

DOUBLE SUPPLEMENT: MOUNT EVEREST/HIGH HIMALAYA

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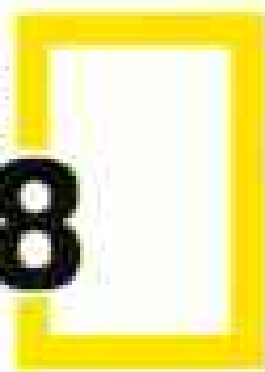
NOVEMBER 1988

NATIONAL GEOGRAPHIC

*Honey
hunter
in Nepal*

*Exploring
the Earth*

1988



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HIGH HIMALAYAS

Exploring Cradle Earth 612

The splendor of Mount Everest, captured by William Thompson in unique aerial photographs, epitomizes the human urge to view the unknown. Editor Wilbur E. Garrett keynotes an issue dedicated to exploration.

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Space-age technology provides a brilliant new look at the central Himalaya. In a double map supplement, the most accurate portrait of the Everest region ever produced. Project leader Bradford Washburn relates its history.



BRAHMAPUTRA FESTIVAL

Honey Hunters of Nepal 660

High in Himalayan foothills, fearless Guringu men risk their lives to harvest the massive nests of the world's largest honeybee. Text and photographs by Eric Valli and Diane Summers.

Long Journey of the Brahmaputra 672

From Tibet's lofty passes through India to the floodplains of Bangladesh, Jere Van Dyk follows the storied river whose course was a mystery for centuries. Raghur Singh and Galen Rowell photograph the scenic region shared by Buddhists, Hindus, and Muslims.



QUEEN ANGELFISH

Down the Cayman Wall 712

By submersible, shark expert Eugenie Clark explores a kaleidoscope of marine organisms living along a 3,200-foot underwater escarpment off Grand Cayman Island in the Caribbean.

Mission to Mars 733

A U. S.-Soviet manned voyage could answer age-old riddles about Earth's neighbor planet. Former astronaut Michael Collins describes a flight scenario for the year 2004, with photographs by Roger H. Ressmeyer and artwork by Pierre Mion and Roy Andersen.



FUTURE MARS BASE

COVER: Suspended from a towering cliff, Nepalese honey hunter Mani Lal directs lowering the brood comb of a giant bee nest to the ground far below. Photograph by Eric Valli.

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Exploring Cradle Earth

When we try to explain a cat's daredevil behavior, we say "Curiosity killed the cat," and when it somehow survives, we cover that with "A cat has nine lives." The same could be said for explorers. No one really knows what drives a person to risk all—to stand on the highest mountain or reach the deepest ocean trench. What we do know is that many follow their lead, and their acts often change the course of history.

When courageous European sailors tested the Middle Ages beliefs that the earth was flat and anyone who sailed too far would fall off the edge, they did more than come home heroes. Entrepreneurs and settlers poured out of Europe in their wake, dramatically changing the world. What would the Americas be like today had those sailors been Chinese or Japanese?

Until Sir Edmund Hillary and Tenzing Norgay in 1953 reached the summit of Mount Everest (right), it had defeated all challengers. Since then, close to 200 men and women have stood there. More than 60 have died trying. The tens of thousands of tourists who have since swarmed to the Everest area to enjoy its beauty have changed life in the Himalaya more in three decades than it had changed in thousands of years. And not always for the better.

Other than the discoveries themselves, the most valuable legacy of explorers is the maps they produce for those who follow. As a special supplement to this issue we include two spectacular maps produced by a team of modern explorers utilizing the latest cartographic technology.

Today's sailors explore not just the oceans' shores but also their depths. In the wake of the Beebes and Cousteaus, even tourists now view undersea life from submersibles, as we see in our article on the Cayman Wall.

Russian scientist Konstantin Tsiolkovsky predicted in 1899, "Earth is the cradle of humanity, but humanity cannot remain in the cradle forever." Explorer-astronaut Michael Collins's article "Mission to Mars" presents a plan that would enable interplanetary travel to leave the pages of science fiction and become reality in the lifetime of most of us. No one can say who the first explorers of other planets will be, or even why they will be doing it, but one thing is sure: Masses of other humans will follow in their wake, perhaps forced to do so because Cradle Earth will have become not only too small but also worn out from misuse. So far as we know, it doesn't have nine lives.

Wilbur E. Garrett

EDITOR

A distinctive plume billows from the east face of Mount Everest. Pierced by the world's highest peak, the prevailing winter jet stream draws moisture-laden air up from southern slopes, condensing a thick cloud blanket on the lee side.

PHOTOGRAPHS BY WILLIAM THOMPSON







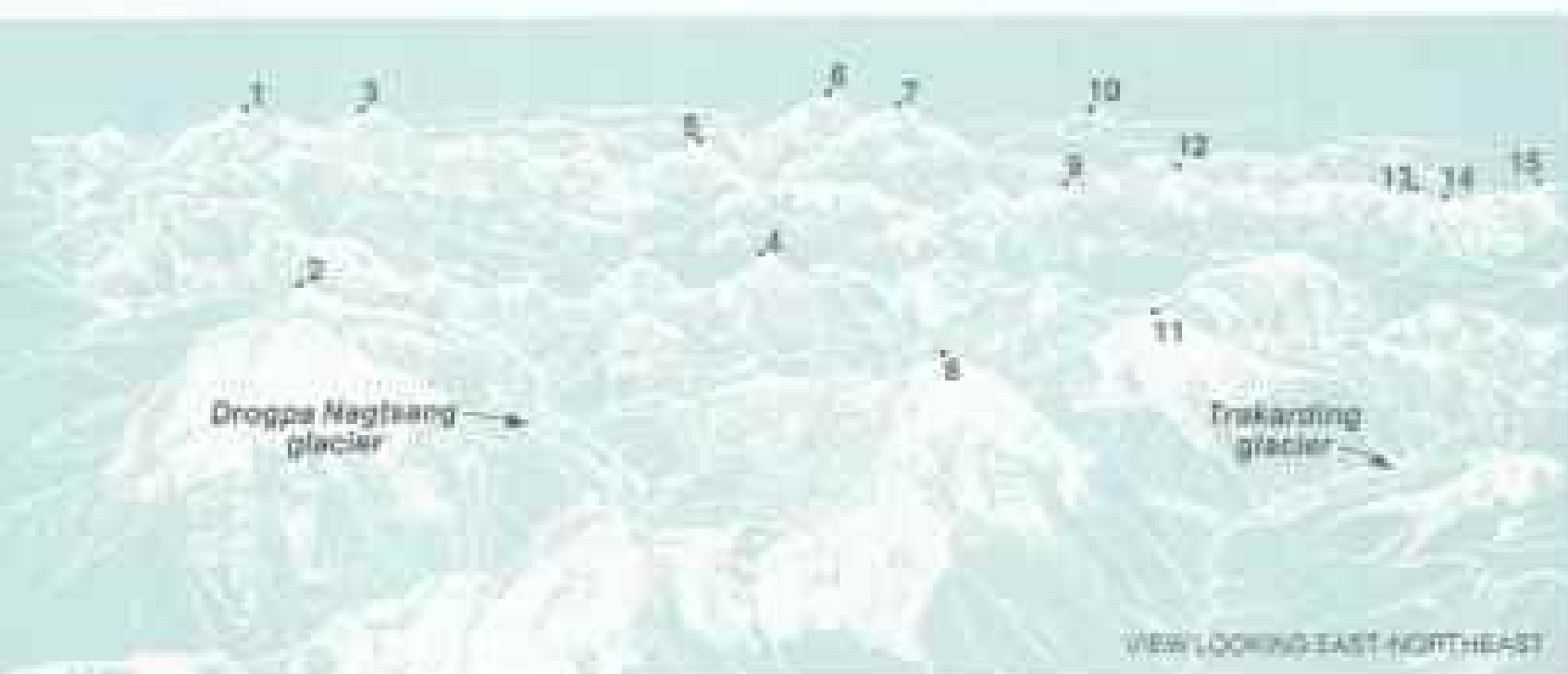


Roof of the world

The highest and mightiest Himalayan peak, Mount Everest was viewed as nature's final stronghold after explorers reached the North and South Poles. The awesome splendor surrounding earth's "third pole" beckoned boldly (left, and key below).

"Lord of all, vast in unchallenged and isolated supremacy," wrote English climber George Leigh Mallory, upon first seeing Everest (right)—known to Tibetans as Chomolungma (Qomolangma), or "goddess mother of the world," and to Nepalese as Sagarmatha, "sky head." A practical route up the mountain was first explored in 1921 by Mallory; he died on his 1924 attempt to reach the summit, disappearing above 27,700 feet.

In 1953 Tenzing Norgay, a Sherpa, and Edmund Hillary, a New Zealander, became the first to stand at the summit, highest point on earth. Ten years later the first American expedition scaled the peak. Some team members—including NATIONAL GEOGRAPHIC's Barry C. Bishop—took the same route as Hillary, while others completed the first traverse of the mountain, up the west ridge and down the southeast ridge. In 1975 a British expedition forged a path up the southwestern face, and in 1980 famed climber Reinhold Messner reached the summit alone—without oxygen or radio.



- | | | | | |
|---------------------------------------|--------------------------------------|--------------------------------------|-------------------------------------|------------------------------------|
| 1. Cho Oyu
8,168 m 26,790 ft | 4. Dzaingnag Ri
6,801 m 22,313 ft | 7. Lhotse
8,501 m 27,890 ft | 10. Makalu
8,481 m 27,824 ft | 13. Kangtega
6,779 m 22,241 ft |
| 2. Manjungtse
7,181 m 23,550 ft | 5. Pomori
7,185 m 23,567 ft | 8. Kang Nachugo
6,736 m 22,096 ft | 11. Tsoboje
6,888 m 22,594 ft | 14. Thameerku
6,658 m 21,830 ft |
| 3. Gyachung Kang
7,922 m 25,990 ft | 6. Mt. Everest
8,848 m 29,029 ft | 9. Tawoche
6,540 m 21,450 ft | 12. Anu Dattam
6,828 m 22,400 ft | 15. Kyzashar
6,759 m 22,200 ft |









A Fragile Heritage

The Mighty Himalaya

By BARRY C. BISHOP

VICE CHAIRMAN, NATIONAL GEOGRAPHIC COMMITTEE FOR RESEARCH AND EXPLORATION

Photographs by WILLIAM THOMPSON

Sentinel to Everest, 22,494-foot Ama Dablam was first climbed in 1961—by the author. The name means “mother’s charm box,” for the ornament Sherpa women wear around their necks. A snowy bulge just below the summit, the “charm box” is formed by a hanging glacier.

< *From high above the peaks, the ridges of Nepal’s lower Himalaya recede toward India’s Gangetic Plain. More than half of Nepal’s population lives in these heavily farmed valleys.*

IT WAS LATE on Christmas Day, 1984. My face was transfixed against the Learjet window like a portrait locked in a frame. We were circling clockwise around that third pole of the earth—the summit of Mount Everest. Two miles separated plane from peak, but the clarity of the air seven miles up made it seem that I could reach down and touch the sharp ridges. Snug in the living-room comfort of the jet, I felt an uneasy detachment. The mountain, highest on earth, poised between Nepal and Tibet, seemed so bloody benign.

I knew better. Beyond the window the temperature was a paralyzing 97 degrees below freezing, and a westerly wind flayed the slopes at 150 miles an hour. It had been a brutal season for climbers on Everest and her sister peaks.

My mind was running on two tracks. One was totally absorbed in the panorama below. The other, faded by time, relived those hours a quarter of a century earlier when I reached Everest’s summit, 29,028 feet above sea level, as a member of the first American Mount Everest Expedition.* We had been lucky that season: Everest had been uncommonly tranquil. In short, the weather had been only miserable, not impossible. . . .

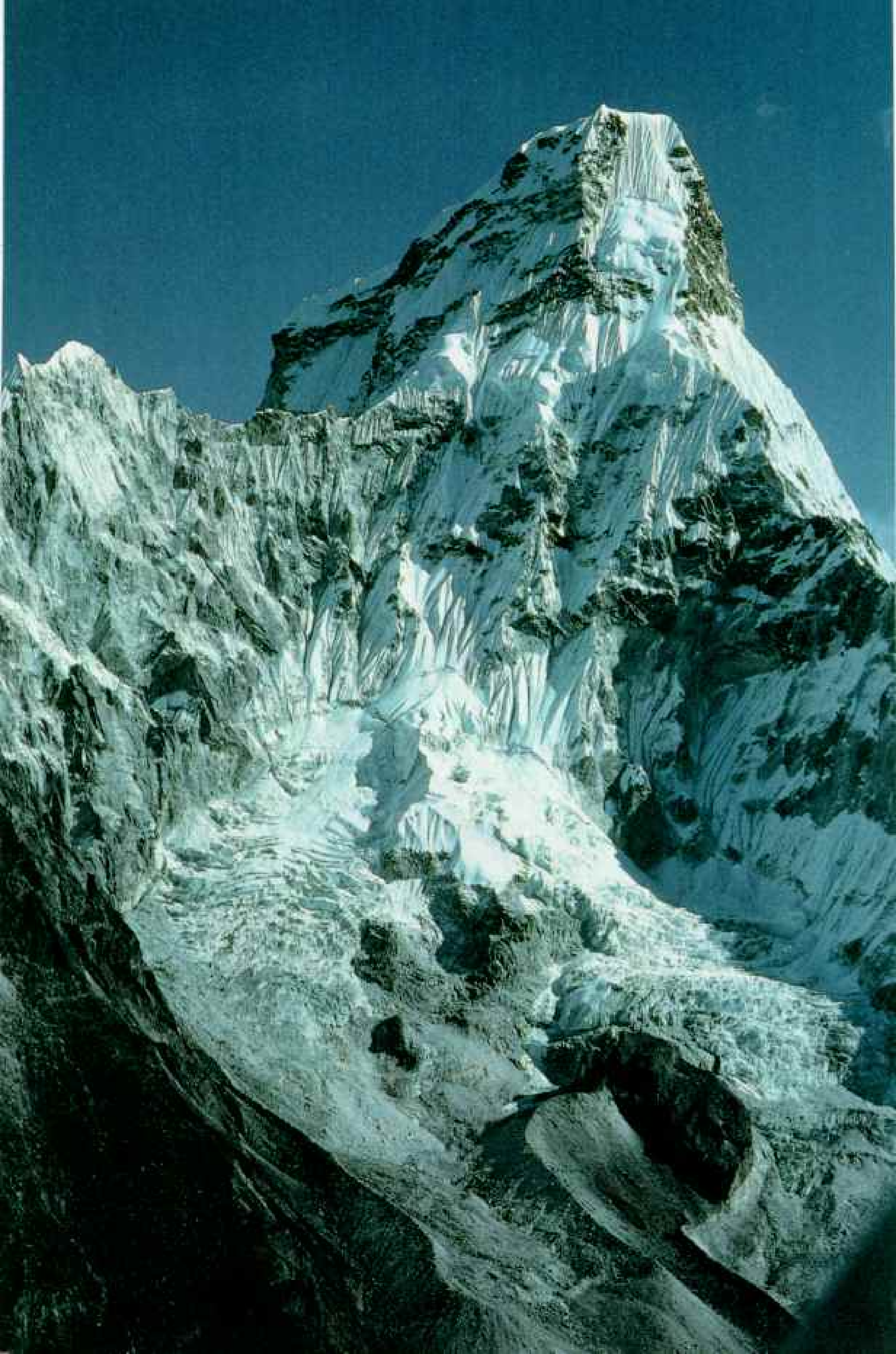
“We’re going to have to break off now—it’s nearly sunset.” The voice of Capt. Bernt Herrlin over the intercom jarred photographer Bill Thompson and me from our thoughts and work. “One more circle,” Bill pleaded, “the light’s fantastic!” We were treated to one last rosy-hued vista (pages 616-19) before Bernt turned southwest toward the airport at Kathmandu, Nepal’s capital.

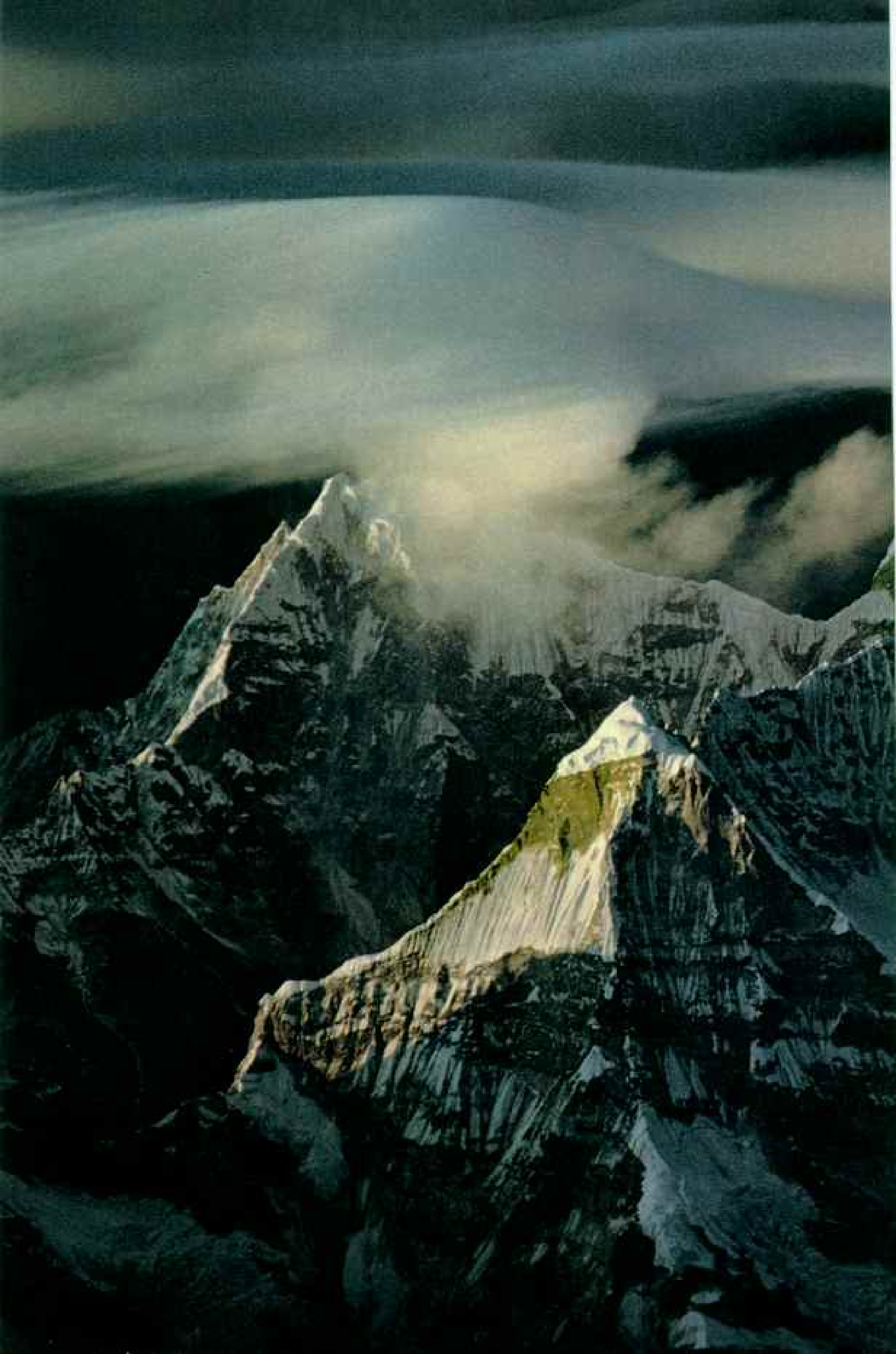
The gods of the Himalaya had been good to us that day and the preceding week, giving us sufficient clear weather to complete high-altitude aerial photography of Everest. We were members of a team assembled by mountain-mapper extraordinary Dr. Bradford Washburn, Honorary Director of Boston’s Museum of Science. His account of the historic Everest-mapping project begins on page 653 of this issue.

