when the plant is in fruit or flower. David assumes the working pose of a tropical botanist: head tilted back, binoculars to his eyes, looking straight up. Flowers and fruit 50 to 100 feet overhead seek light above a canopy of trees. Many tropical plants are epiphytic, meaning they grow on supporting trees, often far out of reach of his pruning pole.

DONATA DEWSNIENE

"We'll find flowers littering the ground," he says. "Then we have to find out where they came from and climb the tree. It can be difficult and scary. Some botanists are really gung ho about climbing trees. Not me."

Ants are profuse in tropical forests and often live in trees. So do wasps. Tom Croat, a garden botanist whose large, scarred hands are proof that botany is no delicate calling, was once climbing a tree in Panama when his nose reached a wasp nest. He kicked his leg spikes free of the bole, intending to rappel down the tree with his safety belt. But his rope snapped, and he fell 75 feet like a stone, crashing against a root buttress. He was able to wiggle his toes. That day he climbed again.

David and his Ecuadorian colleagues are seeking *Minquartia guianensis*, a tree used throughout the Amazon region because it resists rot. Medicine men use its bark to fight intestinal parasites, bronchial disorders, and tuberculosis. Despite the tree's importance, foresters know almost nothing of its natural regeneration and population dynamics. They can't do tree-ring analysis for dating because trees in the tropical rain forest grow year-round and lack rings.

For hours we bushwhack through a study section of Jatun Sacha in search of *Minquartia*, sliding down muddy draws. David turns up only ten. "That's a pretty good average," he says.

In any temperate forest, such as a grove of oaks and hickories in Missouri, you find numerous trees but only a few species. Tropical forests are just the reverse: Individual populations are small and scattered, but the number of different species is enormous. A single tree in Peru harbors as many species of ants as exist in all the British Isles. Within walking distance of their camp, David and his colleagues have identified 1,500 plant species. He believes they are probably only half of what is here.

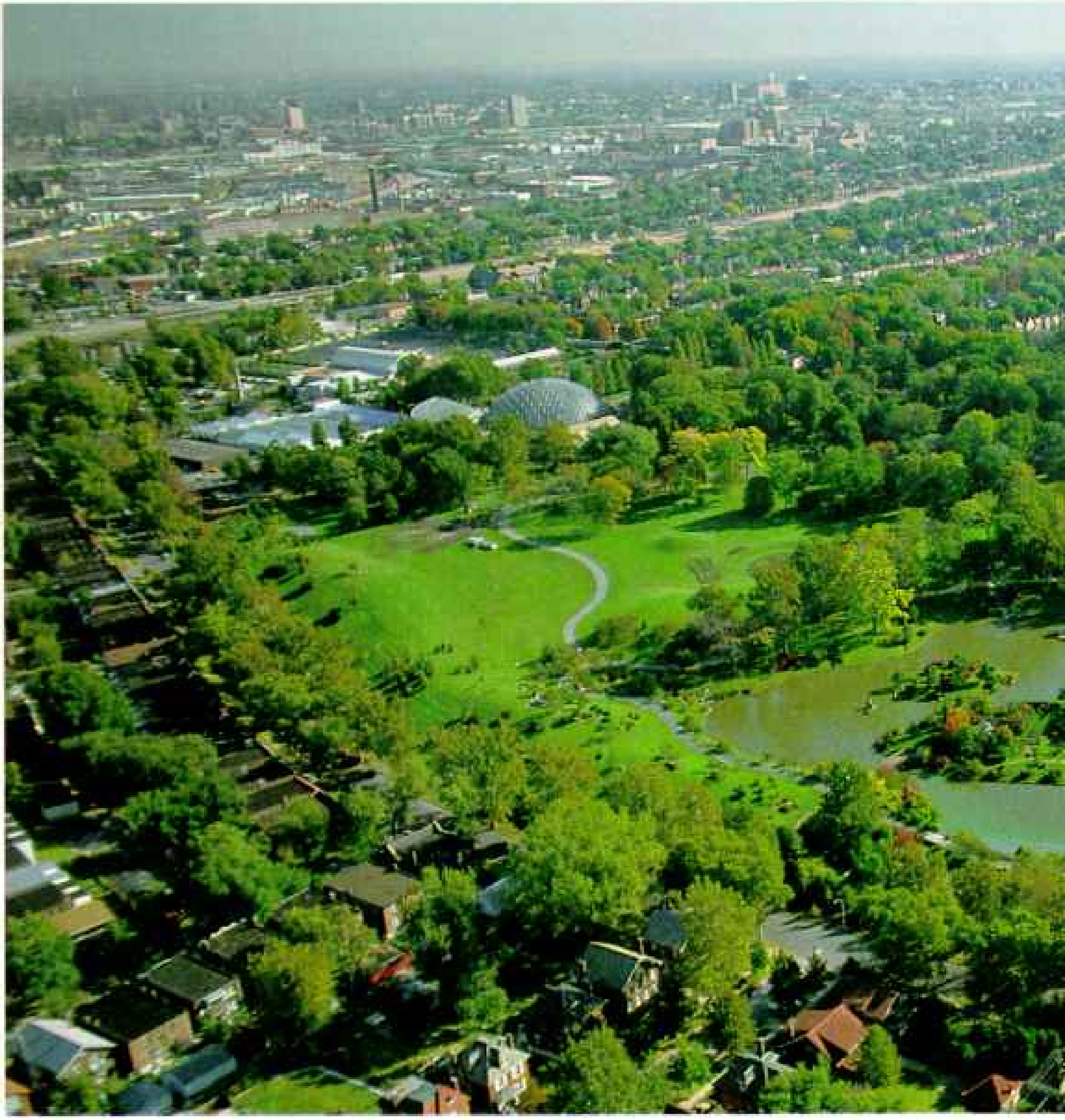
ON THE OTHER SIDE of the Andes, in Ecuador's coastal lowlands, Cal Dodson checks the orchid pots at his farm at Río Palenque. The entire U. S. has no more than 200 species of orchids. Ecuador boasts 2,670 known species, and Cal has collected more than 2,000 of them. He brings specimens to his farm and grows them until they flower, so he can identify the species.

When Cal arrived here in the late 1950s, there was forest everywhere. Since then the population of Ecuador has almost tripled, forcing open the western lowlands to roads and banana and palm-oil plantations.

"It took only about 20 years for western Ecuador to evolve from primeval forest to farmland," he says. "Only 6 percent of the coastal lowland forest is left, and that is rapidly going."

Cal points to a tree behind a storage building. "Río Palenque mahogany—the most prized wood in all western Ecuador, because bugs don't destroy it. And here everything decomposes quickly. It used to be common. Now there are only 12 mature trees left in the world, and they're all on this property."

The Missouri Botanical Garden is one of three institutions collecting tropical plants for the National Cancer Institute in hopes of finding new drugs for treatment. But that's not Cal's motive for being in the tropics. He wants to know what's growing here and how it survives, how it is that the male tachinid fly will mistake a particular orchid flower for a female fly, hop on to mate, and inadvertently pollinate an orchid.



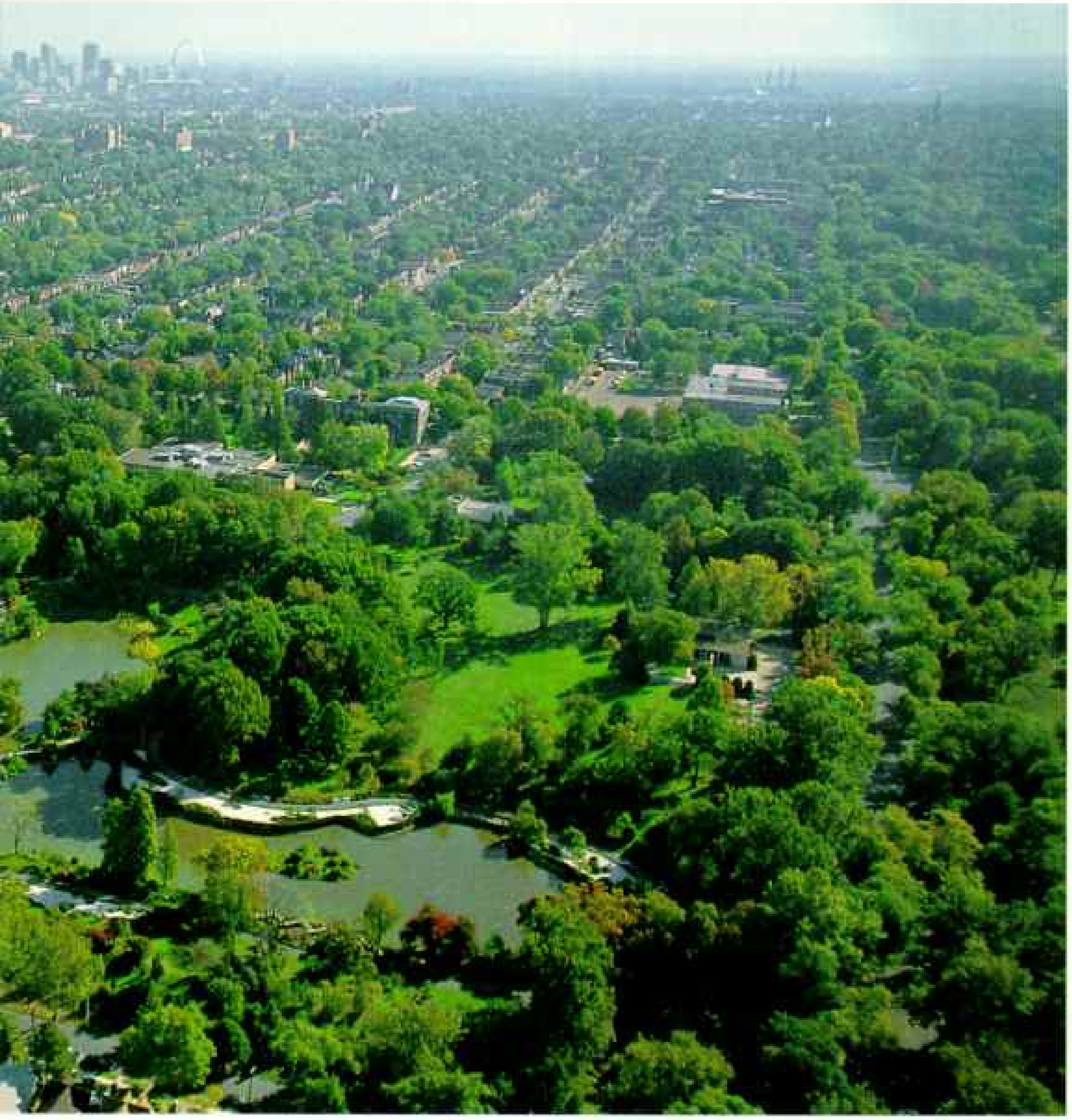
MISSOURI BOTANICAL GARDEN

"I have for many years been engaged in laying out . . . for the use of the public a Botanical garden . . . which should be forever kept up and maintained. . . ."