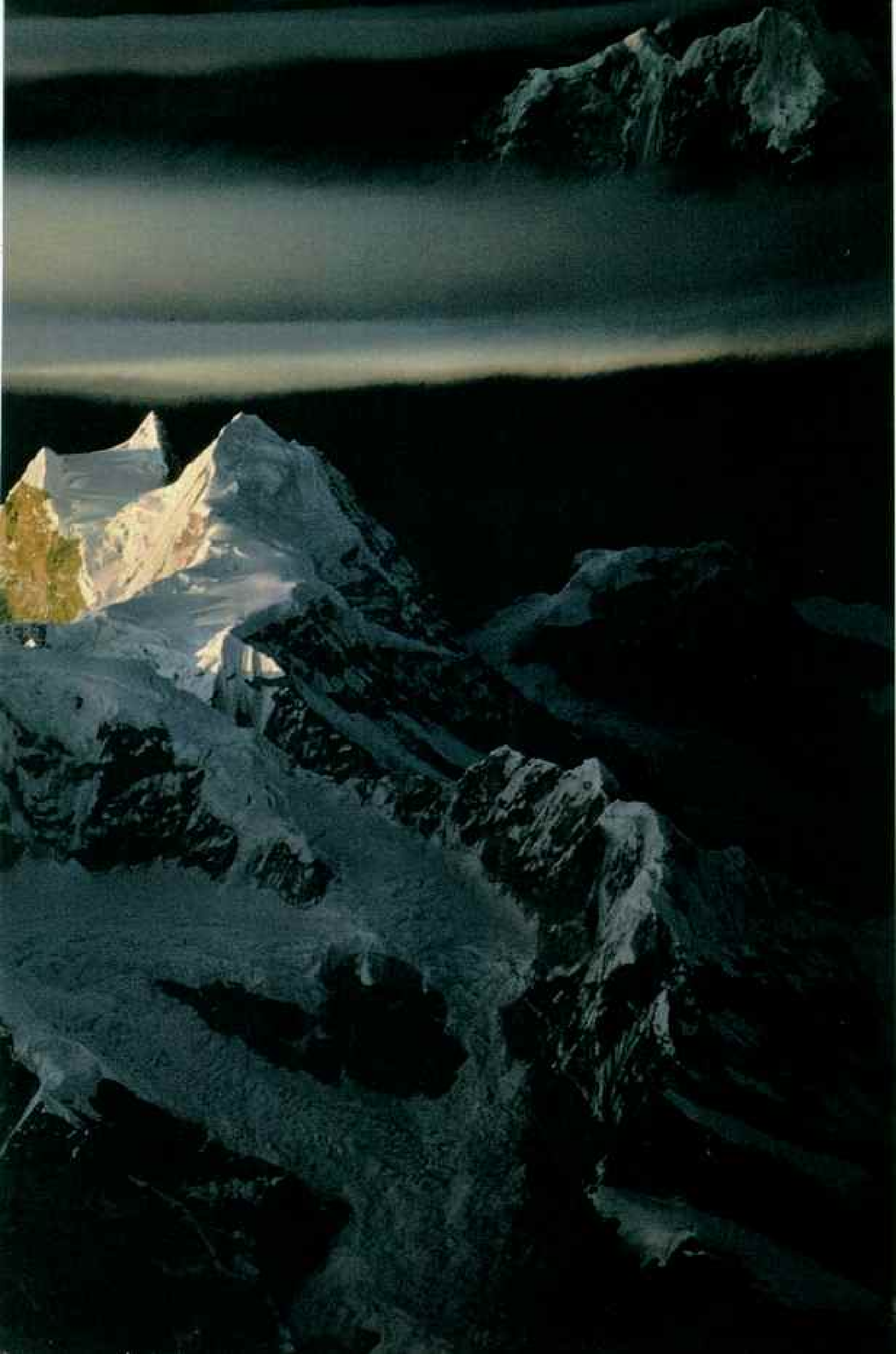
Bill Thompson was right—what fantastic light that day, and what fantastic photographs these are of Everest and the Himalaya. Their sense of unspoiled beauty and splendor is dazzling—and, unfortunately, misleading.

Everest and the Himalaya are in trouble today, precisely because of that splendor. When I first trekked into the Everest region three

*See “How We Climbed Everest” in the October 1963 NATIONAL GEOGRAPHIC.









< *Stark grandeur of glacier-hung peaks guards the southern border of Nepal's Sagarmatha National Park. Here rise, clockwise from foreground, Kyashar, Thamserku, Kangtega, and distant Tawoche—all surpassing 21,000 feet.*

decades ago, perhaps several dozen foreigners a year set foot there. Today nearly a quarter of a million foreigners visit Nepal each year—trekkers, climbers, sightseers. Nepalese authorities hope to quadruple that figure to a million within the next decade.

Sagarmatha (Everest) National Park, which was established in 1976 to preserve the region, may be expanded from its present 480 square miles to 1,500—a threefold increase that can only draw more tourists. On the other side of the border, in Tibet, the Chinese government is considering expanding two current preserves to form a new one as large as 4,000 square miles—among the world's largest.

Meanwhile tourist pressure is increasing on both countries. "We have a new proverb," says my friend Hemanta Mishra, a distinguished Nepalese ecologist and a member of the King Mahendra Trust for Nature Conservation, chaired by Nepal's Prince Gyanendra. "We say there are now three religions in Nepal—Hinduism, Buddhism, and tourism."

The last of these brings desperately needed revenue to at least a small number of Nepal's spiraling population—now over 18 million—whose per capita income of \$160 a year is one of the world's lowest. "An environmental ethic," says another Nepalese friend, "is hard to sell to people whose first concern is the next meal."

Yet Nepal's leaders are struggling to do just that. The government has set aside over 7 percent of its total area in more than a dozen national parks and preserves. The most recent one, the 1,000-square-mile Annapurna Conservation Area, is administered by the King Mahendra Trust with the participation of local inhabitants; most of the income from a user fee imposed on tourists goes directly to the villagers.



One of the greatest threats to the Himalayan environment is the continuing loss of forests for fuel. Traditionally Nepal's hillfolk, including the Sherpas of the Khumbu region, have harvested wood for heating and cooking fires. But the rapidly increasing local population and the influx of trekkers have altered the age-old balance. One trekker—with his party of porters, kitchen help, and guides—consumes as much wood as ten Sherpas, and the impact on the forests is devastating.

Today in Sagarmatha trekking parties must bring their own fuel to the park, usually butane or kerosene. Small hydroelectric units in two of the larger villages are relieving some of the pressure (pages 642-3). Elsewhere, however, officials charged with preserving the forests have gone into the wholesale lumber business. As one foreigner observes, "It takes a strong politician to resist the urge to loot this resource."

The most visible impact of trekkers on the Himalaya is the growing amount of trash and litter they leave behind. The result is more eyesore than permanent damage, and bemused Sherpas refer to sheets of toilet tissue deposited along the trails as "the white man's prayer flags."

A Nepalese scientist, Kamal Kumar Shrestha, puts it another way: "Tourism is not only the goose that lays golden eggs . . . it also fouls its own nest."

The practice of littering once gave rise to signs in American parks that read, "Take only photographs, leave only footprints." But we have learned that even footprints can be destructive when there are enough of them. Will parks in the Himalaya one day come to the system used elsewhere of wood or concrete trails from which visitors are forbidden to stray?

Richly nourished by monsoon rains, the valleys of northern Bhutan offer an unspoiled landscape at the eastern end of the Himalaya. Limited numbers of tourists have been admitted since 1974.

To some the attitude of neglect toward the Himalaya is a legacy from earlier generations. An American friend who has traveled both on the Nepalese and Tibetan sides of the range recalls Americans' early attitude toward their own land.

"When I was a kid in Missouri," he says, "I was taught how we 'conquered' the West—we didn't settle or preserve it, we conquered it. Then we conquered the mountains, we conquered the Poles, and we conquered the ocean depths. Everywhere we went, we conquered. And in the process we destroyed more than we preserved. For God's sake, let's not 'conquer' all the Himalaya."

One who shares that view is Sir Edmund Hillary, now 69, who with Sherpa Tenzing Norgay first reached the summit of Everest on May 29, 1953. They followed a distinguished roster of British climbers who had challenged Everest in the 1920s and '30s and failed. The best known among them was George Leigh Mallory, who with his partner Andrew Irvine vanished near the summit in 1924. Mallory is credited with the now famous reply to the question most mountaineers find irrelevant: Why climb Everest? According to one account he was asked the question in Philadelphia during a lecture tour in 1923. He replied impatiently, "Because it is there."

In Edmund Hillary's view explorers have an obligation that goes far beyond discovery, and he has fulfilled it many times over for his friends the Sherpas. In the past quarter century his Himalayan Trust has built 26 schools, two hospitals, a dozen medical clinics, and countless bridges and water systems, all for the Sherpas. He was also a driving force behind the creation of Sagarmatha National Park.

Meanwhile both China and Nepal are pressing ahead with major economic development. For the first time one can now fly directly between Lhasa and Kathmandu, a boon for tourists. Nepal plans several hydroelectric dams on the Arun River east of Everest, while China contemplates a dam in the great bend of the Brahmaputra, which would be the world's largest hydroelectric generating plant.

NEPAL REMAINS the focus of world interest in the Himalaya as well as a battleground between conservationists and commercial interests. Yet with reason and patience the two can coexist. The charter of the King Mahendra Trust declares that its objective is "to demonstrate through various programs that the relationship between nature conservation and basic human requirements need not be antagonistic."

Slowly Nepal's basic needs are being addressed. Malaria, once the scourge of her subtropical lowlands, has been largely controlled. Thus new agricultural opportunities have been created, particularly for hard-pressed hill people from the lower Himalaya—but at the expense of clearing vast tracts of hardwood forests.

Roads and airstrips are changing the old seasonally paced ways of



subsistence to a cash economy. But again at a price, for the bulldozer's blade triggers erosion of steep and unstable slopes.

In a recent landmark step Nepal's National Panchayat, or legislature, voted to return a sizable percentage of government-owned forestland to local people for their use and management. I'm certain that the nation's hill people are capable of preserving their natural and human resources if given the chance. With their tradition of living close to the land, they recognize the long-range payoff of environmental principles.

Already protective measures for wildlife in Sagarmatha have begun to show results. Species that seemed destined for annihilation in the



1970s, such as the musk deer and the tahr, a type of wild goat, are making at least a local comeback.

WHAT DOES THE FUTURE HOLD for this Himalayan realm? There are those who believe that all of Nepal's problems can be solved by the megabuck, high-tech approach, while doomsayers maintain that there is no longer any hope at all for the Himalayan environment. But most, I think, share my mixture of deep concern and cautious optimism.

Certainly the threat to the Himalaya is real, and certainly it is human. For millennia the mountains' majesty and mystery have inspired. An ancient Hindu scripture declared: "As the sun dries the morning dew, so are the sins of man dissipated at the sight of the Himalaya."

Avarice and indifference must not destroy this heritage of future generations. For it is a magnificent heritage, a blend of the Himalaya's natural wonders and the stalwart peoples who dwell in their shadow. And why should we concern ourselves with either one?

As Mallory would say: Because they are there.

* * *

Treeless and terraced, the hillsides of Nepal's lower Himalaya are prone to erosion and earthquakes. They are threaded with numerous rivers that offer the country its largest potential resource: hydroelectric energy.



Heavy Hands on the Land

By LARRY KOHL NATIONAL GEOGRAPHIC SENIOR STAFF

Photographs by WILLIAM THOMPSON and GALEN ROWELL

EAST OF EVEREST, in an unspoiled wilderness along the Kama River, a woeful harvest is under way, as Tibet's rarest resource—its forestland—falls to the ax. Here, where brightly colored rhododendron trees grow 60 feet high amid stands of juniper, silver fir, larch, and birch, photographer Galen Rowell encountered tracts of tree stumps. Nearby, great stacks of freshly cut timber awaited transport to local villages.

In a land famous for its barren, windswept expanses, only a handful of regions in southern Tibet enjoy sufficient rainfall for forest cover. All border tributaries of trans-Himalayan rivers, whose valleys, according to Rowell, are "like open windows for the monsoons from the south that normally can't penetrate the Himalayan barrier." Conservationists believe that these valleys provide invaluable refuges for wildlife, including the rare red panda. But the government is considering proposals to log the entire Kama Valley to supply building material for the population centers of the arid Plateau of Tibet.

Sparsely populated and remote from most human commerce, the Tibetan side of the Himalayan range nonetheless faces some of the same ecological pressures that plague the entire 1,500-mile arc of the



ALL BY GALEN ROWELL

world's highest mountain system. The source of three major river systems—the Indus, Ganges, and Brahmaputra—the Himalayan watershed is vital for the well-being of hundreds of millions of people in the Indian subcontinent. Today this vast ecosystem stands under great threat, as its inhabitants continue to strip their vertical world

of its soil-holding forest cover for fuel, building material, and cropland.

South of Everest, in the Kingdom of Nepal, the environmental threat is far more urgent than in Tibet. There the toll taken from the land by a large local population is exacerbated by a growing tide of fuel-consuming tourists.



THE BURDEN OF DEVELOPMENT, timber cut in the Kama Valley is hauled to Kharta, a five-day trek, by Tibetan women, who traditionally shoulder much of the physical work. Though timber harvests here are still modest in scope,



GALEN RUMBLE

the threat of wholesale exploitation clouds the future of this virgin forest. To meet the lumber needs of a growing population in Lhasa and other Tibetan cities, the government is considering plans to build a major road into the valley.

WHEN THE FURY of China's Cultural Revolution swept over Tibet, more than 6,000 Lamaistic monasteries were reduced to rubble, as Red Guard propagandists forced Tibetans to lay waste their religious heritage. A hallowed pilgrimage site, Rongbuk Monastery was demolished in a frenzy of revolutionary zeal sometime in the early 1970s.

During a 1981 visit Galen Rowell found the plundered monastery (right) filled with the garbage and litter of

international climbing expeditions. About that time the Chinese government declared that a mistake had been made and that the Tibetans could rebuild some of their monasteries. One who never left Rongbuk, a Buddhist nun (below) survived with others for years in a nearby cave.

Today the monks' chants ring again through the pristine air, though in far fewer numbers, as the world's highest monastery rises from the ruins (below right) under the gaze of Everest.

A pass on the eastern side of the mountain is called Changri

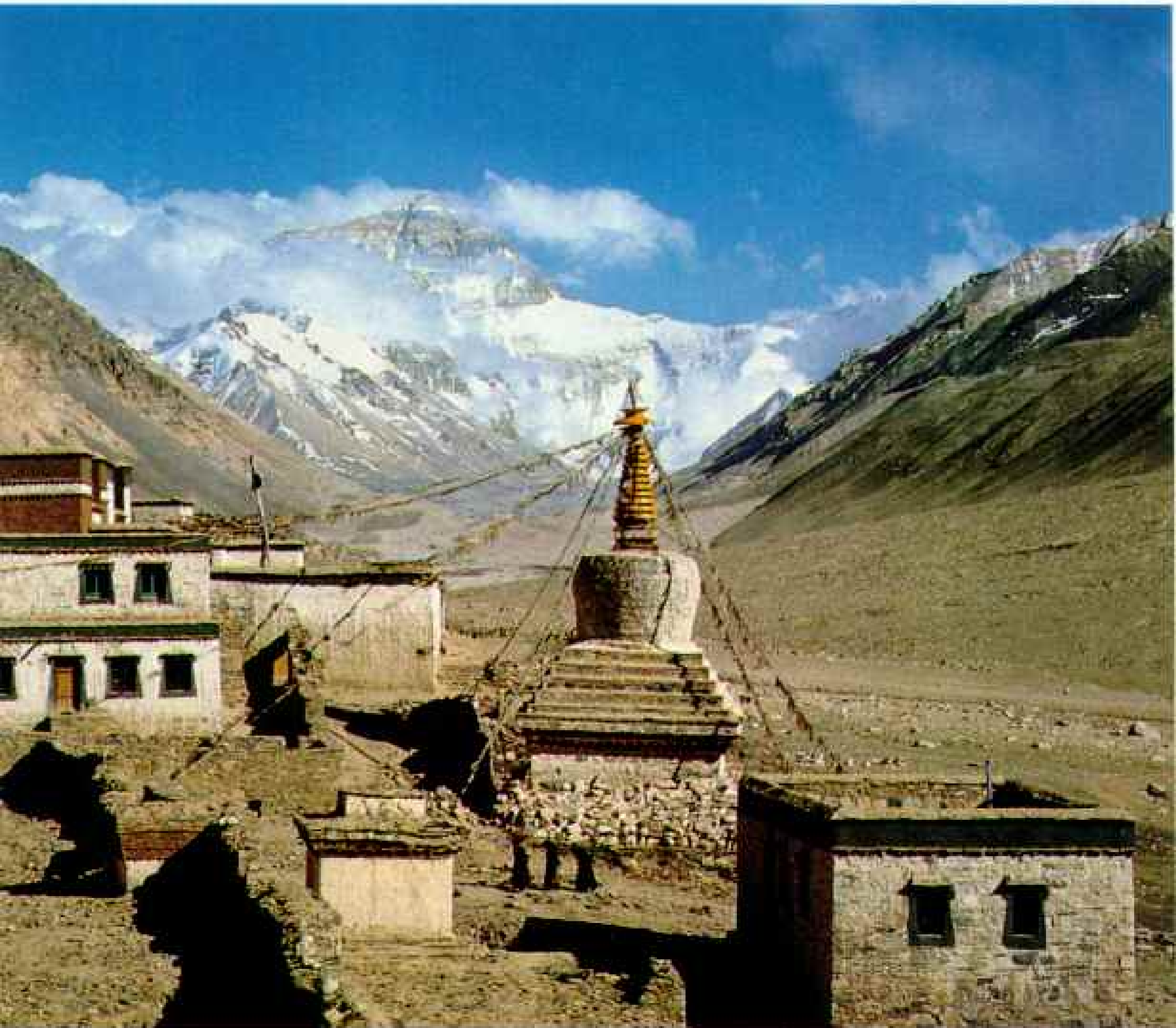
La. Some believe Rongbuk was the model for Shangri-La, the fictional monastery in James Hilton's 1933 novel, *Lost Horizon*. Though Hilton sited his story elsewhere, he may well have drawn his material from George Leigh Mallory's ill-fated expeditions in the 1920s, which used Rongbuk as a base camp and fired the imagination of climbers everywhere.

When Everest was finally scaled in 1953, it was from the Nepal side. The first successful ascent from the north was claimed by a Chinese expedition in 1960.





ALL BY WALDEN HOWELL





BOTH BY WILLIAM THOMPSON



DAY AND NIGHT the wood stoves burn in tourist lodges throughout Nepal's Sagarmatha National Park. Ill-equipped to feed an ever growing horde of foreign guests and their porters, the Sherpa inhabitants of Sagarmatha and the surrounding Khumbu region depend on primitive stoves and dwindling supplies of firewood.

Near the entrance to the park, 1,000 feet above the Sherpa village of Namche Bazar, an old airstrip (right) will soon be rebuilt by Japanese engineers,

while a Japanese-run hotel on the rise above, with its view of Mount Everest (background), will be renovated. When completed, the airstrip will facilitate the movement of visitors and goods from Lukla, 15 miles south of the park.

Since tourism is Nepal's major source of foreign exchange, the government is eager to increase the number of park visitors. Some conservationists oppose the new airstrip, however, fearing that easy access will attract too many visitors and overpower an environment already under stress.





TRASH AND RUPEES line the way to Shangri-La, as thousands of visitors from the developed world descend on Nepal to experience the ultimate adventure: a trek to Everest. Many don't expect, or even desire, Western amenities. Yet increasingly that is what they find in the lodges of Namche Bazar, along the trail from Lukla to Everest Base Camp.

Once a trading post on the route to Tibet via the Nangpa Pass, the village has been transformed into a trekkers' town, with new guest lodges rising every year along the terraced streets. Some offer four-page menus—including yak

steak and chicken tetrazzini—along with private rooms and hot showers.

What many visitors would like to see—the alpine forests that once dotted the slopes of the Khumbu—they probably never will. The stands of trees that greeted Sir Edmund Hillary and Tenzing Norgay at Everest's base in 1953, when they became the first men to scale the mountain, have all but disappeared.

The number of tourists in Nepal has risen from fewer than 10,000 a year in 1960 to nearly 250,000 today; the government plans to quadruple that number by the year 2000. Of the 50,000 who are drawn to the kingdom's sprawling Himalayan frontier,

which offers 122 peaks to climb, some 10,000 visit Sagarmatha National Park, many on expeditions equipped with tents, sleeping bags, and porters. Some 40 trekking agencies employ 5,000 to 7,000 locals, most of whom earn more than twice the national per capita income of \$160 (U. S.) a year. Once the exclusive domain of the local Sherpas, today's portering jobs are also filled by other Nepalese, like this man counting his wages (right). Some Sherpas, meanwhile, have become lodge owners and entrepreneurs, many of them rich by local standards.

The garbage and litter left behind by trekkers has reached appalling proportions. The beat



ALL BY WILLIAM THOMPSON

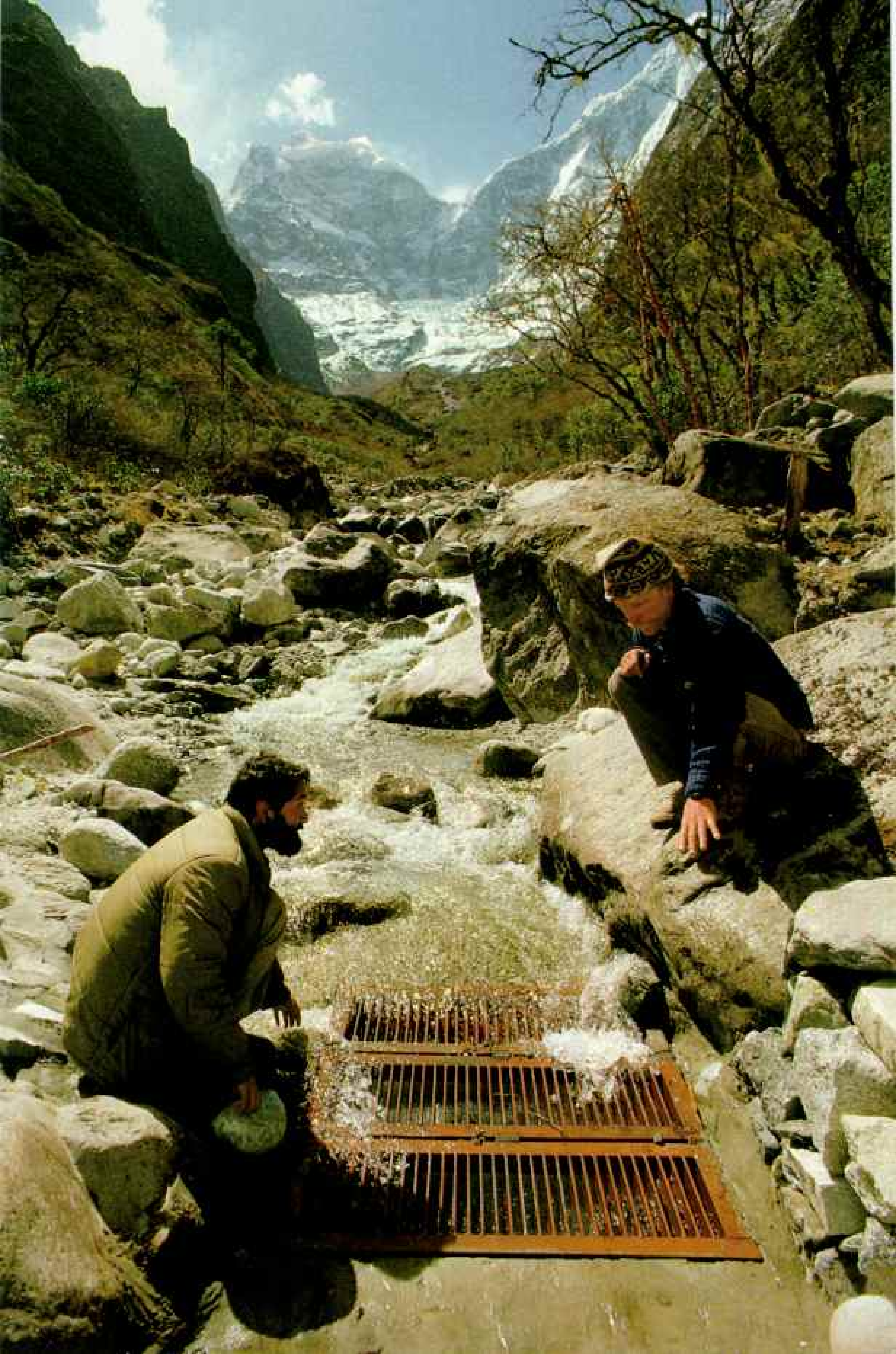
is on for expedition companies to clean up after themselves, but getting individuals to comply is more difficult. Heaps of trash sully the corridor from Lukla to Namche Bazar and all the way up to Everest Base Camp at 18,000 feet, where most trekkers end their journey. Farther up, a parade of climbing expeditions has created the world's highest garbage dump on Everest's South Col.