—HENRY SHAW, 1885

"I suspect that we know a good deal more about the universe than we do about tropical forests. People ask, 'What are you doing down here?' We say, 'We're looking for the cure for cancer.' They say, 'Oh, yeah, that's important.' But the real reason we're here is to learn more about the tropical world."

THE MISSOURI BOTANICAL GARDEN is a few minutes from downtown St. Louis, its 79 acres surrounded by brick houses owned mainly by descendants of the city's German and Irish immigrants. Italians had settled just west of



the garden to mine the clay for this brick that so dominates St. Louis architecture.

Natives are inclined to refer to it as Shaw's Garden. Henry Shaw, who founded it, came to St. Louis in 1819. The 18-year-old Englishman saw in the nearby frontier a market for cutlery and hardware he could ship in from his native Sheffield. Amassing a fortune, he invested in St. Louis real estate. In the 1850s, while visiting the gardens at Chatsworth in England, Shaw was inspired to put his landed wealth to public purpose.

Planning a public botanical garden—the first in the U. S.—on his country estate, he

An oasis of green in the heart of St. Louis, the 79 acres known locally as Shaw's Garden was a treeless prairie when businessman Henry Shaw bought it for his country home. He later added a botanical garden, a museum, and a plant library—all of which he bequeathed to the public.

Today Shaw's gift reaches 800,000 visitors a year, including 100,000 students drawn by the domed Climatron (above, at left) and other educational facilities.

was guided by the eminent botanists Sir William Jackson Hooker of the Royal Botanic Gardens at Kew, England, and Asa Gray of Harvard. But it was the St. Louis physician and botanist George Engelmann who persuaded Shaw to make his garden not just a display but a scientific institution as well.

Shaw endowed the Henry Shaw School of Botany at nearby Washington University, donated land adjacent to the garden to St. Louis for a park, willed the garden to a trust and the bulk of his estate to its maintenance. It wasn't enough. The garden for a time got into the business of selling orchids. By the 1920s, coal smoke from the city became so oppressive that the gardeners couldn't see from one end of the greenhouses to the other. To save the huge orchid collection, they removed it to the arboretum, a large farm purchased farther west.

For years the garden slid into neglect. By the 1950s, as glass was falling out of the greenhouses, a consultant recommended that the garden give up botanical research and turn over its herbarium and fine botanical

Many paths at the garden lead to Seiwa-En, 14 acres of "pure, clear harmony and peace" designed by landscape architect Koichi Kawana along classic Japanese lines (bottom). Equally soothing, perhaps, at the turn of the century was the sight of a lady calmly playing the violin atop a giant water lily.

MISSOURI BOTANICAL GARDEN ARCHIVES

library to Washington University, steps that would have reduced the garden to a historical relic. John Lehmann, a wealthy lawyer, took over the board of trustees, donated $10,000, and began to open up the wallets of St. Louis.

In 1960 the garden finally came out of the doldrums with completion of the Climatron. This geodesic-domed greenhouse displayed some 1,500 species of tropical plants under plexiglass panels suspended from a framework of aluminum tubing. The Climatron was conceived by former director Frits Went, a plant physiologist who had expected its unusual circulation system to create four different climatic zones. The plants themselves defeated the engineering.

"Went had hoped for sharper gradients," Peter Raven told me. "But the Climatron essentially created two zones: warm on the lower end and cooler at the upper end." The plexiglass became so pitted that it reduced the sunlight, and it was eventually replaced with glass. After a multimillion-dollar restoration, the Climatron reopened in March 1990 (pages 136-7).

ON A WARM APRIL DAY Raven walked me around the garden. Redbud trees were in flower, and dogwood, cherry, tulips, pansies, and the aromatic Judd viburnum. A garden volunteer led a group of schoolchildren past us, their noses dusted yellow and black with pollen. "We're pretending we're bees."

We strolled by Shaw's Italianate summer villa, pausing on a bridge over the pond. Raven looked down at the carp assembling in open-mouthed anticipation of bread crumbs and sighed. "Ah, to be a carp in April."

Coming to St. Louis in 1971, Peter Raven expanded the garden and gave it a dramatic face-lift—the English Woodland Garden and the Japanese Garden, a visitors center, sculptures and fountains, and myriad details of taste. His vigorous style of leadership is admired in St. Louis: "Raven has turned a sleepy little botanical garden into a world-class institution. He's got charm, humor—as tight as money is in this city, he can peel thousands of dollars off people."

When one of the garden's fund-raisers

MARK THIESSEN (RIGHT)

Rain forest under glass, the garden's Climatron allows visitors to browse among 1,500 species of plants and interpretive displays like the Fallen Log (above), being positioned by workmen.

expressed his frustration at being stonewalled by a donor, Raven smiled, his mouth a straight line turned up at the corners. "There's no such thing as a permanent no."

A respected scientist on the governing boards of national scientific societies and honored internationally, Raven published the first of more than 300 papers when only 14—on collecting plants in the High Sierra. "I knew that writing scientific papers was important. I began to find my identity by doing that," he said.

Raven was only two when his father took him for the first of many visits to the California Academy of Sciences' Natural History Museum, near his home in San Francisco. "I had the idea of writing very early," he told me. "I spent a lot of time copying things about beetles out of books. By seven or eight I was writing about butterflies and birds." He carted caterpillars around in his red wagon and thought about how they would become butterflies. Then he collected the butterflies.

Soon his interests widened to plants. He would find a plant in flower, fasten it to a piece of notepaper with Scotch tape, and press it between the pages of the telephone directory. His first herbarium was his bureau drawer. "As a boy I went all over by Greyhound bus, collecting plants."

Raven's curiosity continued to widen. His college studies and collecting took him to the Natural History Museum in London, the Royal Botanic Gardens at Kew, Costa Rica,

Reflected grace from an autumn sky bathes the Missouri Botanical Garden during a plant symposium. "This is a special place," says a garden employee. "Kids are always bringing us birds with broken wings. I think it's because people associate us with caring for the earth."

and New Zealand. In Colombia he got his first taste of the tropics and of human misery.

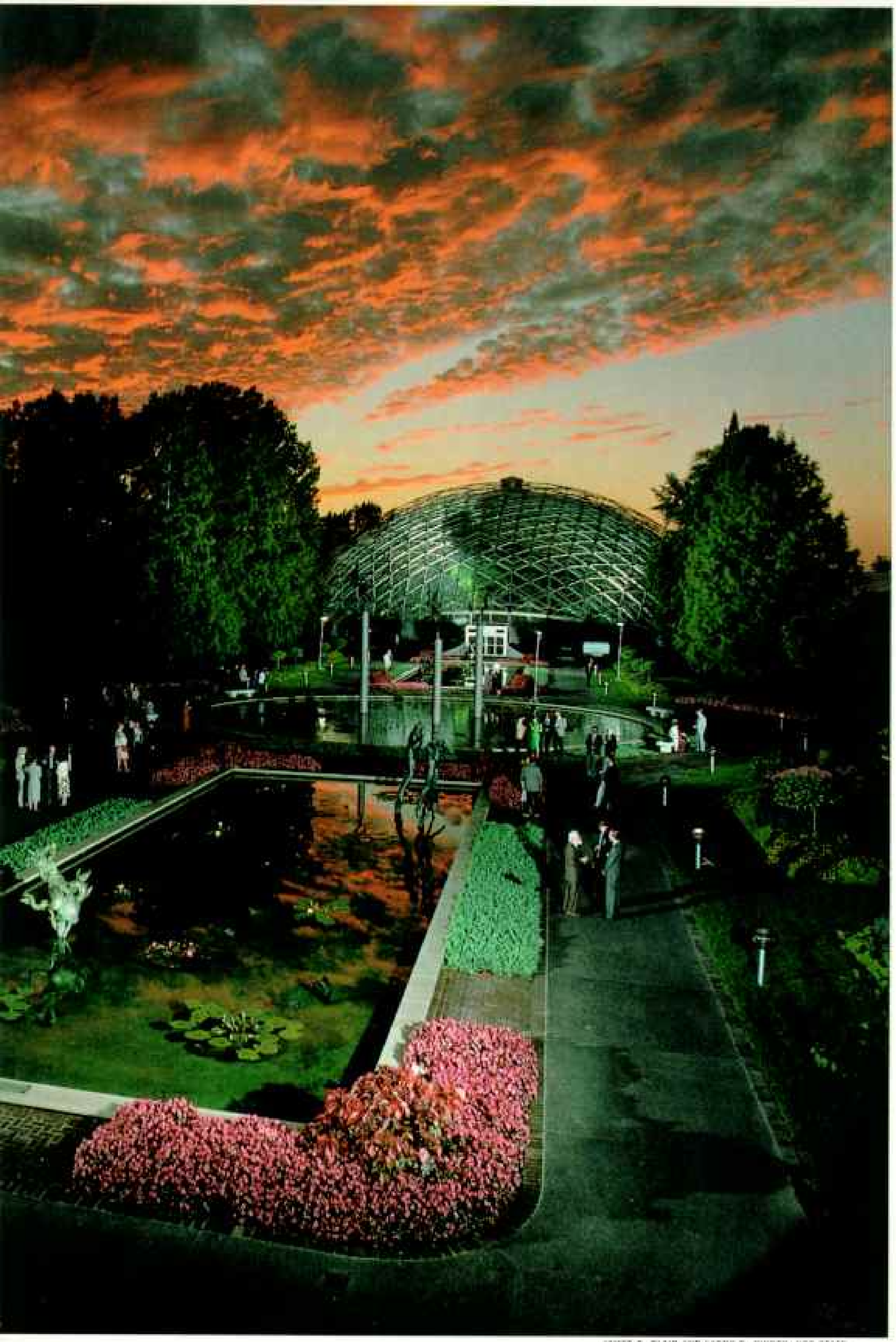
"I saw a lot of poverty—not the stereotypical smiling children. Teaching at Stanford, I became friends with Paul Ehrlich—my office was next to his." Ehrlich and Raven developed the theory of coevolution, how animals, by what they choose to eat, and plants, by the chemicals they produce, influence the other's evolution. "I got very interested in population and in the overuse of world resources."