For a time some locals considered their trash heaps minor status symbols, demonstrating wealth and access to pre-packaged Western goods. But now they too are becoming repelled by the eyesores and are beginning to use garbage pits.



Of much greater concern to scientists is the impact of relentless population growth on the environment, not just in Sagarmatha Park but throughout northern Nepal and the entire Himalayan watershed.

One of the world's poorest nations, Nepal is struggling to provide alternative energy sources to its 18 million citizens. So far these efforts have produced meager results for those living along the Himalayan frontier, and the highlanders continue to strip their mountains of trees and shrubs, sometimes pulling them out by the roots. The inevitable result: rapid erosion of topsoil, which, once lost, will be gone forever.



BRINGING LIGHT to the roof of the world, Nepalese porters haul the last of four 200-meter lengths of power cable through the streets of Namche Bazar on the final leg of a grueling three-day climb from Lukla. Inaugurated in April 1988, the small hydroelectric project to which the underground cables were connected will ease the austere existence of 50 monks at the Thyangboche Monastery near Namche Bazar. Nepalese engineer Girish Kharel (left, at left) and American project coordinator Broughton Couburn inspect the intake grille, through which glacial melt from Mounts Kangtega and Thamserku, in background, flows to a holding tank. From there it drops 90 meters through a pipe to a small turbine in a downstream powerhouse. The project is so simple in design that it was built with only 50 bags of cement.

Requiring little maintenance, the system generates only 22 kilowatts of electricity, the amount needed to power four American homes. The monks at Thyangboche ration their current judiciously, selling the small surplus to a few nearby lodges. Low-watt, energy-efficient light bulbs use only 4 percent of the electricity. A few space heaters and coils for cooking and heating water consume most of the balance.

A 25-kilowatt hydro project at Namche Bazar lights the village at night but provides too little energy to replace firewood for cooking.







RIGHT BY WILLIAM THOMPSON

SCALING the dizzying slopes of a mountainside southwest of Sargamatha Park, sculptured terraces (left) climb some 3,000 feet to the clouds. As the population of the highlands continues to expand, the terraces climb ever higher, often to the very ridgetops.

Many scientists decry the loss of soil-retaining forest cover on such slopes. Others, however, maintain that the continuing upthrust of the young mountain range is primarily responsible for the kind of landslides that have ravaged another mountainside in the same region (above).



BOUN BY WILLIAM THOMPSON

CONSERVATION comes hard in the mountains of Nepal, where survival comes first. On the edge of a virgin forest in the shadow of Makalu, a 27,824-foot (8,481-meter) peak east of Everest, a woman clears timber from a hillside burned over for millet farming. Illegal, and far more destructive than terrace cultivation, slash-and-burn planting

triggers rapid erosion of topsoil from the mountainsides—especially here, where rainfall exceeds 160 inches a year.

As the forests fall, Nepal's wildlife is squeezed into ever smaller habitats, like the Barun River Valley south of Makalu. Even there, rare and threatened species are not safe, as men like this villager with a muzzle-loading firearm illegally hunt with impunity.







SHOT BY WILLIAM THOMPSON

PRECIOUS COMMODITY for the scent shops of Asia, a spoonful of musk is removed from a tranquilized musk deer by a researcher in Sagar-matha Park, one of the few areas in Nepal where the creature is usually safe from poachers' guns. Readily extractable from a small orifice near the urethra, the ounce or so of musk present in a mature animal may bring as much as \$200 on the international market—more than a year's income for the average Nepalese. Little wonder, then, that the musk deer has become endangered throughout most of its Himalayan range. Only males, which sport two tusklike canine teeth (right), produce the substance, which is highly valued by the Chinese as a folk medicine and as an aromatic with reputed aphrodisiac properties.





ALL BY WILLIAM THOMPSON

LIFE RAFT for Nepal's endangered species, Sagarmatha National Park, despite its other problems, has proven an outstanding success as an animal conservatory. Within its sheltered environs many creatures, like the musk deer and the Himalayan tahr (above), are actually on the increase. About the size of an American mountain goat, the sure-footed tahr negotiates the craggy cliffs (right) of the park's wild valleys with similar ease.

In perilous decline outside the park, Nepal's national bird, the impeyan pheasant (left), is not only a popular game bird but also a pest to farmers, whose fields it ravages with its powerful beak. In the park its wild cries resound through great stands of rhododendron trees, the blossoms of which (top left) are Nepal's national flower.

Key to survival for the entire ecosystem, the forests of the majestic Himalaya must be preserved. □





MOUNT EVEREST

Surveying the Third Pole

By BRADFORD WASHBURN



THE BENGALI chief computer rushed into the office of Sir Andrew Waugh, Surveyor General of India. "Sir," he exclaimed, "I have discovered the highest mountain in the world!"

This famous story may be apocryphal, but the excitement was genuine. The year was 1852, and the great mountain's elevation, measured from six different survey stations across northern India, had been calculated as 29,002 feet—only 26 feet lower than the figure accepted today.

The British named it for Waugh's predecessor as surveyor general, Sir George Everest. The Nepalese call the peak Sargamatha; Tibetans know it as Chomolungma (Qomolangma).

My own interest in Everest began nearly 70 years ago in Miss Florence Leatherbee's fifth-grade geography class at Buckingham School in Cambridge, Massachusetts. Every kid in Miss Leatherbee's class wished that he or she could see Everest and climb it.

Later, in 1935, I led an expedition to the Yukon for the National Geographic Society, and, while preparing my report

BRADFORD WASHBURN, a veteran mountaineer and cartographer, was director of Boston's Museum of Science from 1939 to 1980.

at its offices in January 1936, I ran into one of my heroes from Harvard days—the aviator and photographer Capt. Albert W. Stevens. He was working on his account of the flight of the balloon *Explorer II*, which had reached the record altitude of 72,395 feet two months before.

By the time of my retirement in 1980, remarkable improvements had been made in cameras, lenses, film, and aircraft. As I looked around to see what a 70-year-old cartographer with a keen interest in mountains could do, I remembered that long-ago conversation with Steve. The



CAPT. JOHN ROEL BARONEL, EDAM WOOLFIT

Steve had given me my first instruction in aerial mapping. Now he gave me an idea that became a lifelong dream—the mapping of Mount Everest from the air. The British had flown over Everest in 1933, but they had barely cleared the summit. Steve wanted to fly around and *toy* above Everest. "It's a terrific project," he told me with characteristic enthusiasm. I never forgot his words.

Deft hand of an artist airbrushes relief onto the most accurate and detailed aerial survey of Mount Everest ever accomplished. The earliest maps, compiled in 1921, relied on the work of British surveyors Henry Morshead (above, at right) and Oliver Wheeler. "They were among the giants on whose shoulders we stood," says author Washburn.

Mapping Everest

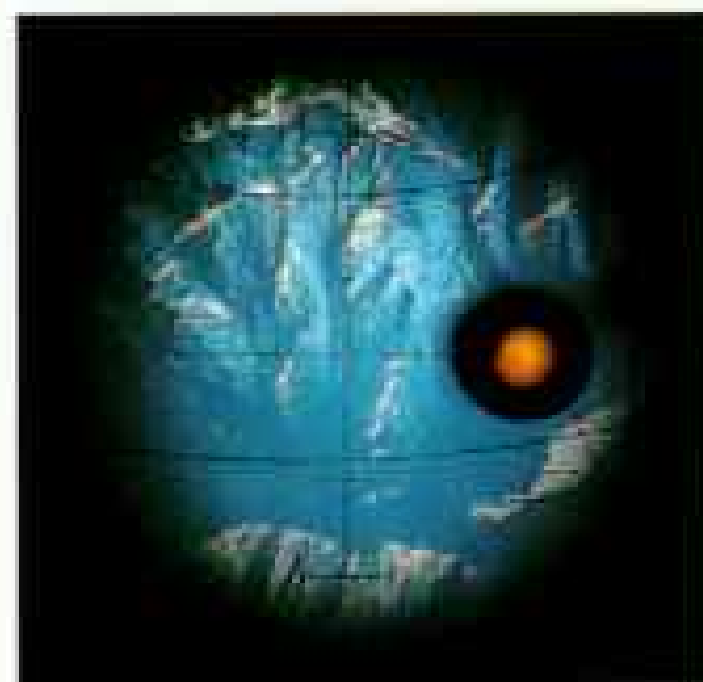
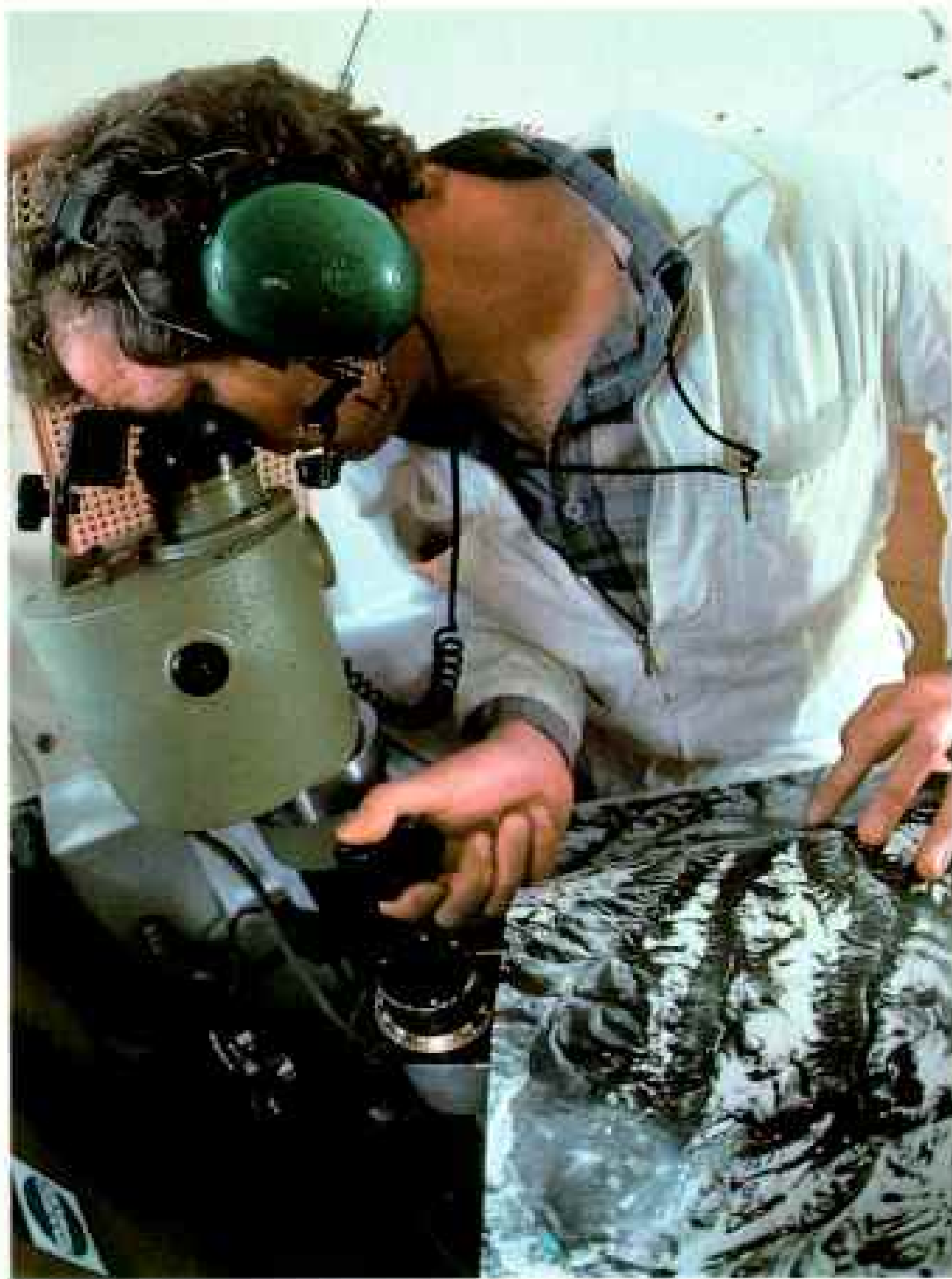
The most recent survey of the high Himalaya, a project begun in 1984 under the aegis of Boston's Museum of Science and the National Geographic Society, mapped 380 square miles of the Everest region. The resulting ten large-scale (1:10,000) maps became blueprints for the shaded-relief map on this issue's supplement.

It all began with the Great Trigonometrical Survey of India. In the late 1840s British surveyors took theodolite sightings of Himalayan peaks from six geodetic stations along a triangulation chain in northern India (diagram, right, at bottom). In 1852 the position and elevation of Peak XV, as Everest was then known, were determined. It took until 1954, however, to establish today's accepted height for Everest—29,028 feet (8,848 meters).

Both this figure and the peak's position were crucial to the new survey, which used Everest as the main ground-control, or reference, point. Crucial too were British, Austrian, and Chinese topographic maps made between 1921 and 1975 by standard ground surveying methods and low-altitude aerial photography.

Stereophotography from space added a new element. On December 2, 1983, the space shuttle *Columbia* passed over Everest at an altitude of 156 miles. A high-resolution West German aerial-survey camera made many overlapping infrared images, each covering 13,800 square miles.

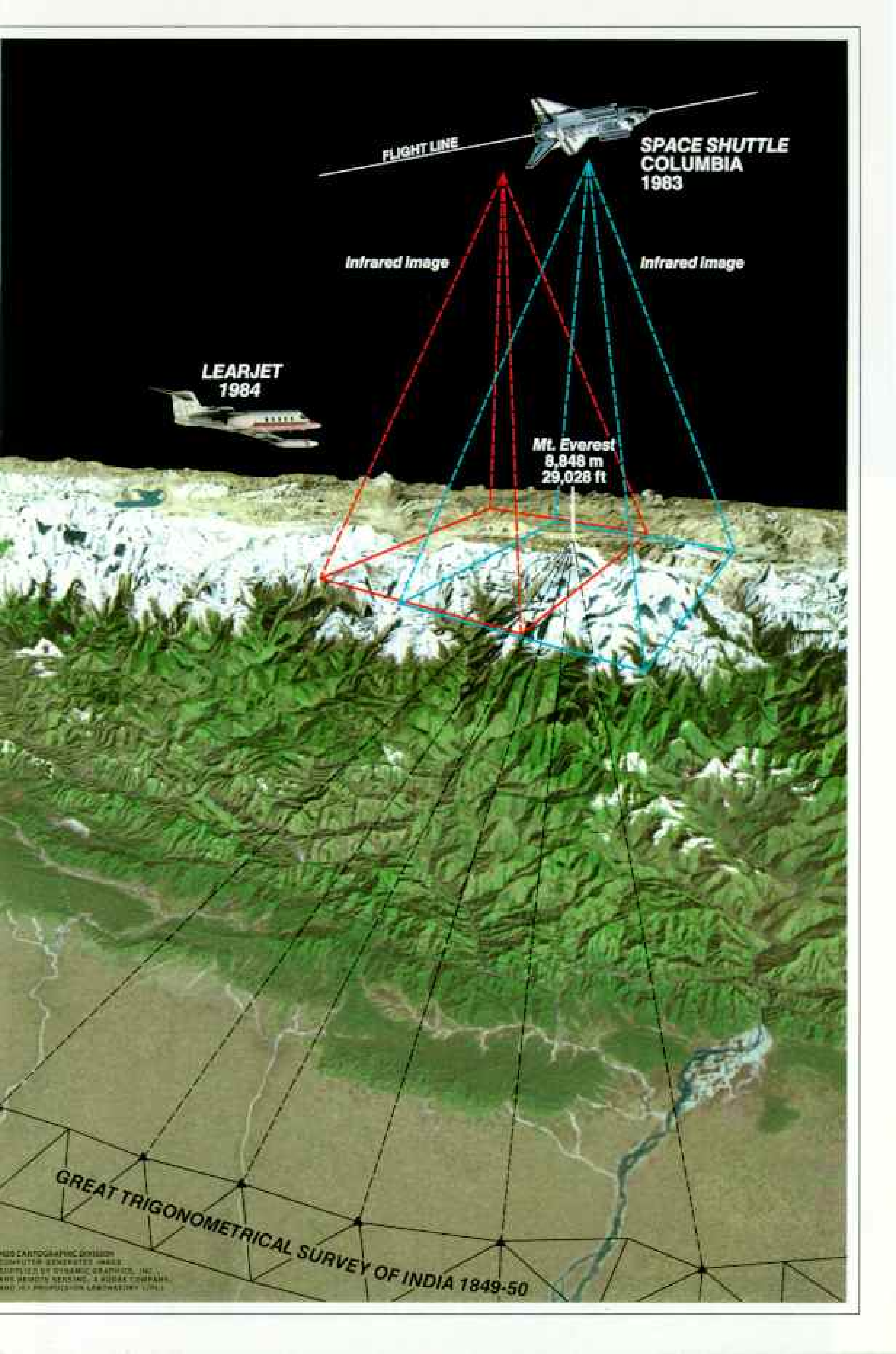
At a Swiss photogrammetry center the locations of peaks and other points on the European and Chinese maps were compared with corresponding features on the stereophotographs. A computer identified map errors and enabled the selection of a hundred new ground-control points used to anchor 160 overlapping vertical aeri-als taken on December 20, 1984, from a Learjet flying at 40,000 feet. The pictures reveal a clarity and richness of detail—borne out on the maps created from them—far beyond the vision of the earthbound 19th-century surveyors.



The view from 40,000 feet aboard a Learjet was "utterly hazeless, like the surface of the moon," said aerial photographer Kurt Keller (above). The camera viewfinder zeroes in on Everest (left). Project leader Washburn (below, at far left) scrutinizes the new map with a team of Swiss surveying experts in Berne.



WILLIAM THOMPSON (TOP AND MIDDLE); ADAM WOOLFIT



FLIGHT LINE

SPACE SHUTTLE
COLUMBIA
1983

Infrared Image

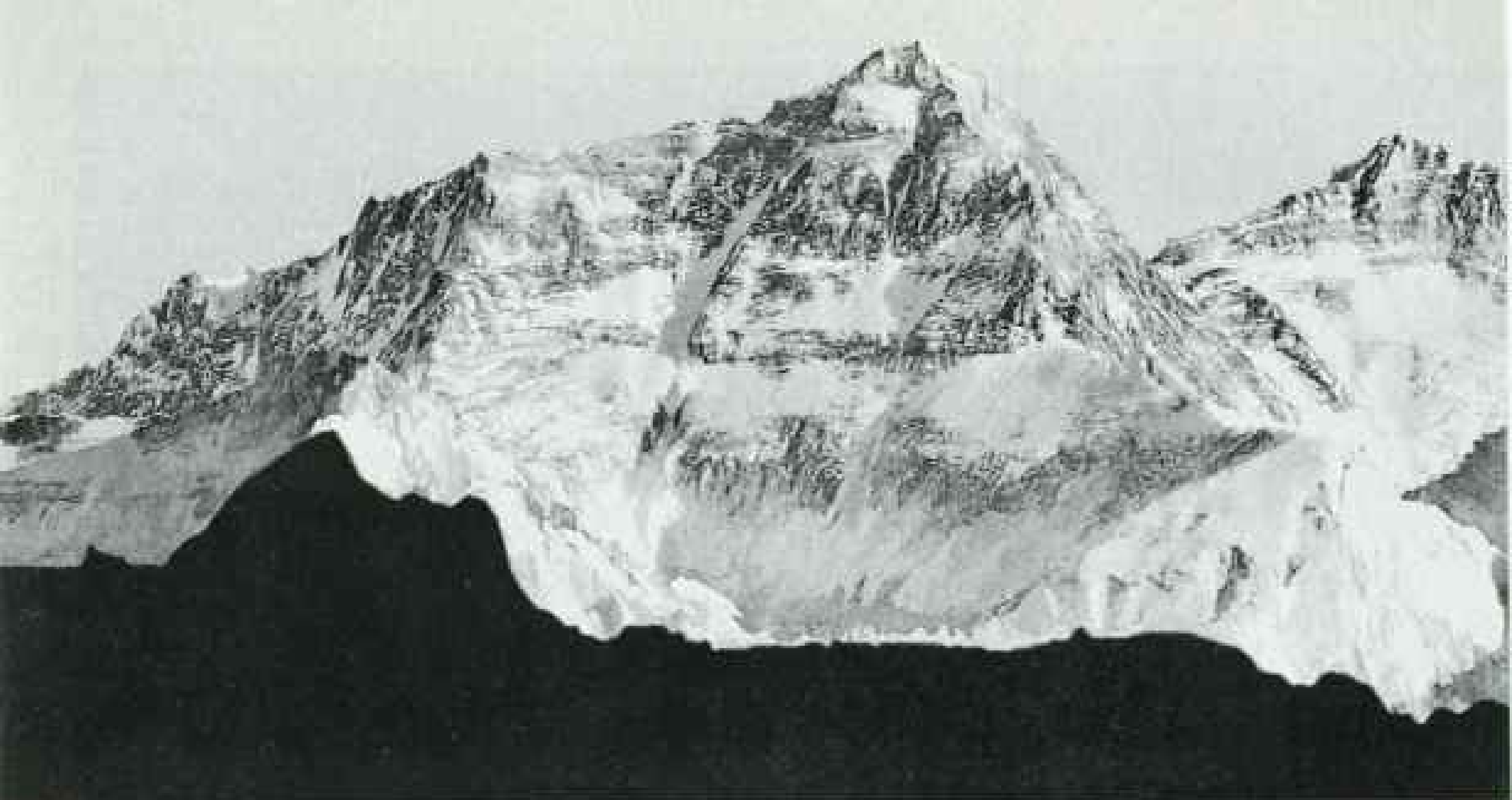
Infrared Image

LEARJET
1984

Mt. Everest
8,848 m
29,028 ft

GREAT TRIGONOMETRICAL SURVEY OF INDIA 1849-50

3D CARTOGRAPHIC DIVISION
COMPUTER GENERATED MAPS
SUPPLIED BY DYNAMIC GRAPHICS, INC.
AND VENTURA SENSIAC & ASSOCIATES
AND U.S. PROPOSITION LABORATORY (1981)



SECRETARIA CORPORATION, ANN ARBOR, MICHIGAN (INDEX); SWISSAIR PHOTO + SURVEYS, ZÜRICH (RELIEF); ADAM WOOLFITT



EVEREST NEPAL



ca. 1:36 000



Dec. 1984



Boston's Museum of Science
Nat'l Geographic Society
Swissair Photo + Surveys Ltd.
Zurich Switzerland



Portrait of Everest (left), one of 160 negatives taken from the jet, shows the mountain from dead above. In a two-year process stereo pictures were converted into a conventional contour map (below). The base maps are so detailed they depict 12-foot boulders and so accurate nothing is more than



30 feet out of place. Using software developed by the Geo-Spectra Corporation, the stereo photographs were digitized and converted into three-dimensional data. A computer can tilt or turn the data to make amazingly realistic images, such as the view (top) of the northwest side.

dream was still very much alive.

With the help of Bob Bates, former director of the Peace Corps in Nepal and my friend of many years, I sought permission from both Nepal and China to fly over Everest with the very latest equipment. Our goal: to map 300 square miles of some of the world's most rugged mountain wilderness.

In the fall of 1981 the King of Nepal opened the door to our project. His Director General of Survey, Arjun Basnyat, told us that if we could secure Chinese permission, Nepal would also agree to our plan. We visited China, and when we returned, we carried with us a treasure that no one had ever brought out of China before—permission to map Everest from the air.

By midsummer 1984 every detail of our plan was completed. Boston's Museum of Science loaned us half the cost of the photographic flight, and our old friends at National Geographic matched this pledge.

To make an accurate map, we needed not only cloudless weather but also a mountainscape that was free of loose snow. We knew that we could count on sub-zero gales generated by the jet stream to sweep the monsoon snow off Everest by early December; after that we could depend on two months of almost constant clear skies.

SOON AFTER we arrived in Nepal, my wife, Barbara, began to run a high fever. It wouldn't go away. The excellent American and Nepalese doctors attending her could not diagnose what was wrong. On November 24 Barbara and I flew to Bangkok, where there were better laboratory facilities. There we were told that Barbara was dying of cancer. If she wasn't flown home at once, she would be too weak to move.

Frantically, I phoned Barry

Bishop at the National Geographic and asked him to take my place as leader of the team (see page 674). Werner Altherr, an expert pilot who was vice president of Swissair Photo + Surveys of Zurich, was asked to direct the aerial photography.

At six o'clock on a Sunday morning Werner met Barbara and me in a snowstorm at Zurich airport with the news that he had been cleared by Swissair Photo to take a Learjet to Kathmandu and meet Barry, ready to fly over Everest with camera, photographer, and lab man.

Twelve hours later Barbara was safely in Massachusetts General Hospital in Boston. Doctors there determined that, though desperately ill, she had not cancer but a rare blood disease—and that they'd caught it just in time.

On Wednesday the Learjet was flown to Zurich, where our big mapping camera was installed and tested at 40,000 feet over the Alps. By Saturday Barry was safely in Kathmandu, and on Sunday the jet landed there with Werner and his crew.

On Thursday, December 20, it took this superb team just three and a half hours to make the mapping photos. Another three hours saw the film developed, fixed, washed, and dried. Werner and Barry pronounced it perfect. It all seemed so very fast, so very easy at the end of so many years of dreaming, hoping, planning.

On Christmas morning Barbara and I were awakened by a ringing telephone. It was Werner: "I've just arrived at Zurich. In my briefcase are 160 gorgeous negatives of Everest. This news and my love are a Christmas present to you both from the team in Kathmandu!"

A
RESEARCH
PROJECT
SUPPORTED
IN PART
BY YOUR
SOCIETY





MAPMAKING from aerial photographs can yield superb results, but it involves a lot of sophisticated science—particularly if you want to make a map that's the best map of its sort ever published. Even small hills distort the accuracy of aerial pictures, and the Everest area is the roughest country on earth.

After the flight our focus turned from Nepal to NASA. To make an accurate map from our photographs, we needed reliable "ground control"—a network of points on the ground, clearly identifiable in the pictures, whose positions and elevations are accurately known. These are as important to the map as a high-quality steel framework is to a big building.

On a cloudless December 2, 1983, the U. S. space shuttle *Columbia* had flown right over Everest at an altitude of 156 miles with a West German mapping camera aboard. The infrared pictures were crystal clear. Our framework was complete.

Our new map, supported by a generous grant from the National Geographic Society, would also depend heavily on the diligent work of the great cartographers of the past. At the department of research photogrammetry (aerial surveying) at Zurich's famous Technical Institute, Professor Armin Gruen took our copies of the old British, Chinese, and Austrian maps and put them through an exhaustive computer-evaluation

To plumb Himalayan heights, space shuttle photographs were used to evaluate the accuracy of earlier maps. Because clouds obscured part of the range in this 1984 image made from Challenger as it passed over Everest, the mapping team relied on photographs from the 1983 Columbia flight.

NASA

program, comparing details with the space pictures.

The Gruen report went directly to the experts of Swissair Photo, half a mile away in Zurich. There Bob Rosenstihl and his assistant, Yoshizumi Shiozaki, used our new large-scale Learjet photographs, fitted precisely to Gruen's control, to make a beautiful contour map. This transformation required two years of the most intricate, painstaking laboratory work.

At the Swiss Federal Office of Topography in Berne, a team of gifted cartographers inscribed the myriad details of Everest's cliffs and glaciers onto the final manuscript map with state-of-the-art precision and scarcely believable patience, often completing only a single square inch of work in a day.

They also added the delicate, airbrushed relief shadows that give the finished map its three-dimensional appearance. Finally all these thousands of hours of work were fitted meticulously together onto the printing plates that went ahead to National Geographic headquarters, where exhaustive studies of the place-names in the area had been going on for two years in cooperation with experts from both Nepal and China. Some of the peaks and glaciers had been named in as many as four languages.

The participants in our Everest project represented nine different nations: the United States, Switzerland, Nepal, the People's Republic of China, Great Britain, West Germany, Sweden, Yugoslavia, and Japan. Truly this was a project of people, each an expert in his own field, working in concert and respect.

As Aristotle wrote, "Each one of us adds a little to our understanding of Nature, and from all the facts assembled arises a certain grandeur." □

HIS NAME is Mani Lal. Like his father and forefathers in central Nepal, he is a master honey hunter. With only a cord around his waist to secure him, he dangles over a 120-meter (395-foot) cliff on a rope ladder to harvest the sweet treasure of *Apis laboriosa*, the world's largest honeybee.

Thousands of angry bees fill the air as he plunges a bamboo pole into their nest. Yet the only extra protection he wears is a loose cape draped over his head and a pair of army pants given to him by a cousin serving in a Gurkha regiment.

Wielding his poles like giant chopsticks, he carves thick slabs of honeycomb into a bamboo basket lined with the skin of a wild goat. When full, the basket will be lowered to companions at the base of the cliff.

The sound of the giant bees is terrifying, but Mani Lal's movements are swift and calm. He has done this many times. He is 64 years old.



Honey Hunters



of Nepal

ARTICLE AND PHOTOGRAPHS BY
ERIC VALLI AND
DIANE SUMMERS



ON THE FIRST DAY of the three-week honey hunt, Mani Lal's younger brother, Sri Lal, joins him carrying their grandfather's percussion musket (left). On days considered inauspicious for hunting honey, Sri Lal plans to go after bear or other game, such as this wild goat shot by fellow villager Bim Bahadur (right).

Of all the hunters in their village, only the nine in Mani Lal's band may hunt honey. Each inherited this right from his father, who taught him his particular skills. Men Bahadur, the strongest of the group, carries the 50-meter bamboo-fiber ladder (below). "Like the many fibers of our rope, our hands are united," says Mani Lal, interlocking his fingers. "Together we can go where one man alone could not travel."



There are no roads in these foothills of the Himalaya, the land of Mani Lal's people, the Gurungs. Decades of porters have worn paths through emerald tiers of young corn and villages nestled up as high as 2,500 meters. Most of the forest has

been cleared. Only the steepest slopes are still wooded. As the trees have dwindled, so have the bees. "My grandfather took 600 nests a year," says Mani Lal. "Last year we took 80."

As the group's leader, Mani Lal decides the appropriate time when each honey campaign begins and ends—one in the spring, another in the fall. He guides his hunters along invisible woodland trails and directs each of their tasks. He alone speaks with the gods. He alone descends the ladder.

Like other sons of large Gurung families, Mani Lal inherited too little land to support himself by farming. But he never wanted that life anyway. "Since my childhood I've preferred running in the forest to mixing dung with the earth," he says. "And so I became a hunter, a man of the forest like my ancestors."







BEFORE HE STARTS down the ladder, Mani Lal takes a small pouch of rice from his waistband. As he sprinkles grains in the air, he recites the different names of Pholo, god of the forest. "I must not cut the comb when the god is not pleased," he says. "I must always pray first."

The Gurungs practice a mixture of Hinduism, Buddhism, and animism. That morning Mani Lal had sacrificed a chicken to Pholo, searching for omens in the animal's lungs.

Mani Lal's father, Barta, taught him the sacred mantras. But Barta's belief had not been strong. As he descended the ladder one day, the bees attacked him by the thousands, and he was blinded by a sting. "He did not make the offerings with a good heart," Mani Lal explains.

Now Mani Lal turns his attention inward. His eyes, normally alert to the slightest movement, lose their sharpness. Without a word, he starts down the swaying ladder like a spider on a frail strand of web. The slightest error of judgment would mean death (left).

Mani Lal stops beneath an

overhang to face a nest nearly as large as he is. Its surface ripples with a thick, black layer of bees. Two of the honey hunters, Krishna and Akam (above), have climbed a third of the way up the cliff to secure the ladder. Clinging to the rock, they pull the rope against the cliff to bring Mani Lal closer to the comb.

Meanwhile a fire has been set at the base of the cliff to disorient the bees with smoke and encourage them to leave the nest. But the wind is blowing the smoke away. Gesturing toward the top of the cliff, Mani Lal issues a silent order. Within minutes a flaming bundle of leaves is lowered, and Mani Lal pushes it under the bees with a bamboo pole. Now panic runs over the living surface of the nest as the bees furiously depart in the smoke. Nothing distracts Mani Lal however. The golden comb has been unveiled.

A husband and wife team, ERIC VALLI and DIANE SUMMERS live in Kathmandu, Nepal. Their book on the honey hunters will be published this month by Harry N. Abrams in New York, by Thames & Hudson in London, and by Nathan in Paris.



TO CAPTURE Mani Lal on film, Eric rappels down the precipice on a nylon rope (left)—the first time a Westerner has ever joined the hunter in his dangerous spot. The rock's name, Samser Bhir, means "cliff of 300 nests," recalling a time when combs were far more numerous.

Bees surround Mani Lal as he begins to harvest the fruit of their labor. The nest has two parts—the honeycomb, attached to the cliff, and the brood comb, the lower crescent with pupae, eggs, and larvae. He uses a pole to push two short sticks into the brood comb. The sticks are tied to a cord dropped from the cliff top. When the brood comb is free, it swings toward him, knocking against his ladder. But Mani Lal holds on tightly, and the comb, a valuable source of wax, is lowered to the ground.

Honey-hunting methods have changed little over the centuries. A cave painting near Valencia, Spain, about 10,000 years old, shows a hunter on a ladder holding a bucket or basket beside a bee nest. Similar scenes have been found in Africa and India.



PHOTOGRAPH OF ROCK ART, ENHANCED FOR CLARITY







“IT’S RAINING honey,” shout villagers gathered at the base of the cliff. Faces upturned, they thrust out pots and pans to catch the sticky liquid as it runs freely from the comb.

These eager bystanders do not belong to Mani Lal’s group, but they are welcome at the cliff nevertheless because they have helped in the past to pay the government’s annual tax on honey hunting. When income from a harvest is slim, the hunters collect the equivalent of six cents from many villagers. These persons then have the right to a taste of honey at the next harvest.

By the time Mani Lal finishes filling the first basket, it’s brimming with 15 liters of honeycomb. As it reaches the ground, villagers swoop upon it, dipping in bowls and breaking off small chunks of comb to chew. It is a honey feast.

Later Mani Lal examines the color of the honey and pours a small amount into the palm of his hand to see if it tingles. If it does, it may not be safe to eat, for the bees are known to visit plants that produce toxic substances. Occasionally a villager consumes the honey before it is tested and collapses on the way home, unable to walk for hours, suffering from cold sweats, vomiting, and impaired vision.

With only capes to shield them, the honey hunters take their share of punishment from the bees. Plucking stingers from his arms with a pair of tweezers later that evening, Mani Lal laughs at the swollen faces of Akam, Amarjang, and Men Bahadur (above right).

“I am old; my flesh is dry and no longer swells,” he says. “But the flesh of young men is soft and blows up with the bites of the bees.”



IN LESS THAN an hour, Mani Lal has harvested perhaps 40 liters of honey and 10 kilograms of wax. The brood comb he'd lowered to the ground earlier (top right) was so large it had to be folded in two by Sri Lal (above right) to be carried back to the hunters' camp in the forest.

Mani Lal is satisfied with the yield from this nest, as he has been with most of the 40 others he cut during the campaign. His group's success, however, carries a hidden price. Although the hunters leave some nests

untouched as "seeds" for the future, their destruction of brood combs has contributed to the insects' decline. But the extensive loss of forest habitat is an even worse threat to the bee population.

Back home on his veranda Mani Lal chats with his wife, Maya (above), as he heats beeswax over the fire. Once it has melted, he pours it through a bamboo strainer into a small well of cold water. Then he kneads the lumps like dough to remove excess water and shapes the wax into bricks of about two

and a half kilograms each.

Mani Lal's brother, Bal Bahadur, the village mayor, measures the group's honey yield and calculates shares for each member. As leader, Mani Lal receives the honey from the four largest nests. Bal Bahadur gets the next largest share, followed by Men Bahadur and Amarjang, who relayed equipment down to Mani Lal from the cliff top. After that, shares go to Krishna and Akam, who tended the fires, and Sri Lal and Nanda Lal, who filtered the honey. The ninth member, Purke, is retired,



but the others like to include him because they consider nine to be a lucky number.

The hunters keep a small portion of the honey for their own families. Most of it they trade for milk or grain or perhaps a day's work. In the past, Mani Lal has given a neighbor three measures of honey (1.5 liters) to plow his field with oxen.

The wax they give to Bal Bahadur to take to Kathmandu. There he sells it to artisans who use it in the lost-wax process of casting bronze. A brick of wax sells for 150 rupees (\$7 U. S.) in

a country where a kilogram of rice is worth only ten.

Kathmandu is a four-day walk and bus trip from Mani Lal's village. The honey hunter has not visited Nepal's capital for 15 years. City life doesn't appeal to him. "We are people of the jungle," he explains. "When we hunt, our bed is made of leaves, our shelter is our cape, our food is the fruit of the forest. We are happy if we have money but just as happy if we don't."

Yet not everyone in the valley shares Mani Lal's attitude. A

younger generation has grown up with a greater appetite for contact with the outside world. To them, Mani Lal's skills hold no interest.

"I'm old. My eyes no longer see well," he says. "Now that I know everything about how to cut the honey, I want to pass my teachings on to my sons. But none wants to be a hunter. They prefer to stay in the village."

Thus Mani Lal has decided that the next season will be his last. And with him the timeless quest will end, for he has no successor. □

By JERE VAN DYK

Photographs by
RAGHUBIR SINGH
and
GALEN ROWELL

One of the world's great rivers, the Brahmaputra begins as a glacial trickle in western Tibet and sweeps 1,800 miles to the Indian Ocean at the Bay of Bengal. Brahmaputra means "son of Brahma," the Hindu god of creation. Like a Hindu deity the river has many avatars, or incarnations, changing its name and nature with the myriad cultures and landscapes of China, India, and Bangladesh. As the Siang, it churns beneath a web of cane and wire built by a mountain tribe just south of the disputed Chinese-Indian border. This region was among the last explored in a centuries-long quest to solve the mystery of the Brahmaputra's course. No one is known to have traveled the entire run of the river.