When Raven came to St. Louis, the garden's research program consisted of only three Ph.D.'s, and its tropical effort was Tom Croat collecting in Panama. Raven hired Al Gentry to go into the Chocó of Colombia, Peter Goldblatt for Africa, and Gerrit Davidse for Central America. He put two botanists in Madagascar, directed by Pete Lowry in Paris, where the National Museum of Natural History has the largest herbarium of Madagascar plants.

The garden now has botanists in the Field Museum of Natural History in Chicago, London's Natural History Museum, and many countries in South America and Africa. "A lot of institutions would have insisted that they be here," Raven said. "But I have always wanted to put people where their work is."

I was in Raven's office one day as his staff tried to make order out of his hectic schedule. He would be speaking the next day at the University of Massachusetts and had scribbled a note to his wife: "Going to Mass. tomorrow." His handwriting admits of interpretation. She telephoned him: "I have this note that says you are going to Mars tomorrow."

IN CHINA botanists have been patiently cataloging their 28,000 known plant species in 120 volumes. Concerned that this would be useful only to those who read Chinese, Peter Raven encouraged the Chinese to collaborate in publishing an abbreviated English version of the *Flora of China*. (The garden is also involved in



JAMES F. BLAIR AND LARRY D. KINSEY, NGS STAFF

Cornerstone of research, the garden's herbarium grew out of a plant collection Henry Shaw amassed during his lifetime. Today it houses nearly four million dried specimens, some of which date from the early 1700s. By comparing new specimens with those already on file, garden botanists can study evolutionary links among plants anywhere on earth.

producing floras of North and Central America, Madagascar, and various countries in South America and Africa.) He brought in a delegation of Chinese botanists and other experts on Asian plants to work out details, the agreement being signed in 1988 in a public ceremony among the garden's lacy trees.

At the ceremony Raven pointed out that 20 percent of China's plants are used in medicine. He held up a chunk of shale containing a 62-million-year-old fossil of a coniferous tree—*Metasequoia*, or dawn redwood—long thought extinct until a forester in the 1940s found some growing near a mountain village in China. Seeds arrived in 1947 at the garden. In the filigreed shade of *Metasequoia*, Raven's voice rose: "We're in an environmental crisis. In the next 25 years one-fourth of the 250,000 plant species of the world will be in danger of extinction."

Raven stirs audiences on the consequences of rain forest destruction. He reminds them that we survive by the ability of plants, algae, and some bacteria to photosynthesize energy from the sun. "We are consuming, diverting, or wasting 40 percent of that production—in large part by deforesting the tropics—and will face enormous difficulties in the future, as world population is expected to double by the middle of the next century."

When Raven speaks, his body swivels from side to side. "The 1.1 billion people who inhabited the tropics and semitropics in 1950 will grow to about five billion people by 2020—more than quadrupling in just 70 years. One billion live in absolute poverty. Each year some 13 million people—mainly children—starve to death in the tropics. It's morally indefensible."

He says that the poor are pressed into clearing forest for firewood and food just to stay alive, while the developed world demands hardwoods, beef, bananas, and other products that tropical countries, deep in a trillion-dollar debt, provide by clearing more forest.

"Rice, wheat, and corn supply more than half of all human energy requirements," he continues. "However, there are maybe tens of thousands of additional plants that could provide human food if their properties were fully explored and they were brought into cultivation. Many of them come to us from the tropics. Oral contraceptives for years were produced from Mexican yams; muscle relaxants come from an Amazonian vine traditionally used to poison darts."

Raven believes that the U. S. and other countries, for charity and self-interest, should help the world's poor to farm cutover lands, replant trees, and save what rain forest is left. He hopes this will happen on Madagascar, which holds about 5 percent of the world's species, some 75 percent found nowhere else. "Unfortunately," he says, "much of the island is now degraded pasture."

With support from the U. S. Agency for International Development, garden botanists are helping the Madagascar government establish a huge national park in what is left of the rain forests in the northeast. They are encouraging neighboring villages to develop plans to reduce pressure on the forests.

Raven wants to show that there are positive alternatives to the ax. As he says, "People won't want to do anything if all you say is, 'Oh, isn't it awful about what's happening to the rain forests?' " □

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FROM THE PRESIDENT

Hands-On High Technology

THE NATIONAL GEOGRAPHIC SOCIETY

"WE'RE TRUCKING IN," said Robert D. Ballard, as seventh grader Jason Williams of Kensington, Maryland, gently piloted the 2,400-pound remotely operated vehicle (ROV)—also named *Jason*—300 feet below the surface of Lake Ontario.

"Twist the joystick left," said Dr. Ballard. "Great. You're really cooking."

As the 13-year-old manipulated the controls, more than 4,000 students in 14 auditoriums across the United States and Canada looked over his shoulder—electronically. Many of them, I know, could almost feel the joystick in their own hands. Others, with the mischief of their age, hoped for nothing less than a spectacular crash.

MARIA STENZEL, NGS STAFF

The future in his grasp, Jason Williams of Kensington, Maryland, prepares to take command of the remotely operated vehicle **Jason** *from more than 300 miles away. The unmanned submersible was taking part in a survey of two American warships that sank in Lake Ontario during the War of 1812. On the video screens above him appears the figurehead of the schooner* **Hamilton.**

Jason Williams, of course, was never in any danger himself. Seated at a console in the Society's Grosvenor Auditorium, he was hundreds of miles from the dark waters of Lake Ontario, where the seven-foot-long ROV was demonstrating the marvels of telecommunication.

And Jason Williams did fine. With each movement of his hand, signals from the joystick were transmitted by the EDS Corporation to a satellite 22,300 miles above the earth's Equator, where they were relayed to a barge on Lake Ontario and then passed along via fiber-optic cable to the ROV.

It was a wonderful example of what Bob Ballard calls "telepresence"—using the immediacy of electronic technology to capture the imaginations of young minds. "Our goal is to pull you into science," he told his far-flung audience. "When science translates itself into the field, it gets very exciting."

For two weeks in May, Ballard, who hosts the weekly National Geographic EXPLORER series on TBS SuperStation, and a team of U. S., Canadian, and British scientists including archaeologist Margaret Rule showed how exciting it could be as they probed the well-preserved remains of two American warships, *Hamilton* and *Scourge*, which sank in a squall on Sunday, August 8, 1813.

It was a tour de force in real-time imaging. As the ROV navigated the lake's murky waters, it utilized three acoustic-imaging systems—side-scan sonar, sector-scanning sonar, and a spot ranger with a laser pointer—as well as two high-resolution video cameras and a 35-mm still camera.

And yet, to my mind, the most striking images of all were the faces of the 34 "junior argonauts" invited aboard the barge to share the adventure. Eighth grader Alicia R. Paul of Columbia, Maryland, and seventh grader Misty L. Cauble of Barboursville, Virginia, represented the National Geographic Society.

If the students' response was any guide—nearly 18,000 of them watched the *Jason* broadcasts from Grosvenor Auditorium—this year's project was an even bigger success than last year's, when the team explored a fourth-century shipwreck in the Mediterranean Sea. Next year Ballard and his colleagues from the Woods Hole Oceanographic Institution will visit the Galápagos Islands.

"Students who join us will get firsthand experience in the excitement of scientific exploration and discovery," Ballard promises. Coming from the man who found the wrecks of R.M.S. *Titanic* and *Bismarck*, that's a pretty safe bet.

Gilbert M. Grosvenor

WILDLIFE AS CANON SEES IT

Nilgiri Langur
Genus: *Presbytis*
Species: *johnii*
Adult size: Head and body length, 51-74cm; tail, 59-97cm
Adult weight: 9.5-13.6kg
Habitat: Evergreen forest and deciduous woodland in the Western Ghats, India
Surviving number: Unknown
Photographed by Gertrud & Helmut Denzau

The Nilgiri langur, a leaf-eating monkey, inhabits remote forests in high hill regions. Despite its endangered status, the langur continues to be hunted for food, as well as for medicinal purposes. A greater threat is posed by deforestation from logging and agriculture. Survival will depend on stricter protection and the designation of additional sanctuaries. To save endangered species, it is essential to protect their habitats and understand the vital role of each species within the earth's ecosystems. Photography, both as a scientific research tool and as a means of communication, can help promote a greater awareness and understanding of the Nilgiri langur and our entire wildlife heritage.

"EXCEPT for the RAW OCTOPUS I really loved NAGOYA."

ANNA CARTER
Newberry, South Carolina

NEWBERRY, SOUTH CAROLINA, is a long way from Nagoya, Japan. But last summer as a guest of the Watanabe family, Anna Carter found the two places were a lot closer than she imagined. "I had an incredible time," she says.

Her Japanese hosts spoke English and were as kind as could be. They sometimes even prepared American style meals just so she wouldn't get homesick.

But after all, the main idea behind the "Summer in Japan" program is to give young people a chance to experience other cultures.

To live the way other people live, strange customs and all.

Japanese meals can be an adventure for anybody. How did they go down with Anna? Tempura was nice. And terivaki's tasty. But as for raw fish, especially sea urchins and octopus, well, the less said the better. "Sometimes I'd have given *anything* for a slice of pizza," she laughs.

There were so many fascinating things about the people and the places she visited, though, that she is eager to go back.

"For someone who'd never been outside the U.S., it has really opened my eyes. I made lots of friends, and I'd love to see them again."

Toyota wholeheartedly supports the "Summer in Japan" scholarship program.

Administered by the Youth For Understanding International Exchange, its aim is to help American kids better understand Japanese culture. A companion program brings Japanese kids here. And in so doing, helps foster close friendship between the two countries.

Since 1975, more than 200 Toyota Scholarship students have taken the trip across the Pacific.

The way we see it, nothing broadens the mind more than getting a little taste of the way other people do things.

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INVESTING IN THE INDIVIDUAL

AUGUST 1990

GEOGRAPHICA

NATIONAL GEOGRAPHIC MAGAZINE

MICHAEL NICHOLS, MAGNUM

Jane Goodall at Gombe: a 30th Anniversary

Thirty years after she first set foot in Gombe Stream Game Reserve to begin a field study of chimpanzees, Jane Goodall's enthusiasm for fieldwork continues unabated.

"Gombe is where I like to be—best of any place in the world," she says.

Since that first field trip in July 1960, much has changed. The reserve is now a Tanzanian national park. Jane Goodall—invariably described in early reports as "the lithe, blonde English girl" inspired by Louis Leakey to live with wild chimpanzees—has become Dr. Goodall, eminent scientist, founder of the Gombe Stream Research Centre, and advocate of chimp welfare. Largely through her efforts the public has become aware of the destruction of chimp habitat and their often inhumane treatment in zoos and research laboratories.

Supported almost from the outset by the National Geographic Society, Goodall says she would rather just be "sitting in the forest with the chimps," but would feel guilty doing so given the problems they face.

Heading the list is the destruction of chimpanzee habitat, "the same sad story as the destruction of forests everywhere." The Committee for Conservation and Care of Chimpanzees, which she and scientific colleagues founded, is pinpointing locations where chimps need help to survive. And Goodall is working with African nations to establish sanctuaries and create agro-forestry programs that would enable Africans to earn a living without destroying chimp territory.

The Jane Goodall Institutes in the United States, Great Britain, and Canada are focusing on education, "to increase public awareness of chimps and why they matter," Goodall explains. "Because chimps are so like us, they are a bridge between man and animal."

She becomes most animated when talking about fieldwork. The researcher who first documented tool manufacture and use by chimpanzees is still thrilled by new discoveries at Gombe—a chimp birth filmed for the first time, the surprise adoption by an adolescent male of an unrelated orphan, or insights in her specialty: family relationships. "They are endlessly fascinating," she says.

Helping Youngsters Understand Geography

The ideas are simple: Create a map for children to find treasures in the backyard. Treat your children to ethnic snacks at a folk festival. Help children understand why their home has an eating area and a sleeping area.

The point of these exercises is explained by the booklet "Helping Your Child Learn Geography." Prepared by the Office of Educational Research and Improvement of the U. S. Department of Education, it is designed to help parents interest children under the age of ten in geography and to teach basics: location, what makes a place special, patterns of movement, relationships among people and places, how and why regions are formed.

"We care about kids learning geography," says Sharon Kinney Horn, the office's director of information services. "Many parents care too, but often they don't have information in a form they can use." The booklet can be purchased for 50 cents by writing to Geography, Consumer Information Center, Pueblo, CO 81009.

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RANDY BRANDON, ALYESKA PIPELINE SERVICE CO

Pipeline Is Corroded, Alaska Oil Still Flows

Corrosion has damaged underground sections of the trans-Alaska pipeline (GEOGRAPHIC, November 1976) and will require extensive repairs over the next three to five years. But the daily flow of 1.8 million barrels of North Slope Oil from Prudhoe Bay to Valdez—one-quarter of domestic production—will not be seriously interrupted, industry and government experts say.

The rust is believed to stem from the failure of a layer of epoxy to bond properly with the steel pipe or the moisture-proof tape wrapped around it. The damage was detected and then measured by ultrasonic testing equipment (above). More than 800 anomalies—areas where the half-inch thickness of the pipe had been reduced by at least 10 percent—were found. In 1989 workers dug up 305 sections; 32 needed repair, in the form of sandblasting the pipe, welding on a reinforcing steel sleeve, applying a new and improved epoxy coating, and rewrapping with waterproof tape.

The most significant damage was discovered in an 8.5-mile section of underground pipe in the Atigun River region of the Brooks Range, about 160 miles south of Prudhoe Bay. The section will be completely replaced in 1991. The pipeline must be shut down for about two days while new concrete-coated pipe is spliced into the main line.

All the corrosion has occurred on the pipe's exterior, and only on underground portions. About half of the 800-mile pipeline is carried on stilts above ground. The eight-billion-dollar line began operating in 1977. Repair costs are estimated at between 600 million and more than a billion dollars.

A Monarch Butterfly Population Explosion

In mid-August every year, monarch butterflies in eastern North America begin to pack up and head south for the winter. Eventually they arrive in Mexico in such numbers that they turn the trees and hillsides orange. But the monarchs that begin making the trip this month will have quite a challenge if they are to top last year's migration. It was one of the biggest.

Fred Urquhart, a Canadian scientist who has been studying monarchs since 1937 and who described the discovery of their winter haven in the August 1976 NATIONAL GEOGRAPHIC, says that the population boom was caused by 1989's unusually warm early summer weather. Caterpillars turn into butterflies quicker in warm weather, and the result was an extra generation of monarchs, explains Urquhart, whose research was supported for many years by the National Geographic Society.

It is impossible to estimate numbers since there are so many. But Urquhart says that when the butterflies arrived last year at the 12 Mexican sites now known to be their winter home grounds, they roosted on more trees than usual, and there were more monarchs per tree.

It's a "Lousy" Job, but Science Has to Do It

Death and taxes aren't the only inevitabilities. So are head lice.

Joseph Zias, an Israeli anthropologist, saw a photograph (GEOGRAPHIC, February 1985) of a head louse found in the intestines of a Greenland Eskimo mummified 500 years ago. He and Kosta Y. Mumcuoglu, a medical entomologist, began examining human hair from archaeological sites in Israel for signs of lice. Early results were negative, but when they looked at combs found there, the picture changed. "Right off the bat, the combs turned up positive," says Zias.

The pair have now found the remains of lice or their eggs from a dozen sites, ranging in age from 9,000 years ago to about A.D. 800. They hope to recover human blood from inside one of the lice. "With it," says Zias, "molecular biologists may be able to replicate the genetic material of someone bitten by a louse."

The scientists are impressed by the combs—mostly made of boxwood but some of ivory or bone—used thousands of years ago to get rid of lice. "They probably were more effective than many modern combs," Mumcuoglu says. One comb (bottom) held the remains of four lice and 86 eggs.

MICHI KAJI-AOI

In an Empty Region, a Series of Surprises

The Kimberley region is a vast, empty area in the northeast corner of Western Australia. Only 23,400 people live within its 420,000 square kilometers. A 2,000-kilometer-long stretch of coast between two of the region's principal towns is almost entirely unpopulated.

CLAY BRYCE

Small wonder, then, that scientists have known little about the invertebrate inhabitants of the region until recently. When Fred E. Wells of the Western Australian Museum led a scientific team into the Kimberley to find out what kinds of snails, crabs, and worms live on and around more than 80 islands off the coast, he expected some surprises. But they weren't all of the sort he envisioned.

The team, supported in part by the Society, found four new genera and 48 new species of land snails, plus at least six new species of marine worms. In addition, they uncovered evidence that creatures known to live elsewhere, such as an octopus (above), also inhabit the Kimberley.

But, unexpectedly, the group also unearthed two Aboriginal burial sites. One contained a bark package of human bones coated in red ocher and rubbed with kangaroo fat.

Finally, the scientists found that many of the islands have never been officially named. They have some suggestions and hope that about 40 islands will now bear names for the first time.

The numbers outside.

Osprey Populations Soar to Old Heights

When Roger Tory Peterson wrote about ospreys in the July 1969 GEOGRAPHIC, many populations in the United States were on the brink of disaster. Now ospreys have become, in the words of one scientist, "good-news birds." They are back and thriving, even trendy.

What first alarmed Peterson was that osprey reproduction rates were dropping very rapidly in New England. He suspected that the birds were consuming DDT and similar chemicals, resulting in eggshells too thin to protect unborn chicks. At the time, the role of pesticides in causing environmental woes was largely unknown.

DDT with other chemicals is now banned in the U.S., and ospreys have bounced back. Alan Poole, author of a book about the birds, says that northeastern populations are growing at an annual rate of 10 to 15 percent; western populations are growing too, though more slowly. Other osprey watchers agree, including Michael L. Smith, who has photographed the bird in Maryland for 17 years (above and right). The U.S. now contains between 6,000 and 8,000 active osprey nests, Poole says.