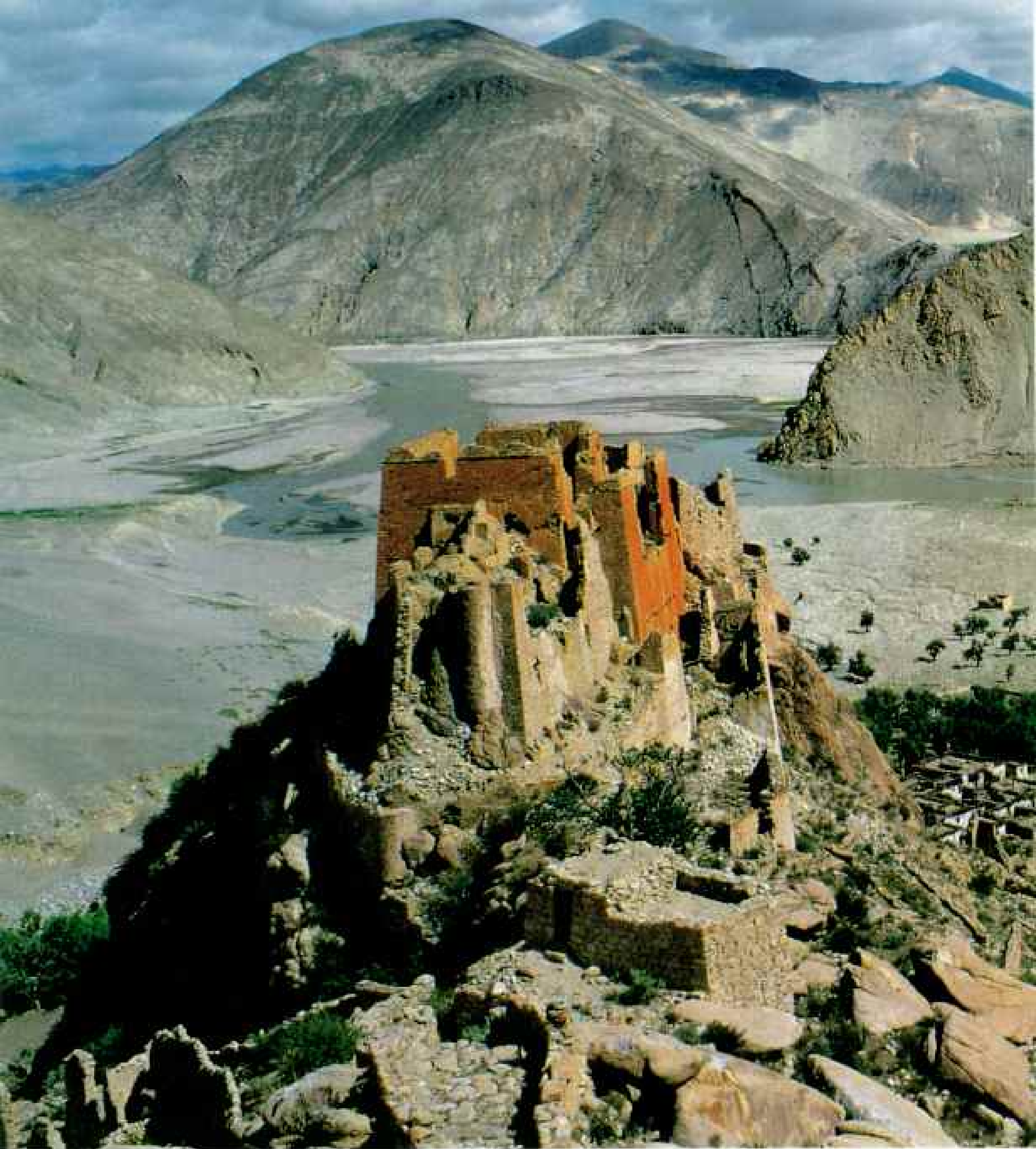


Long Journey



KACRUVE BIRCH

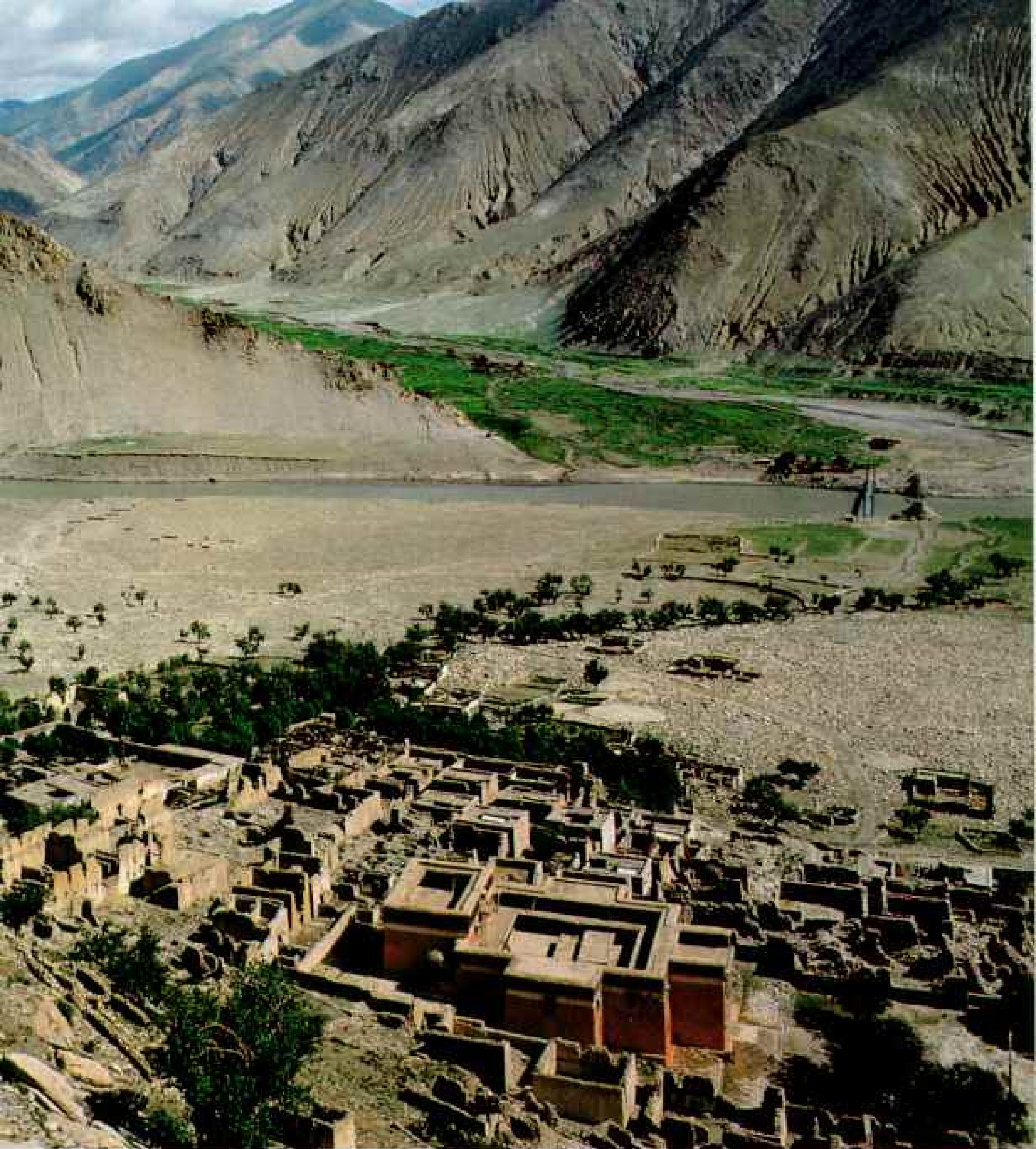
of the Brahmaputra



WE RODE WEST toward the source of the river Tibetans call the Zangbo. High white peaks rose around us. We passed herds of yak and sheep, black wool tents, and solitary horsemen whose long hair blew in the wind. We lived at 15,000 feet and crossed passes of 17,500, where our Tibetan companions shouted "Victory to the gods" in greeting to the beings that protect these places.

Tibetan eagles were silhouetted against high peaks; furry marmots, hares, and foxes bounded up hills or sat still in the sun; giant Himalayan ravens soared above us; antelope stared; and elegant kiangs, wild asses with black manes, tan-and-white bodies, heads and necks held high, ran in herds for miles across the plains.

We passed settlements with fading white-washed mud-brick walls, red flags, basketball courts, loudspeakers on poles. The road, a



THOMAS LAURIE

long thin line, disappeared ahead of us, and then the road became a track.

We had begun weeks before in Kathmandu, where I met photographer Galen Rowell and Ted Worcester, a Tibetan-speaking American who would be our guide. We made final preparations to depart, purchasing gear and food, when word came from Lhasa that our trip was canceled. We decided to try anyway. With our crew of three, Pema, Gompo, and Targye, Tibetans who had fled to Nepal, we made our

SIMPLY CALLED "river," the Zangbo, or Tsangpo in Tibetan, passes the ruins of a Buddhist monastery at Phuntsogling. Monks, nuns, and villagers were forced to destroy the monastery after Tibet's failed revolt against China in 1959. One of the Zangbo's few bridges crosses here, next to the remains of a 15th-century iron suspension span erected by Thangtong Gyalpo, a holy man who built bridges to aid pilgrims.



way to 2.2-mile-high Lhasa, where we heard new reports of fighting between China and India on the Tibetan border.

"You cannot travel beyond Zetang," said Mr. Chen, a soft-spoken officer in the Chinese Army. We could not go near the gorges at the eastern edge of the Himalaya, through which the Zangbo crashes down into India.

"The army controls the border," said Mr. Chen, "and permission to travel near it, which must come from Beijing, has been denied. You can, however, go west to Mount Kailas." He drew on a cigarette and coughed. "I do not like this thin mountain air," he said, smiling. We did not mention our destination, the source of the Zangbo, and were grateful for the permits that he issued us.

Chinese forces conquered Tibet in 1950. There has been great friction ever since between the pragmatic Communists, who have come here to create a new world, and the pious Tibetan Buddhists, whose goal has been to live in harmony in the world as it is. There were many Chinese soldiers on the paved streets of Lhasa, scene of recent rioting.

In a few days we secured Tibetan drivers and rented overland vehicles and a truck to

JERE VAN DYK, author of the book *In Afghanistan*, grew up in the Pacific Northwest and now lives in Manhattan. RAGHUBIR SINGH's photographs illustrated our article on India's Kerala (May 1988), and GALEN ROWELL's most recent GEOGRAPHIC assignment was to Pakistan-controlled Baltistan (October 1987), sometimes called Little Tibet.



ALL BY GALEN ROWELL

LEGENDARY SOURCE of the Brahmaputra, sacred Mount Kailas rises beyond clothing discarded by pilgrims cleansed of their sins. The 30-mile trek around the mountain is one of the holiest devotions for both Buddhists and Hindus. July snow at 18,600 feet adds to the struggle on Dolma La, the route's highest pass (above).

The ancient legend is close to fact—the river is born 60 miles southeast of Kailas in the Chemayungdung range. Its source glacial stream lies at left in this photograph (below), looking east and downstream from a 20,600-foot unnamed peak. Van Dyk and Rowell believe they were the first Westerners to visit the true source since 1864.



A riverine odyssey

"This river must needs have a very long course before it enters the Bengal Provinces, since 400 miles from the sea it is twice as big as the Thames. . . . [There is] the strongest presumptive proof possible of the Sanpoo and Burrampooter being one and the same river."

BRITISH MAJ. JAMES RENNELL
Surveyor General of Bengal, 1788



NOT UNTIL EARLY in this century was it certain that the Zangbo and the Brahmaputra were one. More than two miles high for most of its Tibetan course, the Zangbo picks up speed along with regional names. Most Tibetans live along the Yarlung Zangbo and its tributaries from Xigaze to Zetang, where Tibetan Buddhism developed in the late eighth century. The Zangbo irrigates this land kept dry by

the rain-blocking Himalaya.

The river narrows at Pei into a rapid-filled gorge reaching depths of 10,000 feet and drops a phenomenal 7,000 feet in 150 miles. If China should proceed with plans for a dam in the great bend, it would be the world's greatest generator of hydroelectric power.

Politics as much as geography has limited exploration and exploitation of the river. China and India contest their border; China

rejects the McMahon Line drawn between Tibet and British India in 1914. India and Bangladesh differ over control of the subcontinent's strongest river. Fortified by tributaries, the river broadens through India's Assam valley. It enters Bangladesh as the Jamuna and ends as the Meghna. Normally life-giving monsoon floods raged this September, drowning two-thirds of the country and leaving millions of people homeless.

One thousand people died when one of the region's frequent earthquakes—centered a hundred miles southeast of Kathmandu (left)—triggered slides and leveled villages last August. Grinding northward at about two inches a year, the Indo-Australian plate collides with the Eurasian plate, lifting the Himalaya by perhaps half an inch annually, outpacing erosion.



Flood Ravages Bangladesh

At the mercy of the mighty rivers that converge on their low-lying land, residents of Dhaka, the nation's capital, seek aid during this year's devastating flood. Caused by torrential monsoon rains, the deluge was greatly increased by runoff from deforested regions of Nepal and northern India—an ill omen for the future.

carry extra supplies: a thousand gallons of fuel, dried mutton, and vegetables.

On the second day out from Lhasa we came upon a truck stuck in a stream. "Where are you going?" Gompo asked the travelers.

"To Nyalam. It is our home."

"How far is it?"

They smiled. "Who knows?"

One night we shared tea with three pilgrims. The next night they were at our camp again. "They rode in the back of our truck," Pema said. "They are going to Kailas. They will bring us good luck." We would gain merit, Pema explained, by protecting pilgrims.

Our goal, and my assignment, was to find the true source of the Zangbo, where no Westerner had been in more than a hundred years. I was to follow the river from the Chemayungdung Mountains, where it rises, 700 miles across Tibet down into India, where it becomes the Brahmaputra, and then through Bangladesh to the Bay of Bengal, 1,800 miles away, where, at a maximum rate of 2.3 million cubic feet of water a second, it joins the sea.

On the 16th day two women and four children appeared, gathering yak dung for the fire. Ted smiled. "They must have sneaked on at Paryang." Pema came over. "This woman is from Amdo. Her husband died, and she and her children and sister are going to Kailas. She waited 20 days in Paryang."

Beyond Gurla Mandhata, 25,355 feet, near the borders of Tibet, Nepal, and India, there were more pilgrims, old women with heavy packs, young men together, always smiling, always trying to hitch a ride. We were now 20—six members of the expedition and 14 pilgrims—and had no more room. We reached Lake Manasarowar, at 14,950 feet, 54 miles around. It was turquoise and sparkled in the sun. From there we saw Mount Kailas, 22,028 feet high, the center of the universe for Hindus, Buddhists, and Jains, and the Tibetans clapped and shouted for joy.



ACCORDING TO ANCIENT BELIEF the Ganges descended from Mount Kailas to a spring called Chhimikthungtol. From there four great rivers, the Brahmaputra, the Ganges, the Sutlej, and the Indus, emerged in copper pipes through Lake Manasarowar and, after circling Mount Kailas and the lake seven times, took their courses east, south, west, and north across Asia.

Tamchok Khambab, "the river coming out of the horse's mouth," spilled from a glacier in the Chemayungdung Mountains. The water was cold, the sands were composed of cat's eyes and emeralds, and those who drank from the newborn stream became as strong as horses. This was the source we sought.

"One walk around Kailas," Ted explained, "washes away the sins of a life; 108 (an auspicious number to Tibetan Buddhists) and you achieve nirvana in this life."

At a lake below Dolma La, 18,100 feet on



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our altimeter, Targye and Gompo sought a new vision as they looked into the water. A large pile of clothes lay where pilgrims had cast off the old life and pricked their fingers to shed old blood.

On the far side three Tibetans in their twenties, two men and a woman, sat by a rock with their faces glowing. "We are from Litang, and we have run away from our Chinese school to become monks. She will become a nun. Our parents do not know where we are. We have neither papers nor money, but when we finish here, we want to go see the Dalai Lama in India."

They would take three weeks to prostrate themselves around the holy mountain, walking one step, raising their hands in prayer, lying down on the ground, their arms in front. Their merit would be great; the Marxism vigorously taught in school could not compete against the spiritual force of Buddhism that appealed to their young and ardent souls.

Near Togqen we stopped at an adobe compound, hoping to find a guide. The wind whipped our clothes and burned our faces, and we shivered in the hot sun. Inside we were introduced to a man with a deeply lined face. His ears were pierced. A knife and a flint for making fire hung from his belt.

"Do you know the Chemayungdung?"

"I was born there," he said.

"Would you show us where it is?"

He looked us over slowly. "Yes."

His name was Tsewang Norbu, but we would call him Abu, which means "big brother" in his Horpa dialect. He was a nomad, or *drokpa*, with 50 yaks, 300 sheep, and 6 horses. "My wife and sons are up in the hills," he said, "but I came to build a house."

"A home?"

"No, a place to store barley and wool. I could not live in a house. It is better to be with animals in the open." Pema nodded in agreement.



ALL BY GALEN WIDWELL



"Life is not entirely banished from this naked, sterile, desolate wilderness of stone!" Early in this century Swedish explorer Sven Hedin marveled at the animal life along the upper Zangbo.

Galloping in hierarchical order, herds of regal kiangs, the largest Asian wild ass, live at elevations above 13,000 feet. Their numbers were severely reduced in the 1960s, when Chinese soldiers shot them for sport and food.

"The wild animals do not sense that man is their enemy,"



observed Hedin. "They know only the wolf and are alert against his cunning." Capable of bringing down even a yak, wolves are plentiful in the region but rarely seen.

A gull swoops past one drinking in a lake south of Lhaze (above). Summer residents, rare black-necked cranes breed in the marshy Maquan Valley near Paryang.



"Where we are going, there is much snow and ice," said Abu. "It is where we used to hunt *drong* in the summer."

"Drons, the famous wild yaks. Few Westerners have ever seen them," said Ted.

We traveled across prairies, streams, valleys, ridges. Abu pointed the way. We passed a little girl watching a thousand sheep. Animals stretched out for a mile. Abu pointed to a tent. "My sister lives there." They touched heads in familiar greeting, and she invited us in. The yak-butter tea was hot and made the cold go away. Her name was Sonam Zangmo; she poured yak cow's yogurt from a sheep belly, and we gulped it down. It was thick and sweet and the best I had ever eaten.

"We came down through the Mayum La. Later this summer we'll move the animals across the Yarlung Zangbo," she said.

We continued on and came to a mile-long lake with white-capped waves two feet high. "It must be Tamulung Lake," Galen said. "This must be the Angsi River." We had our maps spread out. No one was certain. Abu pointed south. The vehicles could not go any farther.

SAYING WE WOULD RETURN in four days, but not certain we would be able to do so, Targye, Abu, Galen, and I started walking south. The vehicles turned and disappeared over a ridge. We came to a stream and waded in above our knees. We reached another wider stream and believed it was the Angsi. We walked south-southwest into the wind.

We camped in a hollow by a lake, and Targye made hot mutton soup. On the far ridge a herd of kiangs moved in single file toward the lake. A burst of wind, and they were gone.

The next morning we crossed soft tundra. Water flowed beneath thin ice that cracked as the sun grew warm. We reached a glacier valley floor a mile wide. The Zangbo flowed by in front of us, bright emerald green. The legend was true. It was silent here, with no people, no birds, no trails.

"We are here," said Abu, resting his pack against a rock. The beginning is up there."

We made camp an hour's hike farther up, and with six hours of sunlight left, kept going. Galen consulted a guidebook written for pilgrims by Swami Pranavananda in 1949. "There should be a *chorten*, a shrine of holy relics, a place of offering. The swami saw it in

1937. From there it is not far to the source."

"I do not know this *chorten*," said Abu.

An hour passed. "There it is," Galen cried. We approached a solitary gray monument with tattered prayer flags and Buddha figurines inside, and two stones deeply indented in the center. These were the Buddha's footprints, to show us the way. We came to a gully; the Zangbo now flowed under ice.

"Look, look—drons!" Galen cried. Wild yaks at the source. There were 20 of them, like a line of poetry against the mountains, a few newborn. They stood still for a moment, then ran back up onto an ice lake. Galen grabbed his camera. "Wait here," he said.

An hour passed. Targye drew a mandala in the sand. We curled up like dogs out of the wind and slept. In another hour Galen returned. "I chased them as far as the source."

"The source?"

"It's a ways up there. My altimeter said 16,800 where the glacier began." We walked back to camp, and I climbed into my sleeping bag and fell asleep.

The next morning I set out alone. We had all been together 24 hours a day, and I welcomed the solitude. The only sound was the water rushing beneath the ice and the wind by my ears. Two jagged mountain ranges rose on either side. I walked up across an ice lake, and then a ravine, and onto another lake, half a mile across. The ice was four or five feet thick, except where the stream cut through.

A crack as loud as a cannon shattered the silence as a chunk of ice broke. I followed the stream up another ravine and onto a third lake where—I stopped dead—20 drongs watched from a hundred yards away. They were thin, each the size of a large cow, with thick, long, black hair and horns that came out from the sides of their heads and then turned up. They were bunched together and stared at me with big dark eyes. In the north of Tibet, I had heard, these wild yaks can grow to be 6 feet high and 12 feet long. I walked slowly toward them and pondered Abu's warning: "A herd is safe, but a single drong will attack."

CHURNING YAK-BUTTER TEA, a nomad mother of three and her husband welcomed author Van Dyk and photographer Rowell to their tent near the river's source. Outside the wind blew at 50 miles an hour. Four families, camped at 16,500 feet, graze yaks, sheep, and goats here during the summer. GALEN ROWELL





CASUALTY OF CHINA'S CULTURAL REVOLUTION, Gaden Monastery was destroyed by explosives during the 1960s. Its 3,300 monks were scattered, killed, or imprisoned. Today 350 monks and local volunteers are rebuilding the once powerful Buddhist



DALE H. HOWELL

center overlooking the Lhasa River, a Zangbo tributary. Established in 1409, Ganden became one of Tibet's most influential monasteries, producing the dynasty of Dalai Lamas, who ruled the country as a theocracy from 1642 to 1950.

I got within 75 yards, but the animals turned quickly and ran across the lake and, with the babies behind, bounded up a ridge. I crossed the lake, and at the far end there was a glacier, the source. A trickle flowed from the ice. As Galen had said, the altitude was 16,800 feet. I named the ice on which I stood Drong Lake.

I slowly climbed the glacier. The two jagged ridges continued back. They were, I thought, the two ears of the horse, and the glacier was its mouth. *Tamchok* means "celestial horse," and *khambab* means "coming out of the mouth of." Thus, the Tamchok Khambab.

I was standing at the beginning of the river.

On July 13, 1907, Sven Hedin, the great Swedish explorer, reached the Chemayungdung but misidentified the Kubi and its feeder streams, six miles south, as the true source of the Brahmaputra. Though Hedin was certain he was the first to reach the source, it seems that in 1864 four British hunters, Edmund Smyth, Robert Drummond, Henry Hodgson, and Thomas Webber, got there first when they secretly crossed into Tibet while hunting "the rarest of all animals," the wild yak.

I climbed until I twice sank up to my waist in snow. The drongs were disappearing over the top of the ridge. The glacier continued, and another mountain range rose beyond it. The sun would set in a few hours. I looked once more at the drongs—the last baby had caught up with its mother—and started back down.

WE FOLLOWED the Zangbo downstream. A few days later, Gompo directed us to a single tent. A tall woman with a piece of straw in her mouth invited us in. I sat on a sheepskin next to a full leg of yak. Refrigeration is not needed in this high dry climate. Gompo came in with his 80-year-old uncle, who had been with his herds. The uncle picked up a hot piece of dung and lit his pipe. "We have lived here all our lives," he said, "sharing this land down to the river with other families. The Chinese leave us alone now." Tears came, and Gompo put his hand on his uncle's knee. After many years of forced collectivism, Tibetans are for the moment free to graze their animals and trade, much as they have done for centuries.

We reached Tradom, once a famous monastery, now a town with deep sandy streets, broken bottles, and Chinese soldiers. In 1865 the famous explorer-spy for the British Survey of

India, Nain Singh Rawat, and his servant, Chhumbel, walked from here downstream disguised as pilgrims. Yes, they thought, maybe the Zangbo did flow into India.

South of Tradom soldiers came across the river on a cable ferry, saying: "We do not recognize your vehicles." They looked dubiously at our papers and told us to leave.

At Kanjur we looked out on thousands of sheep, the Zangbo, the Himalaya to the south. "At New Year's," Pema said, "we came here to watch horse racing and lama dancing and make offering to the gods." We stood on rubble that was once a monastery. In the Cultural Revolution, and even before, thousands of monasteries and temples in Tibet were razed. Only a few big religious monuments survived.

As we descended into the widening valley, lying at a little over 12,000 feet, the Zangbo also grew wider. The wind was warmer, and our water was not frozen in the morning.

We stopped at a nomad camp at a bend in the river. A woman named Pema Dolma had clear gray eyes and sat straight as she spoke. "We have been here three months, but soon we will move downstream. It is not like it once was. There are too many people." Tibet is nearly 500,000 square miles, more than twice the size of France; it has about two million people. I had not seen anyone for miles.

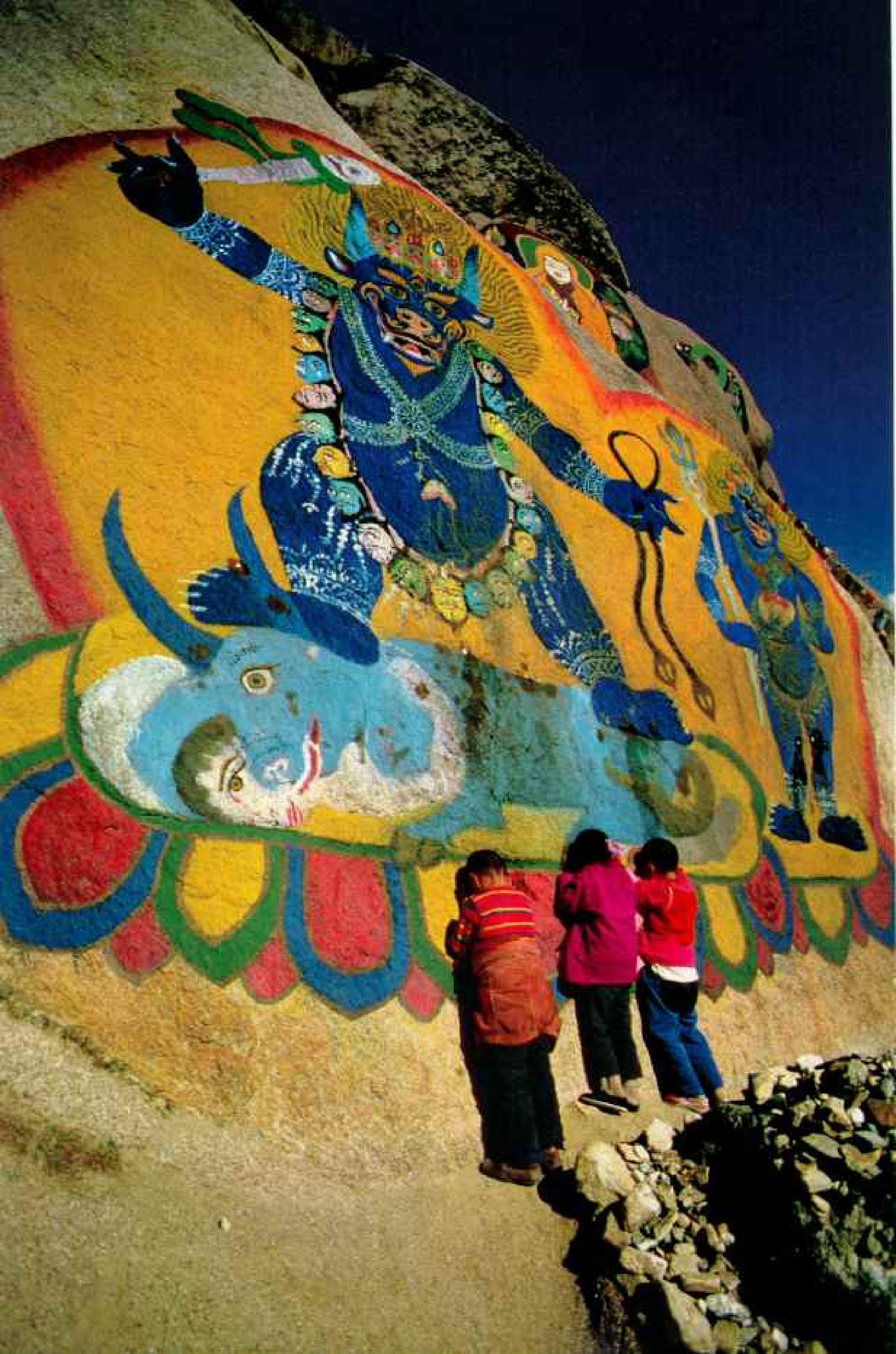
"My husband will return when the light reaches the pole," Pema Dolma said. Through an opening the sun's rays would soon hit one of the tent's poles.

Lobsang, her husband, arrived as expected. He had a barrel chest and squinted in the sun. "Wolves killed two of my horses last week," he said. "A *dremo* broke into a storehouse, killed a little girl, and ate our meat."

Abu had mentioned a *dremo*. It was like a giant bear and stood up on two legs. He called it a yeti—the Abominable Snowman.

At a ferry crossing beyond Lhasa, two Chinese fishermen and a Tibetan brought in their catch. "The Tibetan only helps them," Ted explained. "He does not fish. Water is sacred.

YOUNG PILGRIMS at Sera Monastery pray to Shinje, the lord of death. He can consign evildoers to hell or guide them to better rebirth. Also known as Yama, the god here tramples the symbol of fleshly passions that block enlightenment. Recently repainted, the figures testify to the resurgence of Buddhist devotion in Tibet. GALEN HOWELL



Fishing disturbs it, and it is wrong to kill."

Targye turned up his nose. "I don't like fish," he said.

The ferry was a flat-bottomed skiff with a Chinese outboard motor. Here the Zangbo was flat, silent, and blue-green. A bird, which Pema called a *chup-cha*, swam upstream with only its beak above water. Targye took off his shirt and washed it in the river. Suddenly a thick cloud of dust spread down the valley toward us. We covered our faces and pulled our hats low. Dust surrounded us. The mountains disappeared, and water sprayed over the boat. We hit a sandbar. The motor stopped, and we drifted downstream. Finally it kicked in, and the storm passed.

WE CAMPED in a meadow and the next morning climbed to meditation caves overlooking the valley. A teenage monk led us down stone steps and into one cave and through to another, farther back. Our eyes adjusted, and we saw small statues of Buddha and pictures of the Dalai Lama. A man chanted softly. He wore a thick maroon coat and had close-cut black hair. Later he came outside. "Four months ago I came here," he said, thumbing his rosary. "There are other monks and nuns around us in solitary meditation. I will soon meditate for three years, three months, and three days."

The next day a squall came up, and we stopped in a grove of willows. While the water heated for yak-butter tea, four women came walking across the sand. They wore thick black coats and wide-brimmed felt hats and carried wood-frame rucksacks. "Where are you going?" Gompo asked, as he poured tea.

BENDING A WILLOW BOUGH, a shepherdess helps her flock forage near Zetang. Here at 11,000 feet the Zangbo gradually descends into verdant landscapes. Lumbering is a major industry at Pei, where a Chinese soldier abandons a truck to the mud near a logging camp for prisoners. High wages attract Chinese to this isolated region. In the fast-growing military city of Bayi, population 20,000, a Tibetan pool player aims for the corner pocket. Tensions have relaxed since last year's anti-Chinese demonstrations, when Tibetans put up signs welcoming the Indian Army. Indian reconnaissance planes still pass over this sensitive area.





RALPH HOWELL (ABOVE), RYAN BRIGH (BELOW LEFT), STEVE LENMAN (BELOW)





"We have been on a pilgrimage to the holy sites in Lhasa and Samye, and we are returning home," said one, whose name was Tiejung. "Can you give us a ride?"

She took out a six-inch knife and cut a slice of meat from a bone she had pulled from her pack. Her braided hair shone with yak butter.

The women rolled *trampa*, the Tibetan staple of roasted barley flour, with cheese, sugar, curd, and butter, into small balls and ate it.

"Our husbands are taking care of the animals, the fields, and the children," said Tiejung. They had gone a thousand miles in two months. A truck went by. The women watched it, already bored with us, who were going the wrong way. They put their knives in their scabbards, bowls and teapot in their packs, and waved good-bye.

We reached Zetang. In 1874 Nain Singh, also following the Zangbo, stopped here and returned to India. The river remained unexplored farther on for many years.

"You may not go beyond Zetang," Mr. Chen had said. I heard of thousands of soldiers between us and the northeast frontier of India, served by one main road. We discussed how to go. Our escorts were nervous. I thought of going alone, staying away from the road, relying on Tibetans for help, but if I were caught. . . .

China does not accept the McMahon Line, drawn in 1914 along the eastern Himalaya, dividing India and Tibet. Now, as in 1962, Chinese and Indian soldiers were massed on the border of Arunachal Pradesh, disputed territory that India had just recently declared a state. Reluctantly, we turned around.

At Saga we waited for a break in the wind, then crossed the river on a cable ferry. Two Tibetan women with red-and-blue scarves in their hair pushed us across with long wooden poles. We drove south and within two days reached Nepal. *(Continued on page 698)*



"THE THUNDER of the river was almost deafening, and the whole earth seemed to vibrate," wrote botanist Kingdon Ward, who camped "amongst the boulders" along the Zangbo's gorges in 1924. Assisted by local porters, the first European to enter the great bend crossed the river "by slow, cruel jerks" on a pulley, a method little changed today (right). He reported frequent landslides (top left), a phenomenon that intensive logging aggravates; treacherous waterside roads (left) are often washed out.

THE TRUCK (TOP LEFT) BY STEVE LEHMAN (ARTIST); ON ZICHUAN TRADING POST





A Rare Visit to a World Unto Itself

By RAGHUBIR SINGH

The author was granted extremely rare government permission to travel and photograph in the far north-eastern frontier of India, an area claimed by China.

THE CRIES of mynahbirds and laughing thrushes filled the morning air as I followed the narrow jungle trail. A snake slithered across the path and into the thick vegetation. My load was lightened by two porters who helped carry luggage, cameras, and film. Periodically I stopped as the men sought blessings by walking in circles around small Buddhist monuments called chortens.

I myself felt fortunate to be here in Arunachal Pradesh, a state that hugs the India-China

border. The Indian government seldom permits outsiders to visit this isolated land, the home of tribal peoples who enjoy a degree of cultural and political autonomy unusual in India.

I was drawn here by my lifelong love of rivers. The sacred Ganges, so important to India, has been central to much of my work as a photographer. India's border war with China in 1962 drew my attention to this other great and sacred river, the Brahmaputra.

After descending through the



tortuous gorges of Tibet, the river—here called the Siang—rushes through forested canyons (above left). A 600-foot-long cane and steel-cable bridge serves a village on the far bank. Too swift for navigation, this narrow reach races over rapids and is seldom crossed except by bridges at the larger villages.

Just south of the Tibetan border I visited the Buddhist village of Bishing, one of several inhabited by the Tsanglas. Speaking a Tibetan-influenced language, these people recount a

migration from Bhutan ages ago. Women cleaned rice near the skin of a jungle cat hung to frighten away birds (above). Thatch roofs shed the heavy rains of the monsoon from houses built on poles to escape the soggy-ness of the season.

During my three-week stay I began to understand the Indian government's policy of banning outsiders. Ending this policy could spell doom for a unique culture. Based on experience in other remote regions, we know that newcomers would buy

land, set up businesses, and exert alien influences.

Instituted under Prime Minister Jawaharlal Nehru, the policy has been criticized as thwarting social advancement. Yet I don't consider these people backward. The caste system so ingrained elsewhere in India does not exist here. Democracy is inherent to tribal life, and justice is administered by tribal councils. Many young people attend school, and some go on to universities. It is in their hands that the future of Arunachal Pradesh lies.

AS I ENTERED the village of Gette, some 30 miles south of Bishing, I could sense the excitement as people prepared for the annual winter hunt following the December rice harvest.

The people of Gette are among the tribal groups known as the Adi, animists who sacrifice animals and consider the river a deity. They fear dangerous water spirits called *nip-pongs*. A red robe and headdress of cane and bearskin distinguished an old man as a village elder (below). He carried the head of a freshly killed monkey to place outside his home as a talisman.

Days before, some men had risen at 4 a.m. to trek up the mountains beyond the snow line to harvest poisonous roots. Over and over, until their faces were red, they shouted: "*Gogbat! Gogbat!*—May the poison be most powerful."

On the day before the hunt, the men gathered in the *nam ghar*, or communal hut (below, right), for the pre-hunt feast. Their meal of wild boar, roasted pig, and venison was washed down with draughts of *apang*, a beverage made of fermented grains. Mildly intoxicating, it has a sweet-and-sour taste.

Filing out of the village the next morning (right), the men

carried bows and poison-tipped arrows. Others opted for rifles, a weapon introduced by British colonists. The next day, they returned with prey reflecting wide-ranging tastes: birds, rats, boars, squirrels, monkeys, and deer. Supplemented by grains, eggs, beans, and fruit, the diet of these people surpasses that of many of their countrymen living in the crowded plains of India.

The proud, self-confident peoples of this remote land function quite well, assimilating modern influences at their own pace. I believe they should be left alone to find the right balance between their past and the present. * * *





PERMISSION TO TRAVEL the Brahmaputra in India had been held up for months. Finally the Home Ministry gave me a pass to Kaziranga, a wildlife park in Assam.

In Guwahati, the capital of Assam, two plainclothes police met me at the airport. "You cannot go to the city," they said. "A taxi will take you to Kaziranga in the morning." Rain poured down all night, and I sweated in my bed. At 5:30 a.m. the security man knocked on my hotel door.

Here, as in Tibet, there were rumors of war.

We headed upriver. Steam rose from the jungle by the road. Rice paddies appeared, the valley widened, and the Assam hills rose on either side. The Brahmaputra, swollen by floods, covered the flatlands beyond its banks:

The road passed over a narrow wooden bridge. Beneath it a man poled a boat over to a place where only the thatch roofs of a small village were above water. Nearby, a man named Chokum and his neighbor Hauna split bamboo into strips four inches wide. Then Chokum wove the strips into a wall and with twine brought them firmly together.

He was building a new house to replace the one the flood had washed away a few days before. His wife, Janna, brought a glass of tea with milk, smiling. "Every year this happens. We send our cattle to the hills, and we build a new house." Her toenails showed the red of henna, and she had a tattoo on her arm.

Flies and mosquitoes buzzed around us. A newspaper said medical units were preparing for a cholera outbreak. "We have nowhere to



go, but we are fine." Would I like more tea?

The next morning Gunin Saikia, range officer for Kaziranga, took a sip of tea and unrolled his map. "The Brahmaputra is of great benefit to us," he said. "Its sediment creates rich soil for elephant grass and new islands in the river that animals can use. We want to increase the park from 430 to 884 square kilometers."

This is the home of more than two-thirds of all one-horned rhinoceroses in the world. There were 366 in 1966; in 1984 there were 1,080. Kaziranga was declared a wildlife sanctuary in 1950 and a national park in 1974. Money was provided for park guards, and there is less poaching now. The rhinos are watched closely, but about 30 are killed illegally each year.

Two hundred yards away the Karbi tribe,

whose land the park also wanted, lives near the jungle. Tarun Gogoi, who had become my guide, leaned over.

"A tiger carried off a boy in front of his house last month. Last week an elephant came out of the jungle and stood in the road. A man panicked and crashed his car into a tree. A tiger killed a dog in front of your hotel."

Man has always lived with the fear of wild beasts in northeast India, but as more immigrants from Bangladesh come into Assam and the population rises, there is less room for man and animal alike, and more occurrences like those Tarun Gogoi described.

Dhansirimukh is a ferry landing where the breeze was warm and gentle. An elephant, with its mahout on top, lumbered down a dike. A man fished from a wooden dock. "The other



BOTH BY RAJSHREE SINGH

MONSOON RAINS from June to September more than triple the width of the Brahmaputra in the populous Indian state of Assam. Boys of undampened spirit play on a ferry in Dibrugarh, the river's first major port. Downstream near Sibsagar (above) cables anchor submerged wire screens to fight erosion. Undercut by the Brahmaputra's twisting current, riverbanks may collapse with little warning.

side? Ten kilometers. One ferry a day, cost is three rupees. You're too late." He cast his line back in the water.

"I rent part of the river for 500 rupees (\$40) during the rainy season," said Ajit, who had a three-day beard. "He keeps 40 percent of the fish [he nodded to a boy sitting on the wood-frame support for a net, atop giant stilts] and 60 percent goes to me." He looked out over the river. "The Brahmaputra is sacred. We bathe in it during *bihu*."

"Assam consists of many races and languages," Tarun said. "But everyone takes part in the agricultural festivals called *bihus*. The first, and most important, is Bohag Bihu, in April, in the first month, called Bohag. It lasts seven days before planting begins. The second is Kangali Bihu, in October, before the harvest. *Kangali* means "poor," because this time of year the common man does not have much food and must wait for the next harvest. The third is Bhogali Bihu, in January, after the harvest. *Bhog* means "enjoyment and feasting." Farmers and tribal people go to the Brahmaputra and bathe on the first day of each festival.

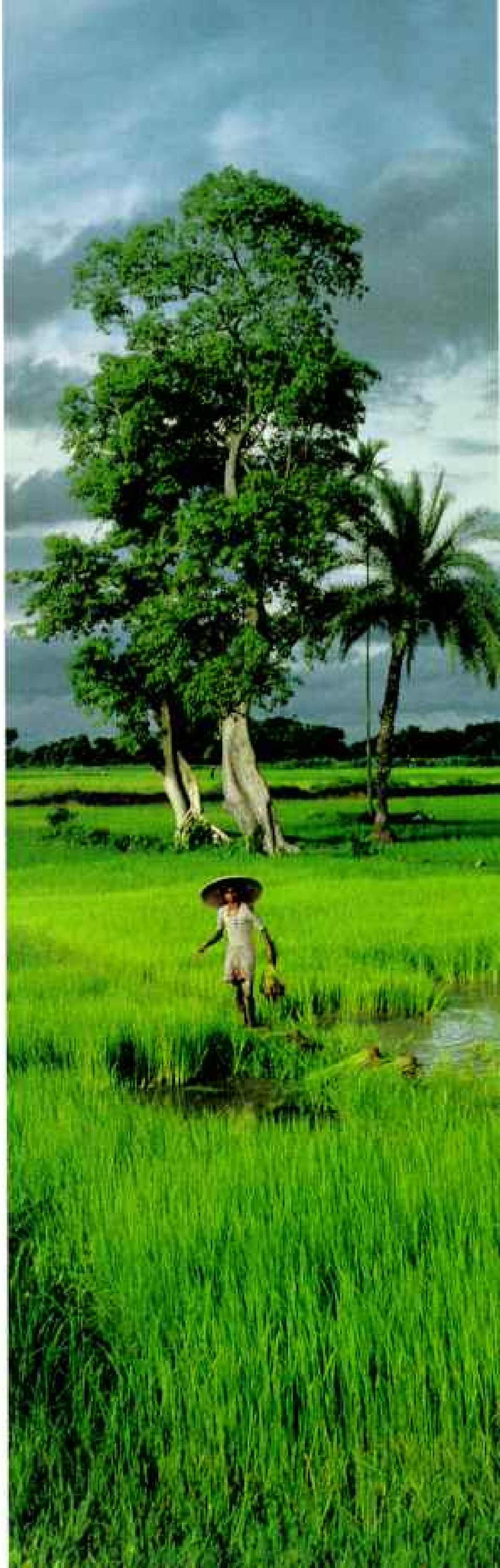
"In primitive times some people worshiped snakes or the sun," Tarun said. "We worship the Brahmaputra. Brahma is the creator and Brahmaputra means the 'son of Brahma.'"

At a long house on stilts men and women filled burlap bags with rice. A girl about 12 with long black hair sat in a white cotton wrap, quietly working a loom. "They are the Mishing," Tarun said, "an early people of Assam of Mongol descent." Traditionally, every girl in Assam must learn how to weave.

At Tezpur, a clean and pretty town on the north bank, Prime Minister Rajiv Gandhi in 1987 opened Kalia Bhomora Bridge, named for an 18th-century Ahom general. It is the second bridge across the river in Assam. On Indian maps Tibet is 85 miles away. On Chinese maps Tezpur is practically on the border.

TWO DAYS LATER I rose early and caught the first bus to Bokakhat, then ducked into a small teahouse and waited for the bus to Jorhat. I wore clothes purchased in India and Nepal; I was dark from the sun and skinny after three months in Asia.

I rode in the back of buses and tried to blend in with the farmers and laborers when the checkpoints came. The police looked closely,



and the road was filled with military convoys, but the local people were good to me, and I arrived in Dibrugarh after dark.

This was the last major Indian town on the Brahmaputra. Burma lay 60 miles southeast. Namjagbarwa Feng (25,446 feet) in Tibet was 150 miles north. Nearby, at a place called Sadiya, two Englishmen, Richard Wilcox and Philip Burlton, set out in 1827 to explore the upper regions of the "Burrumpooter." In Arunachal Pradesh they ran into the warlike Adi and Mishmi tribes. They survived. Most later travelers did not. In 1924 Capt. Francis Kingdon Ward, a botanist, and Lord Cawdor reached the Zangbo gorges, and that segment was finally explored by Europeans.

The river here was wide and bright under grayish moonlight. A high dike separated it from the town 30 yards away. There were rows of wooden country boats with candles flickering on the gunwales as men repaired their nets or ate quietly. A group of men sat talking on the grass, a bicyclist rode by, two men walked slowly, deep in conversation. The air was hot and muggy, and there was no wind in this soothing place.

Razbir Ali, 26, lived in a house 20 feet from the river. "It does not bother us." His friend Islam Khan spit out a sunflower seed and waved his hand. "The river is there." End of conversation.