Many nests are on platforms built by people who have discovered that ospreys adapt to suburban backyards. "Are the birds trendy?" asks Poole. "Absolutely. And these platforms are the ultimate birdhouse, increasing the chances of osprey survival."

MICHAEL L. SMITH

Wildlife Reserve on the Tibetan Plateau

The isolated, unpopulated northwest corner of the Tibetan Plateau is a high and dry world that is virtually the same today as it was a hundred years ago. If the Chinese government and George Schaller are successful, it will stay that way.

Schaller, the prominent wildlife biologist who has written NATIONAL GEOGRAPHIC articles on snow leopards, lions, and giant pandas, has been studying the Tibetan Plateau with Chinese scientists for several years to discover which areas are most in need of preservation (bottom left). They have found that the crucial part of the Tibet Autonomous Region is a Colorado-size chunk of land, at an average altitude of 15,000 feet, whose 100,000 square miles are home to the wild yak, a big-horned sheep called the argali, and the Tibetan antelope, gazelle, wild ass, and brown bear.

"There are many populations of elephants here and there in Africa and Asia. They're all threatened, but if you lose one, you have others," Schaller says. "This is the last stronghold on earth for these Tibetan animals."

Schaller and the Chinese government have signed a letter of intent to turn the area into a reserve. Only herdsmen who traditionally graze livestock on the edge of the area would be allowed to hunt there. And development would be minimal. "It's like the U.S. when the railroad went across; buffalo were wiped out in 15 years," Schaller says. "A few dirt roads, and the animals here would be wiped out as they were elsewhere on the plateau."

GEORGE B. SCHALLER

Suggestions for GEOGRAPHICA may be submitted to Boris Weintraub, National Geographic Magazine, Box 37357, Washington, D.C. 20036, and should include the sender's address and telephone number.

The computer inside.

Since buying a computer today is such a numbers game, here's a simple rule of thumb. Look for 386™ SX, 386™ or 486™ on the outside to be certain that you have Intel technology on the inside. From the company that invented the microprocessor. The company that has shipped over 10 million 32-bit processors. The same company that's investing over $1 billion this year to make sure the computer inside your computer has the technology, power and compatibility to take you into the future.

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FORUM

Antarctica

Thank you for showing us beautiful photographs of our last continent (April) and for including reports of such environmental disasters as the Argentine supply ship run aground. I'm all for scientific research, but leave the resources alone.

MICHAEL J. KRONE, JR.
Fort Leavenworth, Kansas

I noted on page 18 that Buckminster Fuller's geodesic dome is still the most practical way to shelter scientists in Antarctica.

JAMES A. GRIMES
West Palm Beach, Florida

The carcass on page 21 is not a dog but a pony. Scott did not take dogs to Antarctica but relied on tractive power from man and ponies. The difference in speed between his team and Amundsen's spelled Scott's failure.

W. R. OSBORN
Maple Valley, Washington

It is a dog from Shackleton's 1915 expedition. Scott himself used dogs to lay supply depots along his proposed route; he took ponies for the final leg of his journey.

On pages 46-7 you show Japanese taking minke whales, "which can be legally taken only for research purposes." Please clarify for your more naive readers. The Japanese are exploiting a loophole in International Whaling Commission regulations.

STEVEN M. BUC
Germantown, Maryland

You are correct. For more information see our December 1988 article on whales.

Although Bellingshausen was one of the first to see Antarctica, the renowned Captain Cook probably saw it nearly half a century earlier. Cook circumnavigated the entire southern continent; he definitely saw many of the islands, and quite possibly the mainland. Ironically his revelations led to Antarctica's earliest ecological disasters. After he and his crew reported sighting vast numbers of whales and seals, extensive overhunting began in the area. Sadly, the story of Antarctica's earliest exploration is also a tale of its earliest exploitation.

DANA DENNISTON
Lexington, Kentucky

As one of the "party of cross-country skiers" at the South Pole, I take exception to Bryan Hodgson's judgment that we skied the 50-plus days "just for fun." Each of us had his own reasons. Patriotism and exploration were involved, and scientific and medical studies were made along the way. Each of us incurred great expense, trained very hard, and dealt with many hardships. No one had ever covered our route before. I would hope that in these days of high-profile, multimillion-dollar expeditions there is still room for individual efforts to be of value. Incidentally, another team member and I returned to the ice in January and skied out from the Pole to the Ross Ice Shelf.

JERRY CORR
East Lansing, Michigan

Berlin Wall

As a proud member for 50 years, I have noticed the many changes made to the magazine. Some of them I haven't liked, but the overwhelming majority have been great improvements. "Berlin's Ode to Joy," by Priit J. Vesilind (April), is an extraordinary piece of writing. Please keep up your high standards. I'll be interested to see what you do in the next 50 years.

KENNETH F. PLUMB
Vienna, Virginia

For the German people the fall of the Wall was the greatest moment since 1945, because nobody wanted to live in two different Germanys. That was only the will of the four conquerors of World War II. Now we have the chance for reunification and to stay at peace in one nation.

HEIKO HOEWERT
Hamburg, West Germany

As one of the few Americans at Brandenberg Gate on New Year's Eve, I saw, felt, and even tasted—from a communal bottle of German white wine freely passed among the revelers—the strong nationalistic desire for *Ein Berlin, Ein Deutschland*. Since we helped to divide Germany, I hope we help to reunite Germany.

WILLIAM D. CURRAN II
South Holland, Illinois

On page 117 you say that women offering flowers were West German. The truth is that flower exporters from Aalsmeer in the Netherlands sent trucks with flowers to West Berlin; the bouquets were handed out by Dutch girls in folk dress.

ROBERT E. TAMMERYN
Blaricum, Netherlands

November 9 was in my life the most beautiful day. My wife and I saw again our daughter Ulrike at Berlin's Invalidenstrasse; the picture on page 117 shows my daughter and me. She fled East Germany in August 1989 over the Hungarian border, and now she studies at the Free University in West

THE TERMINALLY ILL NEED LOVE, SUPPORT AND THE ONE THING THEIR FAMILIES CAN'T ALWAYS GIVE THEM.

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The "Living Needs Benefit."

ThePrudential

Berlin. We saw the terrible communist system collapse. We had thought we would not see our child again for ten years. We were not allowed to travel. But now after 28 years we can again see the western part of our capital. So we wept for joy.

JOACHIM KRAUSE
East Berlin, East Germany

I recall in November 1989 many East German refugees in Czechoslovakia. Then change came like a thunderbolt—the Berlin Wall was broken down. I asked myself, when is it Czechoslovakia's turn? Later that month, I saw it happen in my fatherland. It was incredible for me! I am ecstatic. I wish the people of East Europe wanted not only the West's material life but also its spiritual life. As a teacher I would prefer that.

JAROSLAV VÁVRA
Semily, Czechoslovakia

Japanese Women

Deborah Fallows shows us the typical life-style and way of thinking of Japanese women. Her article in the April issue is correct in every particular and contains keys to understanding the structure of Japanese society. I'm a Japanese woman doctor in my 30s. I'll go back to Japan next year. Now anyone who reads the article will realize a case like me is really an exception in Japan.

MISAO NAKAZAWA
Overland Park, Kansas

When my Japanese roommate and I graduated from college, I had no idea that the pressures awaiting her in her homeland would be the opposite of what I would face in America. I am thankful for the variety of career opportunities here. But I think we could learn from the Japanese that the raising of our children is, in itself, a worthy pursuit.

NANCY PETRILLO
Houghton, New York

Your correspondent's assessment that "Western concepts of romance play little or no part in Japanese marriage" applies only to the thin veneer of wealthy city dwellers and landowning rural people, not to the propertyless majority in the cities. There, compatibility and mutual acceptance based on love and respect are the criteria, at least among the many Japanese I have known in almost half a century of life in Tokyo.

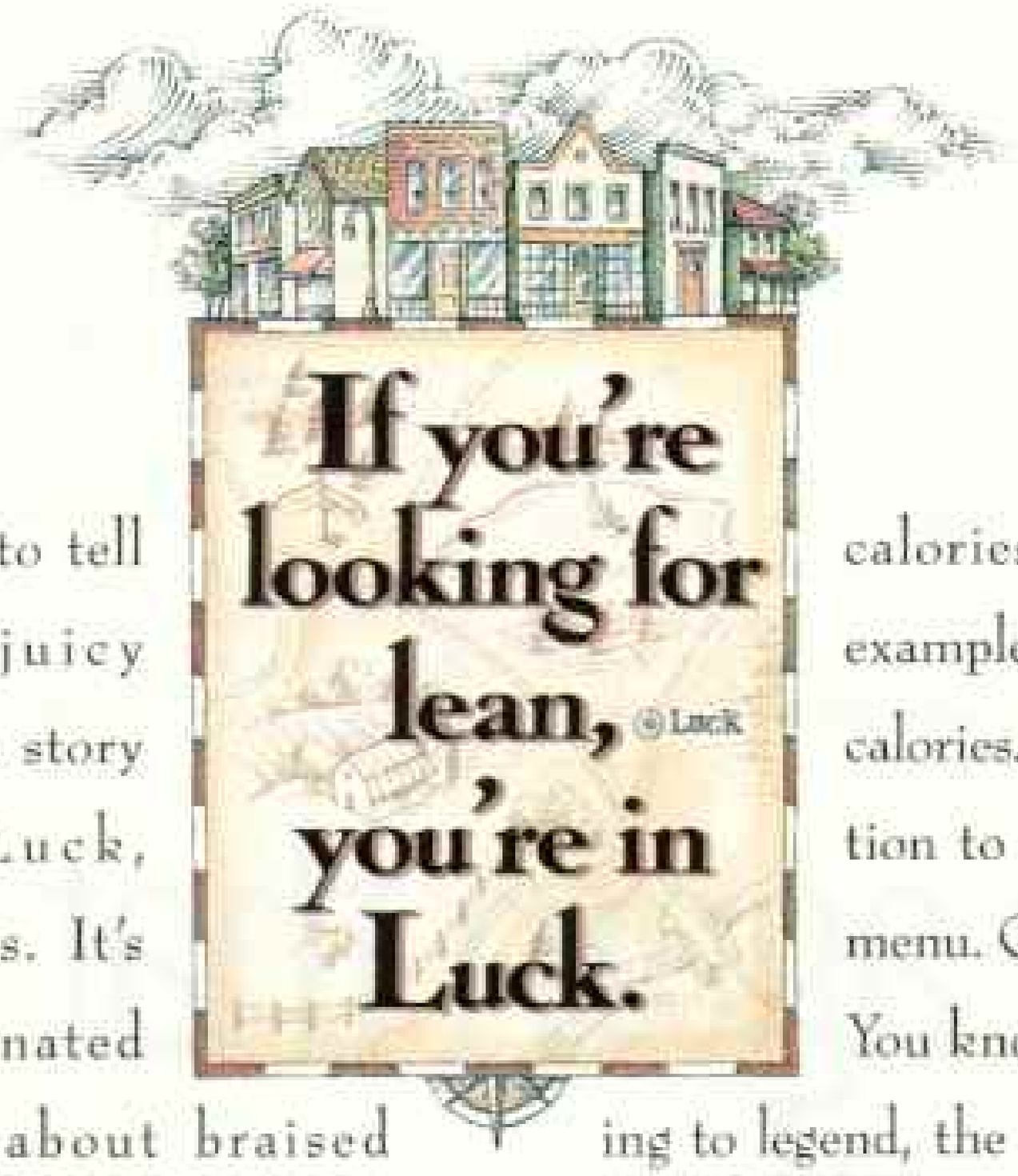
RUDOLF VOLL
Kowloon, Hong Kong

Vanishing Wildlife: A Personal Vision

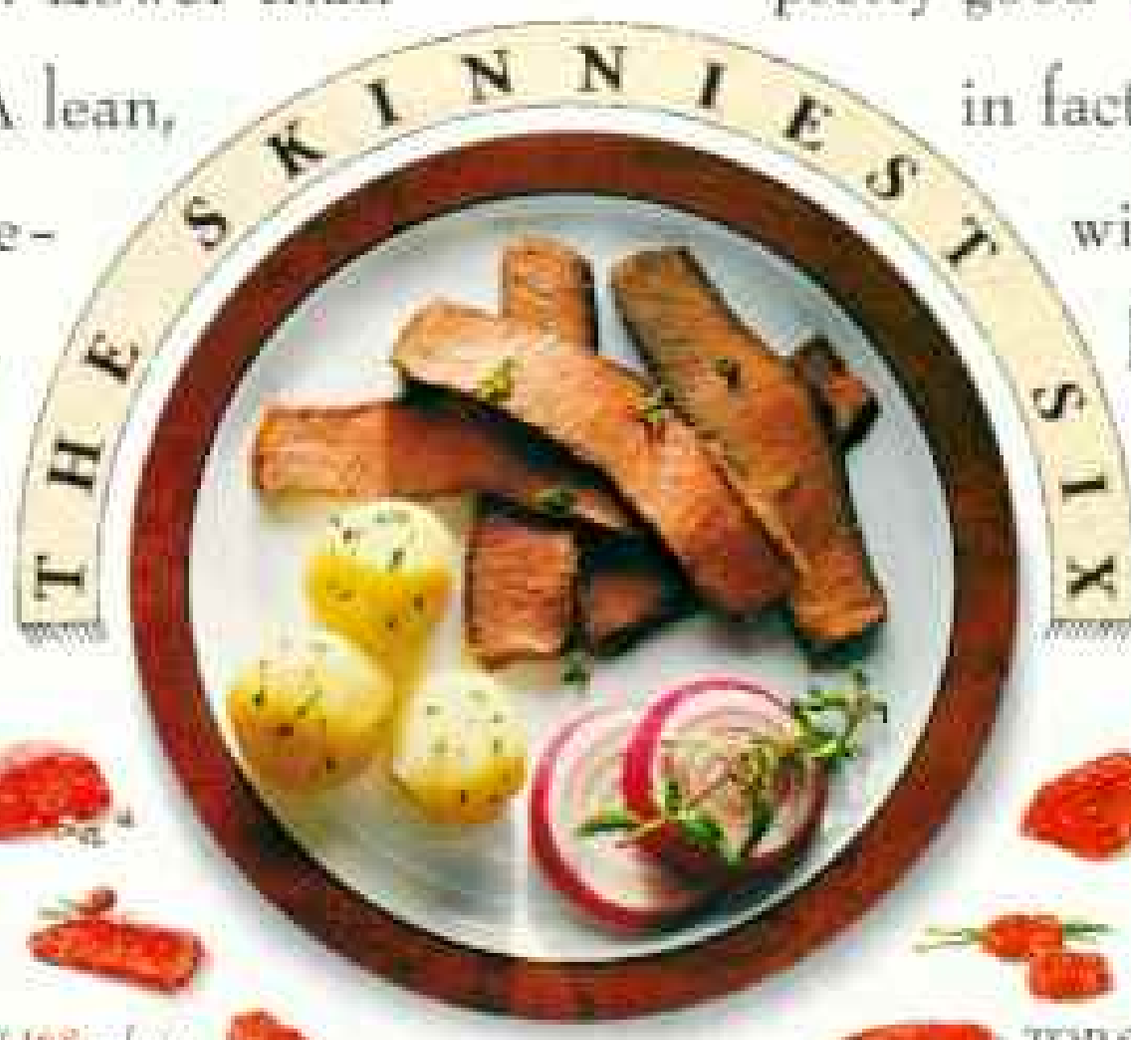
James Balog's photographs are extraordinary (April). He captured the unnatural circumscribed world these animals are engulfed in.

LISA A. SITKO
Trenton, New Jersey

The animals meticulously posed are endangered, but they are also captive. Their innate beauty and dignity have already been exploited by the performing theaters, zoos, and aquariums that "own"



I'd like to tell you a juicy story. A story everyone in Luck, Wisconsin knows. It's about herb marinated beef steak. It's about braised steak provençal and broiled steaks with company potatoes. But most of all, it's about good fortune. Because many cuts of beef are surprisingly low in calories. Lower than most people think. A lean, trimmed three-ounce serving averages less than 200 calories. Round tip, for example, hardly tops 149 calories. That's an inspiration to anyone holding a menu. Or following a diet. You know, according to legend, the town of Luck was named by Dan Smith, an early logger. Having faced much adversity in life, he solved the problem by always being "in Luck." Today, our luck is still pretty good —delicious, in fact. Where would we be without beef? Out of luck, I'd say. See you in the next town.



ROUND TIP 149 *calories*
5.0 gms total fat (1.8 gms sat. fat)*

TOP ROUND 169 *calories*
4.3 gms total fat (1.5 gms sat. fat)*

TOP LOIN 168 *calories*
7.1 gms total fat (2.7 gms sat. fat)*

EYE OF ROUND 141 *calories*
4.0 gms total fat (1.5 gms sat. fat)*

TENDERLOIN 178 *calories*
8.1 gms total fat (3.0 gms sat. fat)*

TOP SIRLOIN 162 *calories*
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them. Mr. Balog has exploited them further. In creating fashion-photography poses and draping the animals in scrims of chiffon, he is demanding that they further entertain the absurd sensibilities of man. No matter how striking the image created, it cannot match the magnitude of a wild animal.

JANICE STAGNITTO
Hoboken, New Jersey

It's as if we are given a glimpse into the future, only to see the ghosts of these wonderful creatures. Have we written them off already?

MARC KRIEGER
Bradford, New Hampshire

The poses were humiliating and unnatural. The images made me both sad and angry. Then I realized that Balog's work had evoked just the response that he intended.

KAREN YACOS
Underhill, Vermont

Animals stripped of their habitat in a studio setting made me concentrate on their individual beauty in a way I'll never experience again. I got the feeling many of them sensed it may have been their last sitting. Congratulations on a well-done piece.

RON MONTI
Baltimore, Maryland

I am a high school senior. For the past year I have been monitoring environmental issues—listening to political debates, watching Society programs, reading articles and reports. When I see how man treats the earth, I become very frustrated. All the signs tell us to stop and fix our mistakes, but we do not heed. I hope to find in some future issue a comeback story—"A Hope of Life for the Wild."

DANNY WEISS
West Bloomfield, Michigan

Geographica

Regarding the item "Granny Is Reburied, This Time With Dignity," in the April issue, I wonder why many Native Americans are denied this basic show of respect. In archaeology the subject of reburial is hotly debated. Lately many states have required the return of some skeletal remains to tribes that could prove a relationship, but it is difficult to prove. Thus, remains stay on museum and university storeroom shelves.

I realize the importance of archaeological research in establishing knowledge of prehistory, but as a Comanche/Kiowa I would hope that archaeologists would show my ancestors the respect they showed "Granny" by giving Native Americans the dignified treatment all humans deserve.

OSCAR T. CODOPONY
Binger, Oklahoma

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

Forum

Jerome BENDER & TURNER

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NATIONAL GEOGRAPHIC MAGAZINE

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FROM THE EDITOR

Epilogue to a Space Odyssey

WITH THIS ISSUE we say farewell to two of the most celebrated instruments in the history of exploration—the plutonium-powered space probes Voyager 1 and Voyager 2, which for 12 years mapped, imaged, and analyzed the giant planets of our outer solar system and their moons. The two spacecraft have transmitted more than 57,000 portraits of our celestial neighbors back to the Jet Propulsion Laboratory in Pasadena, California, furnishing scientists with enough raw data on the solar system to keep them busy well into the next century.