They were Muslims. Ali, a taxi driver, would take me back to Kaziranga. His price was high, but I had no choice. The police barricades were up. Ali turned on the tape deck to stay awake. A logging truck bore down on us, and both drivers, in a game of chicken, swerved at the last second. We struck a cow, and Ali hit the throttle. Cows, like certain rivers, are sacred to Hindus but not to Muslims.

I REACHED GUWAHATI the next night, hoping to find a hotel where I could stay unnoticed. I found one on the river, but the clerk asked for my passport and then called the police.

The policeman was a Sikh. He wore a turban, a beard, and shiny black boots. He held my passport. "You are not supposed to be here? How did you come?"

"I came from Kaziranga, where I saw the great Indian one-horned rhino, a magnificent animal. I hired a taxi to come here. I needed a place to stay, and tomorrow I fly to Delhi."

He called headquarters, but it was late and



BOOTH BY RACHINIS SINGH

SHOULDERING RICE SHOOTS, the staple of the Brahmaputra Valley, an Assamese farmer heads for his paddy. The alluvial soil produces as many as three rice crops a year (facing page). Assam marks the farming seasons with bihus, festivals celebrated by bathing in the sacred Brahmaputra.

there was no answer. "Your visa expired yesterday, but no one is in the office, and so you may stay today, but you must leave tomorrow. I am sorry that we must be like this, but it is difficult here right now."

The next morning before I left, I visited a market. Between jagged cracks on the river's clay bank, men in loincloths sold spices, onions, and jackfruit. Farther on, three men bathed near a pile of rotting coconuts. A fishing boat went by, and a thin old man threw out a net. A dolphin, here called a *su*, rolled over. I was told that they go up the Brahmaputra from the Bay of Bengal to Dibrugarh.

Just downstream, at the holy shrine of Kamakhya, there was a temple beside a green pond with schools of small fish and giant turtles. A young priest in a pinkish red cloth draped over one shoulder slowly drank from a copper cup. Another Brahman, with hair to his shoulders and a long black beard, joined

us. He wore three *tikas*—red, yellow, and blue-gray forehead marks—the last from the ash of the incense hovering over us.

"You have come to see the tortoises?" asked the bearded one.

"Yes," I ventured.

"Is that the only reason?"

"I have come to look. I am not sure why else I might be here."

It was the opening he needed.

"All around you God is here—in our hearts, in that cow, in those fishes, everywhere. We must, however, choose to see him."

His voice grew stronger. On one finger he wore a cobra ring. Behind him three men with bare chests sat on the temple steps, smiling. "Inside the temple is a stone. It is not God. We do not worship the stone or sacrifice animals to

it alone. It is a symbol of God." I looked at the trees, the birds, a cow beside us, a dog lying in the grass, the priests staring.

"We are all brothers in God," said the Brahman.

AT KURIGRAM in Bangladesh, near the Indian border, on the white sand beach, we found a boat with a motor. Shafiur Rahman, an engineer, and Abdul Fazal, my escort from the Bangladesh Water Development Board, and Akhtar Ahmed, from the Press Information Department in Dhaka, made a deal with the boatman to go up near the border, despite reports of dacoits and smugglers.

We moved out into the channel. "It is miles across," Rahman said. "Two million cubic feet of water a second are passing by; it could be 2.3 million in a few months. Since the Assam earthquake in 1950, the sediment has slowed it down." Fazal took his tea glass, dipped it into the river, and drank.

"The water is at its lowest in February," said Rahman. "When the snow in the Himalaya starts to melt and the rains come, it rises and is at its coldest. It is high in June and in September, after the monsoon."

On an island near the middle of the river six newborn turtles stood, wondering whether to take the plunge. "They are a delicacy to Hindus," Fazal said, "but not for us Muslims."

The island was flat and sandy, without trees or grass. A man named Rashid invited us into his home. He held a little girl with big round eyes and a ring through her nose. "I sell bamboo, which I bring down the river from the border," Rashid explained, "but my life is waiting for my submerged land, that of my forefathers, to return. Soon the water will be up to my waist."

We headed downstream. The wind had come up. The sun was about to set, bright orange over the sand and the tree line in the west. The current was swift, but the wind was in my face. The current carries a boat downstream, but a strong wind can carry it up.

At Sirajganj, Mohammad Babar Ali, a young engineer in wire-rim glasses, stood on a concrete-block jetty. He said, "Our job is to save the town." He pointed to small twisting currents in the water. "Erosion takes place from the water up, which is characteristic of this river. The strong undercurrent, twisting like a cyclone, eats at the soil, undercutting the



BOOTH BY RADHUBIR SINGH

BESTOWING A BLESSING with a touch of vermilion, a priest at Kamakhya Temple in Guwahati, Assam's capital, honors the Hindu goddess Shakti, the essence of female energy. The sacred syllable "Om" decorates another Guwahati temple on the Brahmaputra (right), classified in Hindu cosmology as India's only male river.



COAX COMES TO SHOVE: Market-bound Assamese villagers guide a water buffalo cart across an embankment near the Bangladesh border. A woman's umbrella signals the beginning of the monsoon. When the Brahmaputra floods this road, tires become more useful as toys. "The river has a domain of its own," one man told the author, "and we must respect it."



bank. It is difficult to detect until, maybe, one day before it gives way." A group of men stood next to single blocks of concrete, eight feet square, a thousand pounds each.

Shantosh, 22, had a mustache, curly black hair and rotting teeth. "I was a farmer, but one day when I came home, my house was gone." He joined his fellow workers. Eight men wrapped rope beneath the concrete slab, ran a pole beneath the rope, and lifted. Their bare feet shuffled along the shore as they sang: "Push, push Mohammed/Lift, lift Habib/We can do it/We can do it/Allah help us/Allah give us strength/Mohammed is his Prophet/Peace be unto him/Lift, lift, we can do it."

At Gaibandha, Mohendra, a Hindu fisherman, stood next to his narrow boat. "Seven days ago we made an image of Sannyas. He lives in the water, and we pray to him for a

good catch. Sometimes we make a beautiful girl of clay, a Ganga Puja, and an image of fish on either side of her. We put it on our boats and pray to her. If I succeed in my fishing, I will make a Ganga Puja."

THERE ARE NO BRIDGES across the river in Bangladesh. The ferry stop at Aricha, where the Ganges and the Brahmaputra meet, was jammed with trucks, people, and rows of wood huts. The ferry's horn shrieked, and we ran through the dust to the ghat, or river station. The ferry was four decks high, made in Denmark in 1980. There were 30 trucks on the lower deck and hundreds of people above sitting on plastic chairs and on the floor. There were soft drinks and food in a Kelvinator freezer and an upper-class deck on top.



BOH BY RAHUBIR SINGH

I realized I had taken a similar ferry from Germany to Denmark years before.

As we crossed, the ship's master, Saleh Mohammad, explained his job. "I judge which way to go by the color of the water. The darker it is, the deeper. New islands appear and channels change. I go where the river lets me."

The control room was clean and modern, with the latest equipment. The service began in 1964. "I started out as an apprentice," said Mohammad. "I have been doing this for 12 years. The ferry makes eight to ten trips a day," he said.

Sadarghat, on a side stream, is the old port of Dhaka, the capital of Bangladesh. The water was thick with oil. Hundreds of small craft plied the river, each with a boatman who propelled and steered with a single long oar. One carried a lone woman whose white veil blew in

the wind. Others were stacked high with barrels of oil and coconuts.

Everywhere there were men in long skirts, the descendants of ancient Aryans and Arab, Turkish, and Burmese traders. Long boats with masts 30 feet high and giant square sails flowed majestically upstream. Nearby, children bathed, men walked down planks with wicker baskets of coconuts, melons, and squash.

A muezzin called the faithful to prayer. There were a hundred men inside a small mosque, and outside there were ten thousand more. A singing beggar with one leg rolled over and over, moving his bowl with him. Three women fixed dinner in metal pots over a fire. The smell of mango, diesel fumes, and spices filled the air.

In an upstairs room of his home B. M.



Abbas, one of the country's water experts, wiped the moisture from his glasses. "If we could only dam this river . . . but we have no money. Nearly 60 percent of our rice is produced during the monsoon; the rest of the time there is not enough water."

We reached Chittagong, on the Bay of Bengal. As we walked toward the water, Khaled

Belal, my guide, turned. "Bangladesh has affectionate soil. It grabs you, holds you, and lets you go." I smiled, wary of what lay ahead. It was 16 miles to the first island, Sandwip.

We climbed into one of the waiting boats. The helmsmen shouted, and two Bengali oarsmen pulled on their oars. Bare chested, with cotton *lungis* wrapped up around their waists,



RAFIQULLAH CHOWDHURY

they rose in the air, and their muscles glistened. A quarter mile out an old rusting trawler, the *Hatia*, waited. "Thirty years ago I left Sandwip for the first time," Belal said. "It is the same." The boat rocked slightly. The cyclone season had not begun. The tidal waves would come later, after the monsoon.

Captain Shamsul Huda had a long thin

GOING AGAINST THE CURRENT, Bangladeshi boatmen south of Chandpur carry bundles of jute upstream to Narayanganj. Near the end of its journey, the river loses its name to the Ganges-Padma and Meghna Rivers, but its waters dominate the Bangladesh delta system, the world's largest.

beard and a withered right hand. "More than 60 percent of the seamen in Bangladesh once came from Sandwip. They worked under many flags, all over the world."

We were joined by a man named Mohammed Islam. "I am going to Sandwip and other islands to settle land disputes. If the land disappears and then reappears, it belongs to the government, but former owners get preference if it is reallocated." Every year the Brahmaputra shifts its course and with the Ganges carries two billion tons of sediment to the sea, more than any other river system in the world.

Rafiqullah Chowdhury was an administrator on Sandwip. "In 1872 this island was 425 square miles," he said. "Today it is 93 square miles." He pointed to thatch houses a hundred yards back and ten feet above the water. "They probably will not be there in July." Waves slapped hard at the bank beneath us, turning Sandwip into silt.

I asked a man with a beard and a skullcap why the boys around us were not in school.

He shouted back, "Food first, school next." He put his hands to his mouth, and his angry eyes stared at me. A hundred people crowded around.

"Our people must live, and to live, they must fight the sea," Chowdhury said. In November 1970 a tidal wave roared over Sandwip, killing an estimated 40,000 people. "When the waves come, the winds are 100 miles an hour, the waves 20 feet high, and they often come at night," Belal said.

Night came. The black sky was filled with white stars, crickets, quiet voices. Palm trees rustled in the breeze.

Two days later the water fell over us, and the trawler shuddered against high waves. Near shore the Bengali boatmen, chanting as they rowed, brought loads of passengers, vanishing between five-foot waves as they came. People frantically climbed aboard while others jumped down into the boats. The boatmen lifted the babies by one arm and passed them high above the water to men on board. Others bailed water, everyone shouted. A boat filled,



THE RELENTLESS WATERS of the Brahmaputra affect the lives of two-thirds of Bangladesh's 110-million people. It is the main traffic artery, here plied in Chandpur by a passenger ferry, water taxis, and noukas loaded with salt. It feeds the world's most densely



RAGHOBIR SINGH

populated major country with fish, and its sediment creates small islands called chars, transient footholds of soil for farming. A devastating torrent during the monsoon—when 80 percent of the year's rain falls—it is also the most reliable dry-season irrigator.

FACING MECCA, a traveler prays aboard a launch steaming between islands in the Bay of Bengal. Most Bangladeshis are Muslim and do not consider the Brahmaputra's waters holy. Yet as an ever changing creator and destroyer, the river shapes the soul of the country. RASHMID SIRHAN

and the oarsmen pushed people back, and another boat arrived. Babies were passed overhead, people pushed, the screams continued. I jumped on. The helmsman stood in the wind and called out to Allah. The people prayed in unison, and we rode the waves, turning, falling, gliding. On shore again I sat in the sand and buried my head in my arms.

FROM KHULNA I caught the "Rocket Service," a giant orange paddle-wheeler, through a labyrinth of waterways toward Narayanganj, 12 miles from Dhaka. A few hours later a young boy came by selling puffed rice and coconut that he carried in a wide metal pan on his head. He had bright eyes and white teeth. His name was Mohammad Harej. He said he was 12, but he looked about 8. "I work on this boat. I have for six months," he said.

"What about your family?"

"My father died six years ago."

"What does your mother say?"

"She died three days ago."

I put down my pen.

"We lived next to the river," Mohammad said. "My sister lives with neighbors now. I make 20 taka [65 cents] a day, and I give ten to the family to buy rice for her."

"What did you do before?"

"I was a porter for three years. Before that I didn't do anything. My mother worked and brought some money home."

He had to return the leftover food to the man he worked for.

"What is this for?" he asked.

"*Baksheesh*—a tip," said my guide Akhtar. The boy smiled and wrapped the money in the new lungi someone had given him.

That night I walked around the boat, stepping over many young boys sleeping on the deck, but I could not find Mohammad.

Before dawn we arrived in Chandpur, and boats passed mysteriously in the dark. Then the sun rose, and the river was calm and wide and filled with boats and people as far as I could see. □





DOWN THE CAYMAN WALL

By EUGENIE CLARK

THROUGH A GIANT undersea lens—the bubble window of their small submersible—passengers inspect the sheer face of the Cayman Wall, a submarine escarpment that is part of Grand Cayman Island in the Caribbean.

The recent development of small, relatively inexpensive submersibles has revolutionized undersea exploration almost as dramatically as did the Aqua-Lung four decades ago. Moreover, scuba gear is restricted to those who can swim, while submersibles can accommodate all, whether research scientists or tourists. This 22-foot-long craft, built by Perry Oceanographics, carries two passengers in the forward compartment and a pilot in the conning tower above. It has a depth limit of a thousand feet and usually remains submerged for about eight hours. Compressed-air tanks, batteries, and ballast hang beneath the pressure hull. Viewed from a sister submersible, the craft hovers at 300 feet near strands of rope sponge, lower left. The cylindrical object in the lower foreground is a combination video camera and 35-mm still camera.

During a year's research on the wall I logged more than a hundred hours on dives ranging from a few hundred feet to 3,200 feet, the latter in a craft of heavier design (page 729). The dives revealed an extraordinary world. The wall is a great layer cake of life zones, with widely differing species of marine animals at various depths. During our dives we discovered several new types and species and observed others in their natural surroundings for the first time. The scenes that follow provide a portrait of one of the most beautiful and bizarre habitats for marine life that I have encountered in 42 years of undersea research.







BEAUTY BEHIND BARS, a green-banded goby (right) takes refuge beneath the protective spines of a red rock sea urchin in the shallows at the top of the Cayman Wall. Photographer David Doubilet, a longtime associate, calls this goby "the most outrageously colored fish in the Caribbean." Yet it is rarely seen, for it is only about an inch and a half long and lives in the surf zone close to shore, where fish are rarely looked for. Another shallows denizen, a tiny flag blenny (above) arches from its burrow to feed. Cayman Islanders call this area the iron shore, for the brownish seaworn coral that forms its beaches.

Challenging its own image, another blenny (above left) lunges at a small mirror placed outside its burrow by Doubilet. "This was probably a male," David reports. "Normally they are very shy. But even in the tiny world of blennies, there seems to be something called machismo."

Multiple arms outstretched, an anemone (left) clings to a cinder block while feeding on plankton and small fish at a depth of ten feet. In places the sea is often so calm that clouds can be clearly seen from under water.



Marine biologist EUGENIE CLARK teaches at the University of Maryland. Her most recent NATIONAL GEOGRAPHIC article, "Sharks at 2,000 Feet," appeared in the November 1986 issue.



COURTESY PLATT (FACING PAGE), BOTTOM: DAVID DOURILEY

1 The Reef

0-200 feet Shallow water and abundant sunlight support a coral reef that provides a home for thousands of species — and prey for predators.

2 The Wall

200-600 feet In the "spoggs belt" an assortment of the animals clinging to the wall face. Few fish are seen, but worms, crustaceans, and primitive forms of life abound.

3 The Haystacks

600-1,000 feet Strange deep-water fish and other bizarre creatures live amid the stacks, some reaching heights of 100 feet.

approx. 3 miles

DEEP ISLAND SLOPE

4 The Deep

1,000 feet and below Cold and dimly lit, a "white desert" of smooth sediment is inhabited by living things weirdly adapted to their distant world.



Zones of life



Atlantis I
150' max

PC 1203
1,000' max

Pisces II
3,280' max

CATARACT IN STONE, the Cayman Wall drops from the western shallows of Grand Cayman to 3,200 feet three miles offshore. Portions of the sheer, upper face of the wall may have eroded and fallen down to form distinctive "haystacks" at a level between 600 and 1,000 feet.

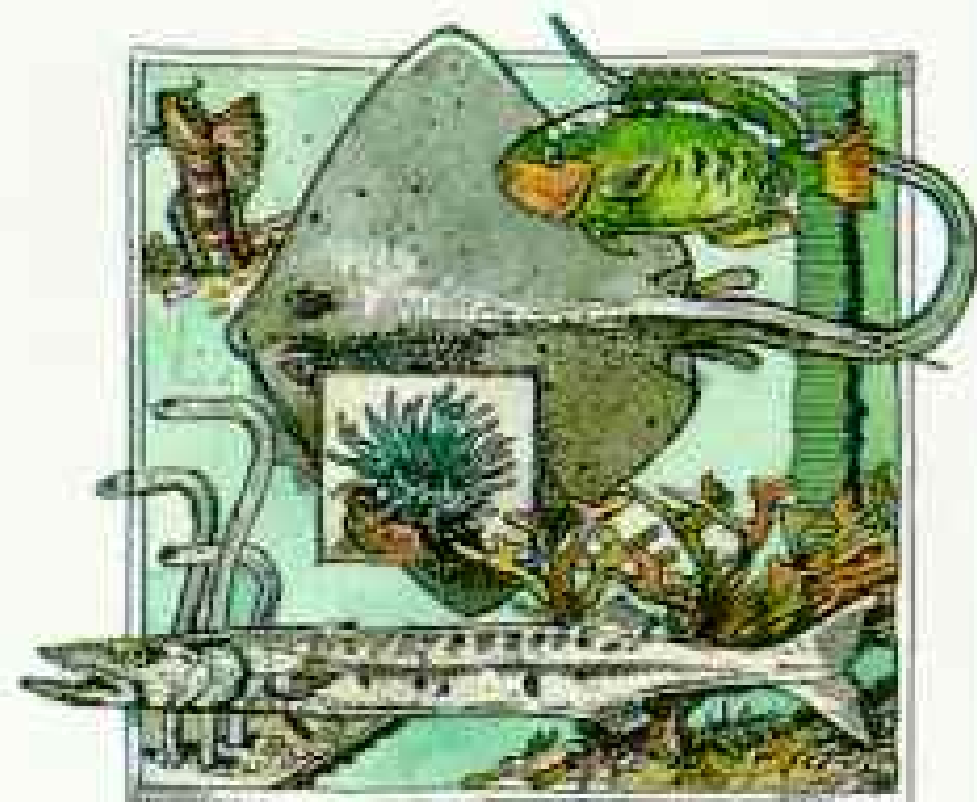
The wall can be divided roughly into four zones of life: reef, wall, haystacks, and deep. Bathed in bright Caribbean sunlight, the reef abounds with corals and fishes, including (top right) barracuda, stingray, parrot fish, and garden eels. In dimmer reaches the wall curves in sharply. Here lives an immense variety of sponges: tube, elephant ear, ginkgo-leaf, rope, barrel. The haystack zone, with even less light, is frequented by sharks, starfish, sea whip corals, and umbrella-shaped crinoids, kin of sea urchins. Here too lies the wreck of the freighter *Kirk Pride* (pages 726-7).

Below, in the fourth zone known as the deep, the seafloor banks gently for three miles in the Deep Island Slope, then plunges once more to 3,200 feet. Lacking sunlight of any kind, the deep is home to a variety of strange species, such as the cookie-cutter shark, the coffin-fish, the tripod fish, the spidery-armed jellyfish, and a swimming sea cucumber, which to me resembles a pink Michelin man. Three submersibles explore the wall at varying depths: *Atlantis I*, Perry (PC), and *Pisces II*.

South of the deep zone the seabed drops off to a 24,720-foot abyss known as the Cayman Trench, the deepest hole in the Caribbean.*

*See "Window on Earth's Interior," by Robert D. Ballard, with photographs by Emory Kristof, in the August 1976 *GEOGRAPHIC*.