Last summer in a spectacular flyby of far-distant Neptune, Voyager 2 transmitted a final series of priceless images. NATIONAL GEOGRAPHIC presents a selection of images from the entire mission, some of them additionally enhanced and corrected, in an incomparable final chapter of the Voyager space album.

Articles by Assistant Editor Rick Gore and imaging team leader Brad Smith on pages 35 and 48 tell the story of the Voyager project and its final transmissions. Though their cameras are now shut down, their mission complete, both spacecraft will take another 60,000 years to leave the outer limits of our solar system, the so-called Oort cloud of comets.

As our world bids Voyagers 1 and 2 farewell, it welcomes an equally spectacular space explorer, the Hubble Space Telescope, which began orbiting Earth last April, following its launch by the space shuttle *Discovery*. Though it will remain far closer to home than the Voyagers—a mere 380 miles out—the 12.5-ton telescope will peer into the far reaches of space with incredible precision. From its vantage above Earth's obscuring atmosphere the Hubble could detect the light from an ordinary two-cell flashlight a quarter of a million miles away or read the face of a nickel six miles away.

To train the Hubble telescope precisely on its distant targets, a list of more than 15 million guide stars was compiled—a project funded in part by your Society. In future issues we will report on the Hubble's discoveries and present some of the images it sends back to Earth. Like those of the Voyagers, they promise to be breathtaking.

Wilbur Garrett

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"The Snowy Owl"
Actual diameter: 8½ inches
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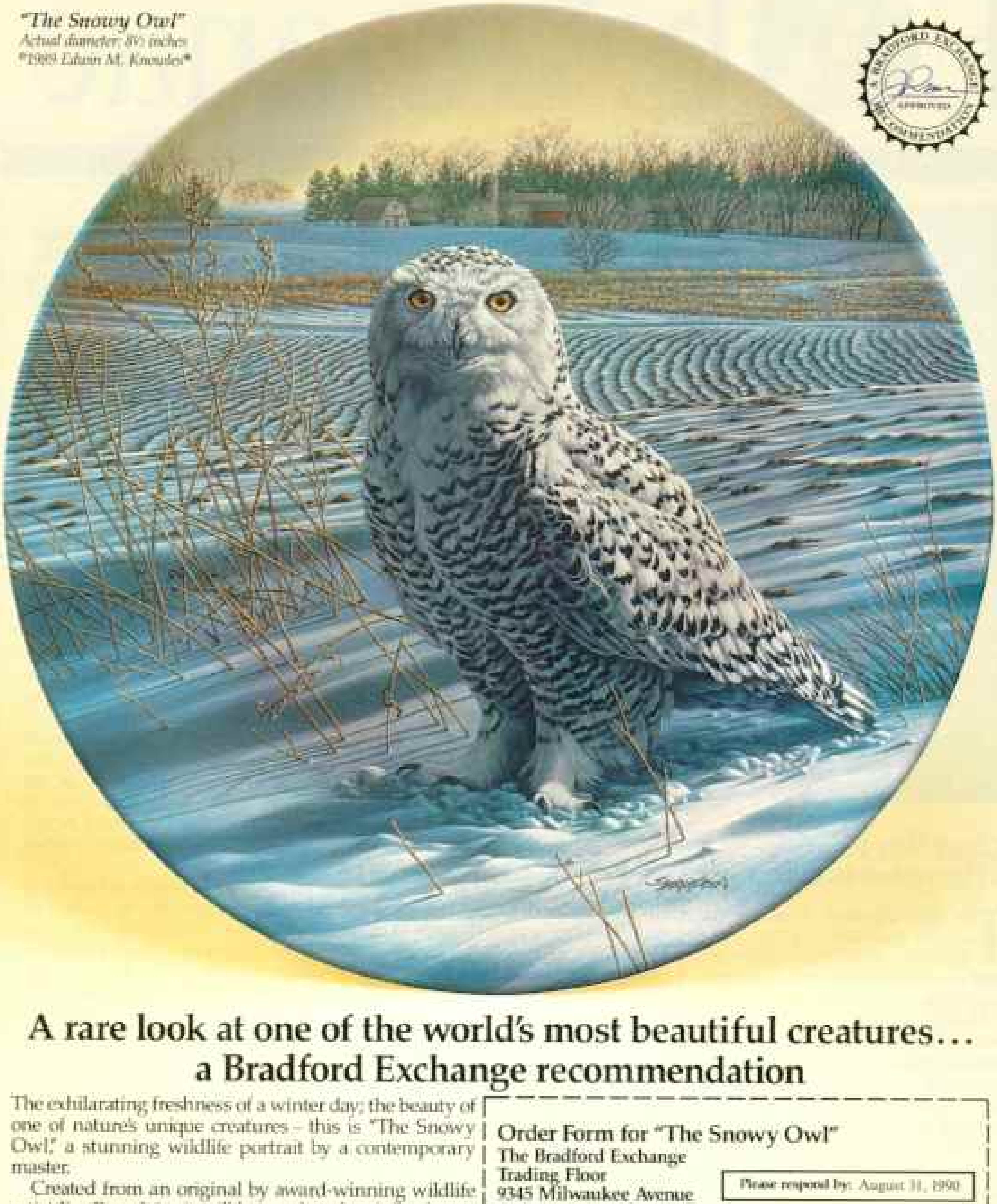

A rare look at one of the world's most beautiful creatures… a Bradford Exchange recommendation

The exhilarating freshness of a winter day; the beauty of one of nature's unique creatures – this is "The Snowy Owl," a stunning wildlife portrait by a contemporary master.

Created from an original by award-winning wildlife artist Jim Beaudoin, it will be produced in full color on fine china under the prestigious hallmark of Knowles China. And like exceptional collector's plates that now command hundreds of dollars on the plate market, "The Snowy Owl" appears to have what it takes to go up in value after the edition closes.

Not all plates go up in price; some go down. But the edition of "The Snowy Owl" is strictly limited to a maximum of 150 firing days, and demand is expected to be strong. So if you wish to obtain this plate at the $29.90 issue price, the time to act is now. To order your plate – fully backed by our one-year money-back guarantee – send no money now; simply complete and mail the coupon at right.

Order Form for "The Snowy Owl"

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Please respond by: August 31, 1990

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Earth Almanac

NATIONAL GEOGRAPHIC MAGAZINE AUGUST 1990

ROGER GRACE, GREENPEACE

Ghost Nets Reap a Harvest of Death

The grim toll taken in marine life on the high seas by huge, nearly invisible drift nets continues, despite attempts at international regulation.

Marine mammals, seabirds, and unwanted fish destroyed and discarded by drift-net fishermen far outnumber the fish sold at market, say critics, who call the practice "strip-mining the seas." Much of the catch is tossed overboard.

From May through December boats operating mostly out of Japan, South Korea, and Taiwan nightly set thousands of miles of fine-filament nets, each up to 30 miles long and hanging 30 feet below the surface. Seals, whales, seabirds, and numerous unmarketable fish —like this ocean sunfish (above)— blunder into mesh that was set primarily for squid and albacore tuna.

Efforts to control drift netting have met limited success. The 16-nation South Pacific Fisheries Forum Agency in 1989 called for immediate cessation of the practice in the South Pacific, but nonmembers Japan and Taiwan did not comply.

Because some species of Pacific salmon spawn in American waters, the U. S. considers their depletion by Asian drift nets an act of poaching. Threatened by the possibility of U. S. trade sanctions, Japan, South Korea, and Taiwan have agreed to temporary restrictions on their fleets in the North Pacific. But undercover investigations indicate that some Taiwanese boats are cheating on the agreement.

A UN resolution calling for tough restrictions on drift-net fishing by 1992 depends on voluntary compliance.

"The issue of sovereignty on the high seas makes monitoring and enforcement difficult," says Larry Snead, director of the Office of Fisheries in the U. S. Department of State. "Multilateral cooperation including possible trade sanctions against offending nations will be needed to stop illegal drift netting."

Planet Walker Ends His Long Silence

If silence is golden, John Francis is rich. He agrees with that assessment after being mute for 17 years.

Disturbed by the death of a friend and a 1971 oil spill in San Francisco Bay near his home, the young California band manager made two vows. He would shun motor vehicles to explore life-styles more in harmony with the environment. And he would not speak.

Communicating with gestures, sign language, and the written word, he earned a master's degree in environmental studies and began a doctoral program in land resources. He also walked thousands of miles across the U. S. to highlight his dedication to earth stewardship and world peace. And he published a newsletter called "Planet Walker."

After resuming speech on Earth Day last April, Francis, now 44, insists that his long silence was rewarding. "The novelty of not speaking dramatized some issues that I wanted to address," he says, in a soft, resonant voice. "And I learned more about myself. We cover up our deepest thoughts with too many words." Francis plans to continue his pilgrimage around the world, traveling across the seas by sailboat.

ART ROBBINS

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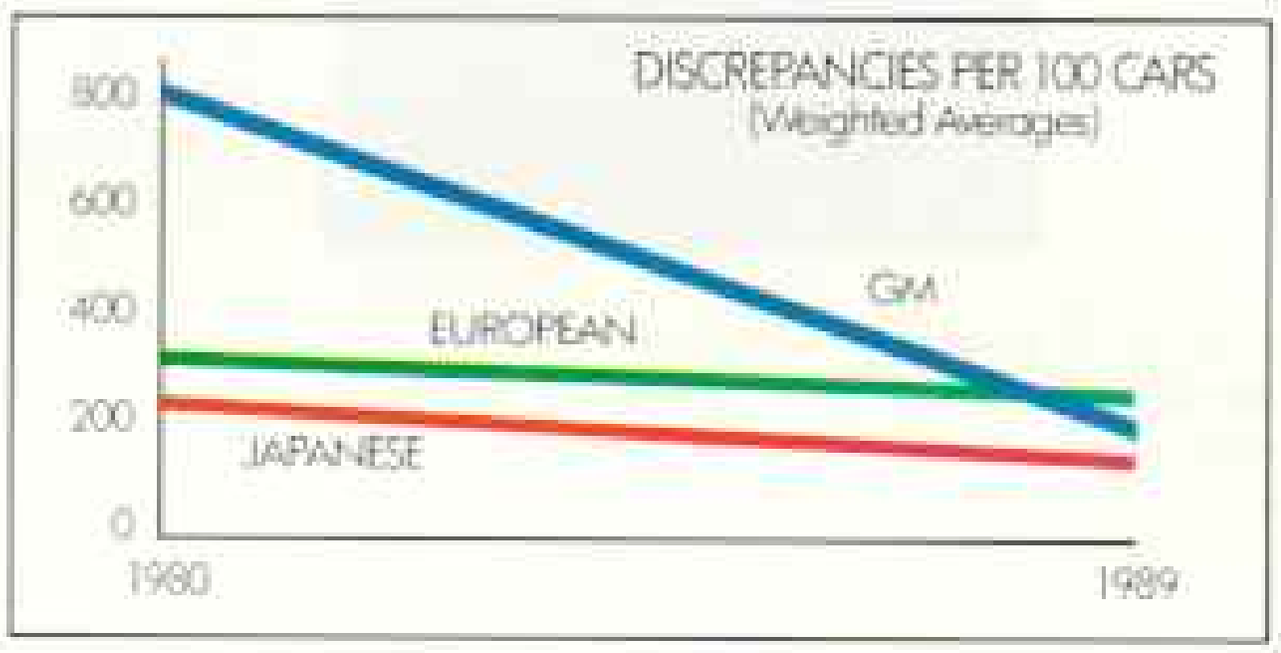
According to one quality survey by Harbour & Associates, GM vehicles are better built than the average European import, and the difference between GM and the average Japanese import is less than one-half of one discrepancy per car. Other studies confirm GM's improvement.



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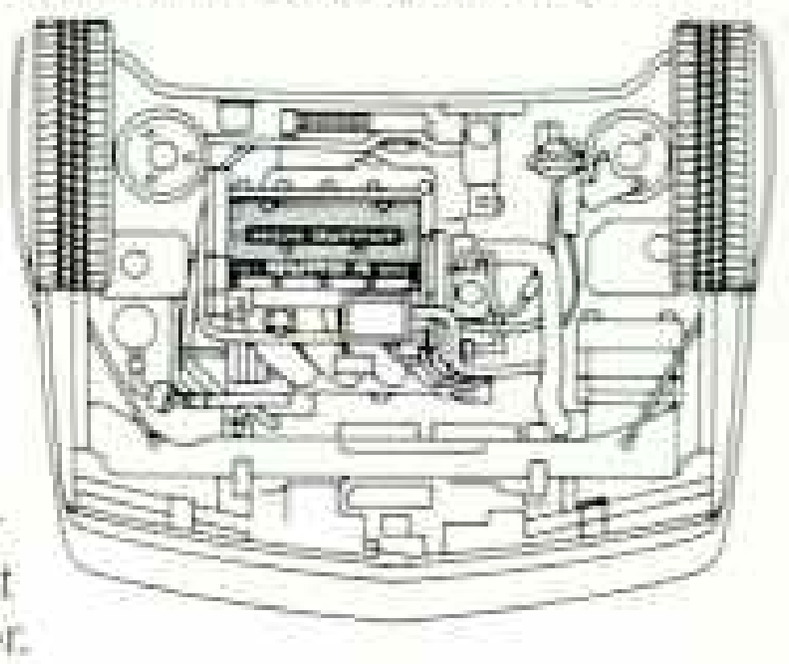

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Greening of an Argentine City, a Century Old

The millions of trees planted a few months ago as part of Earth Day activities will not seriously affect global pollution for years. It's worth the wait, say citizens of Mendoza, Argentina.

Each year a mature tree can consume as much as 50 pounds of carbon dioxide, one of the major contributors to the greenhouse effect.

A city of 660,000 on a formerly treeless plain at the foot of the Andes, Mendoza began a tree-planting program after an earthquake leveled the town more than a century ago. Today the "City of Trees" counts as many trees as inhabitants, a ratio matched by few metropolises in the U. S.

Planted for shade in a time of carriages and pedestrian traffic, the large sycamores and white mulberries are believed to reduce air pollution by nearly one-third. Mendoza's natural air conditioning also provides relief from the dust and direct sun of the nearby desert.

GAIL RICHARDSON

Buried "Marshmallows" Save Irrigation Water

Electronic snoops are growing in popularity among farmers concerned about overwatering their crops. Buried near plant roots, marshmallow-size gypsum blocks containing electrodes soak up moisture at about the same rate as the surrounding soil. A wet block conducts more electricity than a dry one. When a charge is sent from a portable metering device through the sensors, farmers can determine when the roots need water.

Excessive irrigation depletes the groundwater supply, increases runoff of farm fertilizers and pesticides, and

promotes salinization of the soil.

When introduced in the 1940s, the gypsum block found little market, because water was cheap and plentiful. Today it isn't: farmers in 17 western states, who use about 85 percent of their area's annual water supply, can't afford to waste the precious resource.

"To make sure their crops don't dry out, farmers have tended to overwater," says Gail Richardson of INFORM, an environmental research group. "These sensors have cut down water use by 20 to 40 percent a field."

With startup costs under $500 and per-acre costs averaging a dollar in ensuing years, one California farmer saved $18,000 in expenses. Another increased his alfalfa yield by $124 an acre, because he did not damage the plants by overwatering.

Getting to the Root of the Firewood Problem

Roots of common gourds could serve as cooking fuel in underdeveloped countries, reducing tree and shrub loss caused by gathering firewood.

Some 60 percent of women in the Third World spend one day a week scavenging scarce fuel, adding to deforestation, say Eugene B. Shultz, Jr., and Wayne G. Bragg of Washington University in St. Louis, Missouri. Their laboratory tests have shown that the taproots of gourds and squashes of the Cucurbitaceae family, after being dried in the sun, burn more efficiently than wood. Women in Mexico, Senegal, and Niger tried the fuel and declared it highly satisfactory.

The plants, found in North and Central America, Africa, and India, grow in nutrient-poor soils. Most are inedible. Noel Vietmeyer, research scientist for the National Academy of Sciences, has called the concept "innovative and farsighted."

Prairie Winds Blowing Help to the Sioux

The persistent wind that sweeps across the South Dakota plains could change the financial climate of the Oglala Sioux, who want to sell wind-generated electricity to power companies.

An agreement signed with Wintec, Ltd., of North Palm Springs, California, calls for construction of 400 wind-powered generators on the Pine Ridge Reservation, one of the poorest regions in the United States, where annual incomes average $2,800. Electric bills often consume more than half of a family budget because of high rates and drafty housing.

Each 80-foot-high windmill could power 33 homes on the reservation, but the electricity will go instead to area utility companies. They must, under federal law, buy power produced by independents at competitive prices. Royalties from the sale of electricity plus rent paid by investors for the ground where the windmills stand are expected to bring hundreds of thousands of dollars annually to the 18,000-member tribe.

To help the Oglala reduce their personal electric bills, Wintec has offered to install small windmills at individual homes, with payment coming out of the family's monthly savings in electricity costs. "If the windmills reduce a monthly bill by $300, the customer pays us $150 toward the cost of the machine [about $4,000] until it is paid for," says

MARY L. KUNKEL

Jim Dowty, a Wintec engineer and an Oglala Sioux himself.

Tribal members find no conflict with Sioux tradition in harnessing Tatiya—the wind—to produce income, says Dowty. "Indians believe anything put on the earth is a gift. You shouldn't destroy it, but you should use it."

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On Assignment

EMILIAN SOKA (LEFT); ROBERT SHAI

THE LINE between near miss and tragedy stretched frighteningly fine for two veteran photographers working on different continents for this issue.

Contract photographer STEVE MCCURRY, who has covered stories from Afghanistan to Beirut to the Sahel for NATIONAL GEOGRAPHIC, survived his closest call in Yugoslavia. Not far from Zagreb, where Steve had enjoyed a quiet moment with a feline friend (above), he boarded a light aircraft to make aerials of an island in Lake Bled. Blinded by reflections on the lake's surface, the pilot dipped too low, flipping the craft upside down. As the plane sank, Steve struggled—under ten feet of 40-degree water—to release his seat belt and shoulder harness. Fortunately he and the pilot were picked up by a fisherman within ten minutes; days later the plane was raised (above right), but Steve's equipment is still 60 feet down.

At Penn State, Steve had studied filmmaking before turning to still photography. "Stills allow me to spend more time in the field instead of in the editing studio or out raising money. I can grab my camera and be out the door. Travel is as much my passion as photography." Steve has published two books: *The Imperial Way* and *Monsoon*.

RICHARD OLSENIUS had a close call along Baffin Bay on the Northwest Passage. He was following narwhal hunters along the edge of the sea ice when, he reports, "I jumped to what I thought was a solid piece of ice. It was pure slush, and suddenly I was up to my neck in ice water—as if a trapdoor had opened. I was weighted down with camera gear, and I could feel water filling my boots and wind pants and creeping around my chest."

A hunter heard Richard's cries for help and pulled him to safety. "Soon I was back in our tent changing into dry clothes. For years I've carried a spare set of everything, wondering if it was worth the weight and effort. This one time made it all worthwhile."

In 12 years as a staff photographer for the *Minneapolis Tribune* and nine years as a free-lancer Richard has logged thousands of miles, working as far afield as Thailand, where he photographed Cambodian refugees in the 1970s.

His lifelong interests in music and photography have combined in one of his current projects—*Distant Shores*, a book and accompanying tape recording celebrating his native Great Lakes.

ROBERT SHAI

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