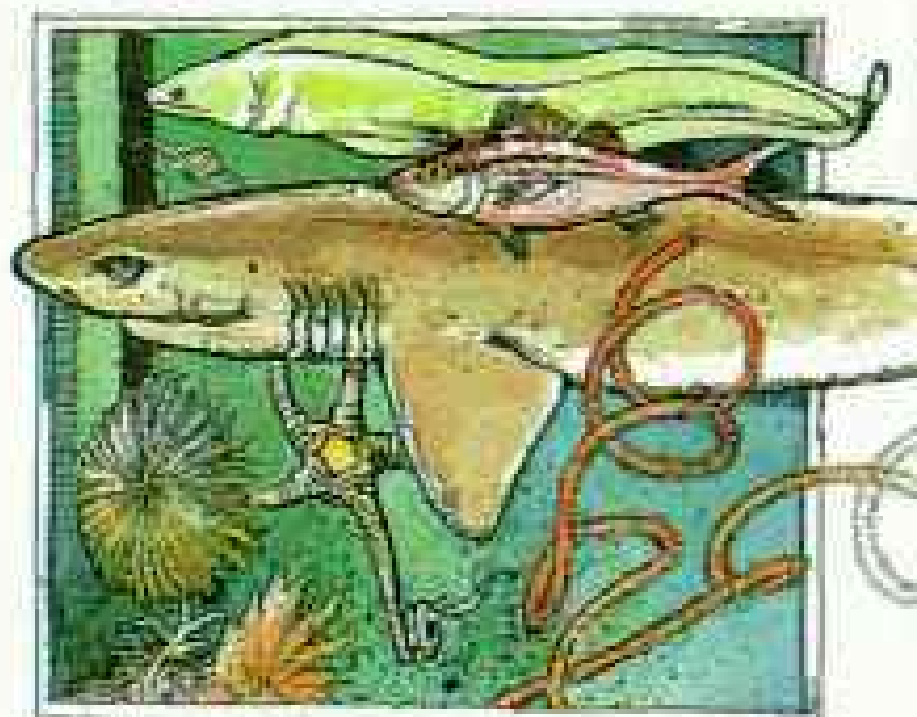
ARTWORK BY RICHARD SCHLEIF



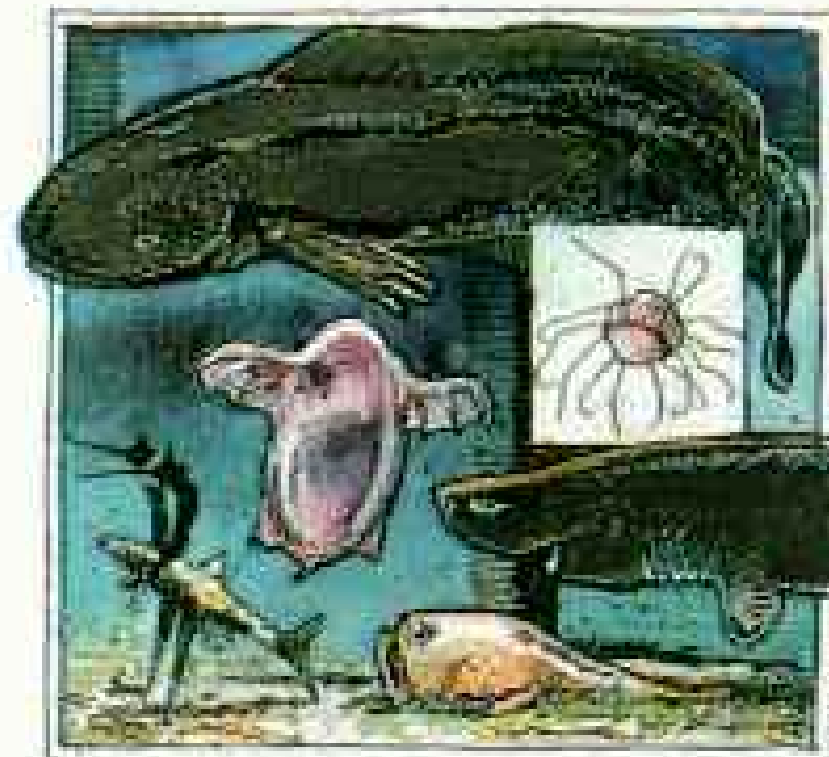
1 The Reef



2 The Wall



3 The Haystacks



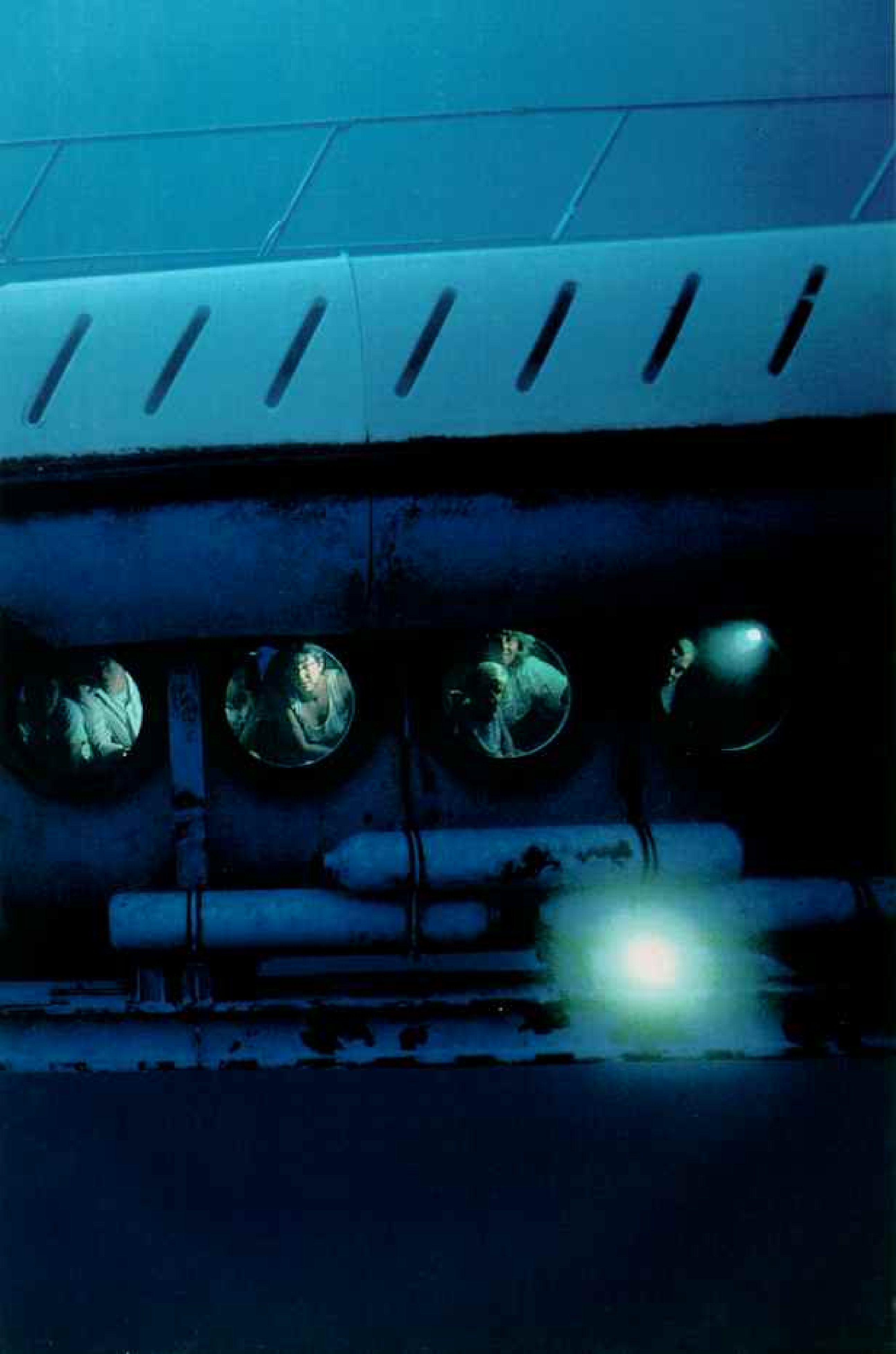
4 The Deep



TOUR BUS of the sea, the 28-passenger *Atlantis I* takes visitors on a one-hour dive to depths of 150 feet. Such dives are so popular that 46-passenger submersibles are now operating in Barbados and the Virgin Islands. Others are planned for the

DAVID DOUBILET

Pacific, the Red Sea, and the Mediterranean. Photographer Doubilet's wife, Anne, and 3½-year-old daughter, Emily, peer from the second viewport on the right. "Emily loved the deep reef," David says, "but the best part was when her daddy swam up to the viewport and waved."



ROUTING A KILLER, a school of crevalle jacks turns on a great barracuda that had attacked them moments earlier. Closing ranks, they forced the barracuda to retreat. Although fish have no expressions, these jacks seem outraged.

Barracuda often feed in evening light when schools of small-

DAVID DOUBILET

er fish tend to be confused. This one attacked at midday when the jacks were a well-organized, cohesive unit. The entire episode, which Doubilet photographed at a depth of 40 feet, took only six seconds. A small bar jack, just behind the barracuda's pectoral fin, stayed with its host throughout the encounter.









COURTNEY PLATT (LEFT); DAVID DOUBLET

GLANT AMONG GIANTS, an elephant-ear sponge (left) spreads its 15-foot-wide "fan" above an outcropping on the wall at a depth of 250 feet. Spying the sponge on a dive in a Perry submersible, pilot Courtney Platt returned with scuba gear to photograph the animal. He was accompanied by his wife, Cozy, seen at left holding a flashlight.

"It was the biggest elephant-ear we'd ever seen," says Courtney, a veteran of more than 2,000 dives for Research Submersibles Ltd. (RSL), owner of the Perry. "At that depth we didn't waste time; we were there for about five minutes, just long enough to photograph the sponge. Cozy's lamp gave us enough visibility, while my strobes exposed the film. It's too bad the film couldn't pick up the colors, they were fantastic.



The size of the sponge shows how well protected marine life is at such depths. Even if a hurricane was raging on the surface, the elephant-ear wouldn't budge." Two other types appear at upper right, rope sponges and a spherical sponge.

A garish forest of sponges and corals (top) sprouts from the

wall at a depth of 120 feet. A brilliant orange elephant-ear sponge stands framed in shrub-like gorgonian corals. Schools of blue chromis fish swarm around a diver poised above.

Black hood over a magenta body distinguishes a blackcap basslet, seen feeding beside an orange elephant-ear sponge.

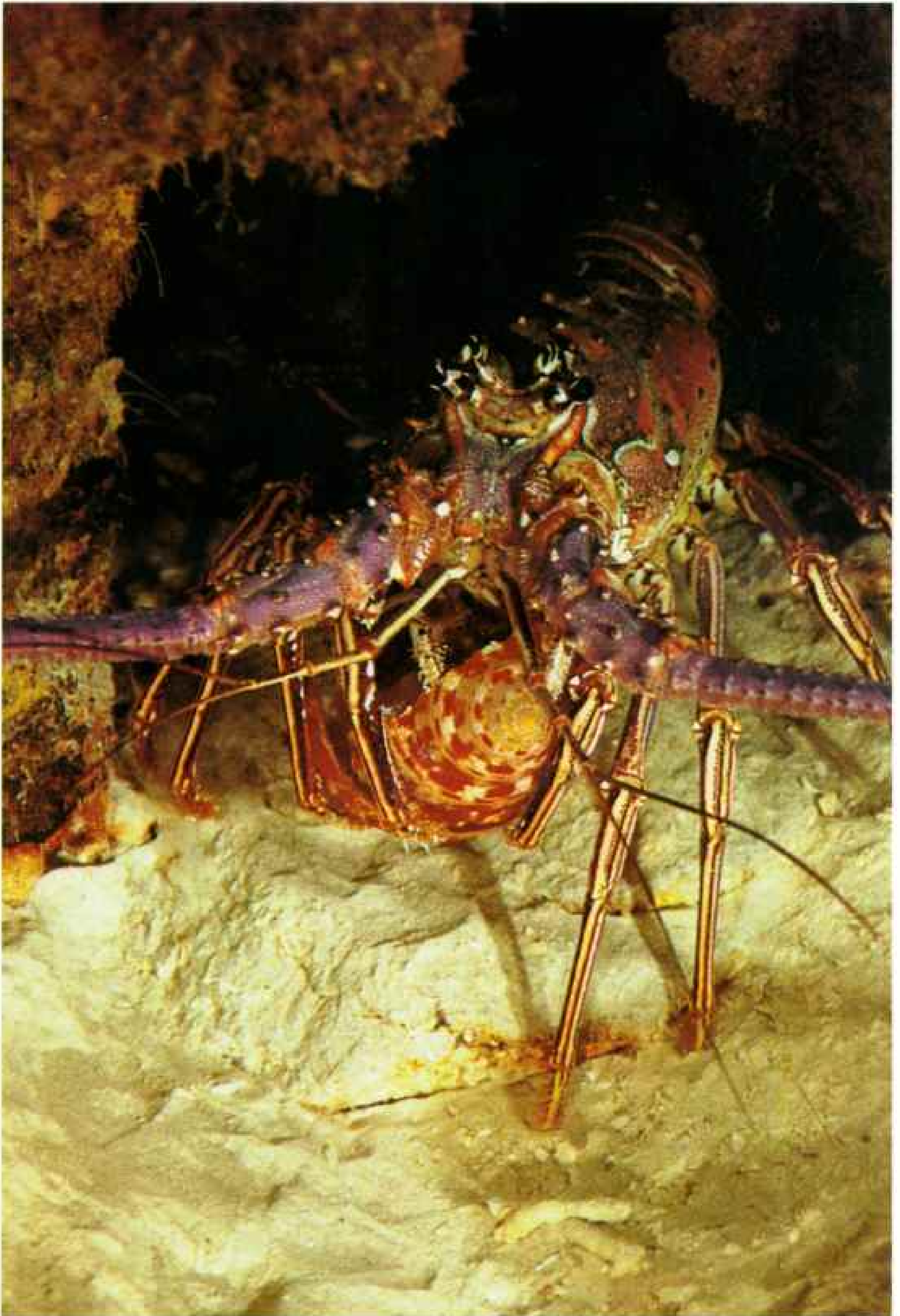


DEVOURING a treasure, a spiny lobster (right) cracks a rare slit shell with its powerful legs and mandibles to get at the mollusk inside. Slit shells (left) in perfect condition bring hundreds of dollars in the collector's market. A vent near the bottom edge of the shell allows the flushing of waste water. Mature shells average five inches in diameter.

In some 3,000 dives pilots of Research Submersibles Ltd. have observed only 20 live slit shells and a dozen dead ones. They retrieve the latter, some with shells destroyed by spiny lobsters and others dead of natural causes or victims of some unknown predator that leaves the shell intact. Courtney Platt photographed this lobster at a depth of 630 feet.

Like a rusted drainpipe, a nine-foot-long tube sponge (below) lies amid a tangle of rope sponges at a depth of 300 feet. To me the sponge belt is the most colorful area of the wall. Some tube sponges come in shades of royal purple and cling to the wall in upside-down bouquets. Festoons of rope sponges in bright orange, raspberry, or vivid yellow drip from the rock face down over green, violet, and brown giant barrel sponges. Elsewhere orange elephant-ear sponges, their surfaces often frayed with cracks and holes, hang like the remnants of velvet curtains in an abandoned opera house.





ALL BY COURTNEY PLATT





EMORY KRISTOF WITH ALVIN W. CHANDLER, RSL STAFF

GHOSTLY HULK of the freighter *Kirk Pride* (left) lies heeled over to starboard amid the haystacks at a depth of 800 feet. During a 1976 storm the vessel left George Town harbor on Grand Cayman and struck the reef. Attempts to save her failed, the crew abandoned ship, and she went down just off the Cayman Wall. Her whereabouts were unknown until 1985, when RSL pilot Stuart Mailer discovered the wreck by chance on an exploration dive. Twisted davits and buckled superstructure plates attest to the ship's violent end. Amid the wreckage on deck lie two fire hoses with which the crew tried in vain to pump the ship free of water.

To take this remarkable picture, photographer Emory Kristof and his colleague Alvin Chandler used two submersibles, one of which appears with a light at the bow on the far side of the wreck. To illuminate the wreck itself, Kristof filled a pair of deep-sea glass floats with two dozen flashbulbs each, triggered by a photoelectric cell. The com-

bined lighting power of the bulbs was six times the intensity of a standard Coast Guard lighthouse. Kristof then suspended a float above each of the two submersibles and positioned them on either side of the wreck. At the moment the picture was taken, one of the two floats failed to ignite, but the light from the other globe still ranks as one of the most powerful photoflashes ever set off underwater.

Gossamer parasol, a stalked crinoid (below left) spreads its feathery arms to catch plankton and other food particles drifting in the water at a depth of 800 feet.

Also known as sea lilies, stalked crinoids are related to sea urchins, starfish, and sea cucumbers. Fossil records date this family of stalked crinoids back as far as 230 million years, and they appear to have changed little since that time. They move across the ocean floor by loosening their grip at the base of the stalk, lying flat on the bottom, and pulling themselves along by means of their arms. The pace is unhurried; an enterprising stalked crinoid may move all of ten feet in a week. Others never travel at all, and many have been observed in the same spot for three years running.

Curiously, few observers of the wall have ever seen a dead stalked crinoid, suggesting that the life span is extremely long and slow. Tourists on board an RSL submersible peer through the bubble window (left) at a pair of stalked crinoids. The craft are highly maneuverable, and observers can get literally within inches of subjects for scientific study or photography.

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EMORY KRISTOF WITH JOSEPH E. STANCAMPANO, RSL STAFF (LEFT); COURTNEY FLATT



UNDERSEA BANQUET of fish heads and squid (above) draws a variety of diners at a depth of a thousand feet among the haystacks. A four-foot-long green moray eel, here turned pale yellow by the submersible's powerful floodlights, slithers across the bait bag beneath the legs of a spider crab. Clusters of bright red deepwater shrimp, each about five inches long and resembling a bunch of carrots,

feed on the squid tied at left to the bait canister. We simply dumped the burlap bait bag on the bottom here and held onto the can by the submersible's extension arm.

On this dive in search of six-gilled sharks, Courtney Platt and I spent three hours on the bottom, switching off the submersible's floodlights for half an hour or 45 minutes, with only the faint green shine of chemical light sticks to suggest what was outside the sub. Then we would

snap the floodlights back on to see what the bait had attracted. The variety was far greater than this picture suggests. In addition to these creatures, we saw snake mackerel, serpent starfish, conger eels, and queen snappers, all of which darted away, making them difficult to photograph. We also saw a huge six-gilled shark, but couldn't get a good portrait either. On an earlier dive, we had been more successful (pages 730-731).

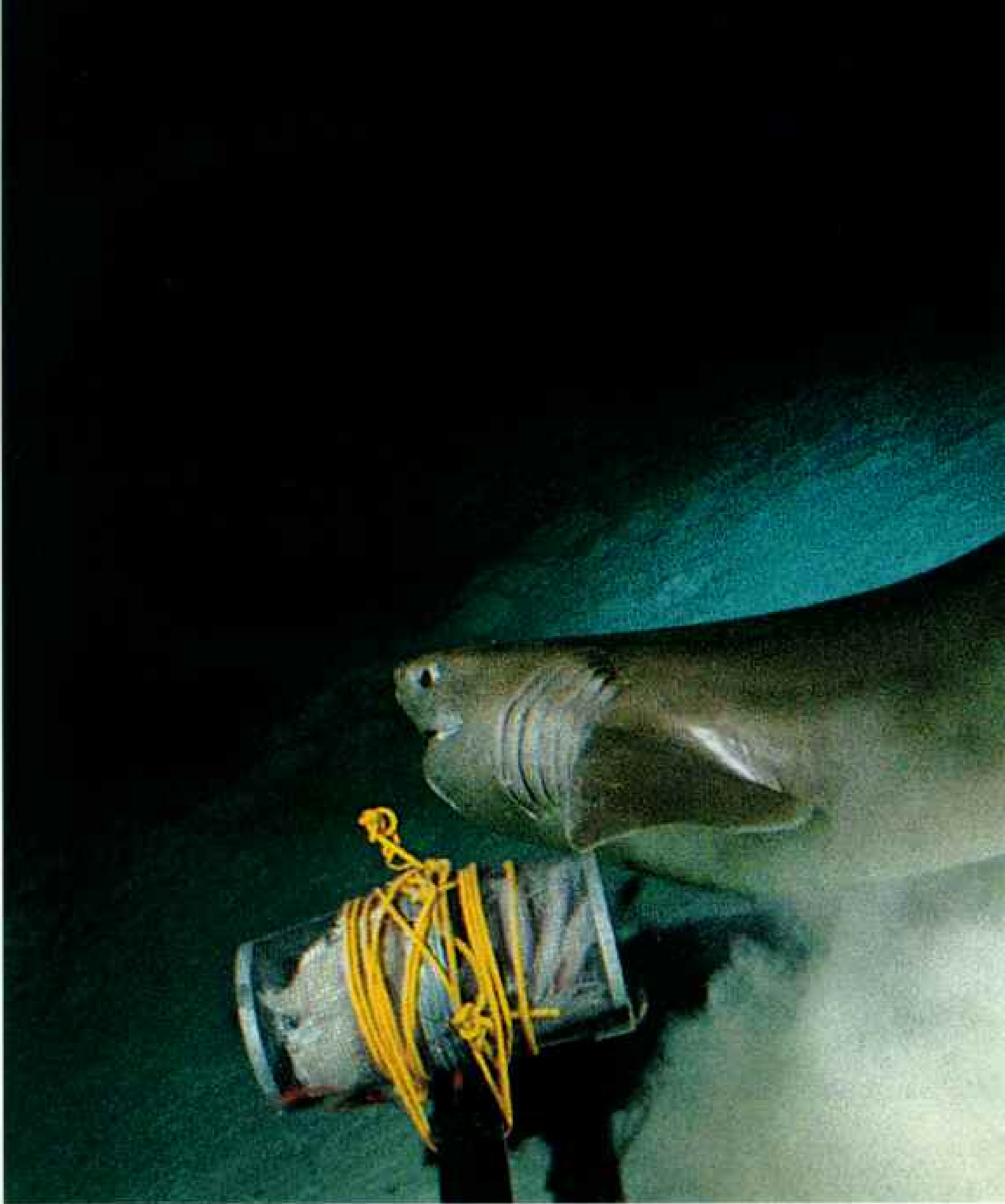
Like a tiny burst of fireworks



a sea dandelion (top right) clings to a rock spur 730 feet down. The four-inch gorgonian captures plankton and other small prey with tufted tentacles, stings them, and eats them.

The deep-diving submersible *Pisces II* (right) carries a pilot and two passengers and can reach 3,280 feet. The manipulator arm lets the pilot retrieve objects from the seafloor; the large black "claw," a leftover from work for the Navy, is a torpedo-recovery device.

ALL BY COURTNEY PLATT



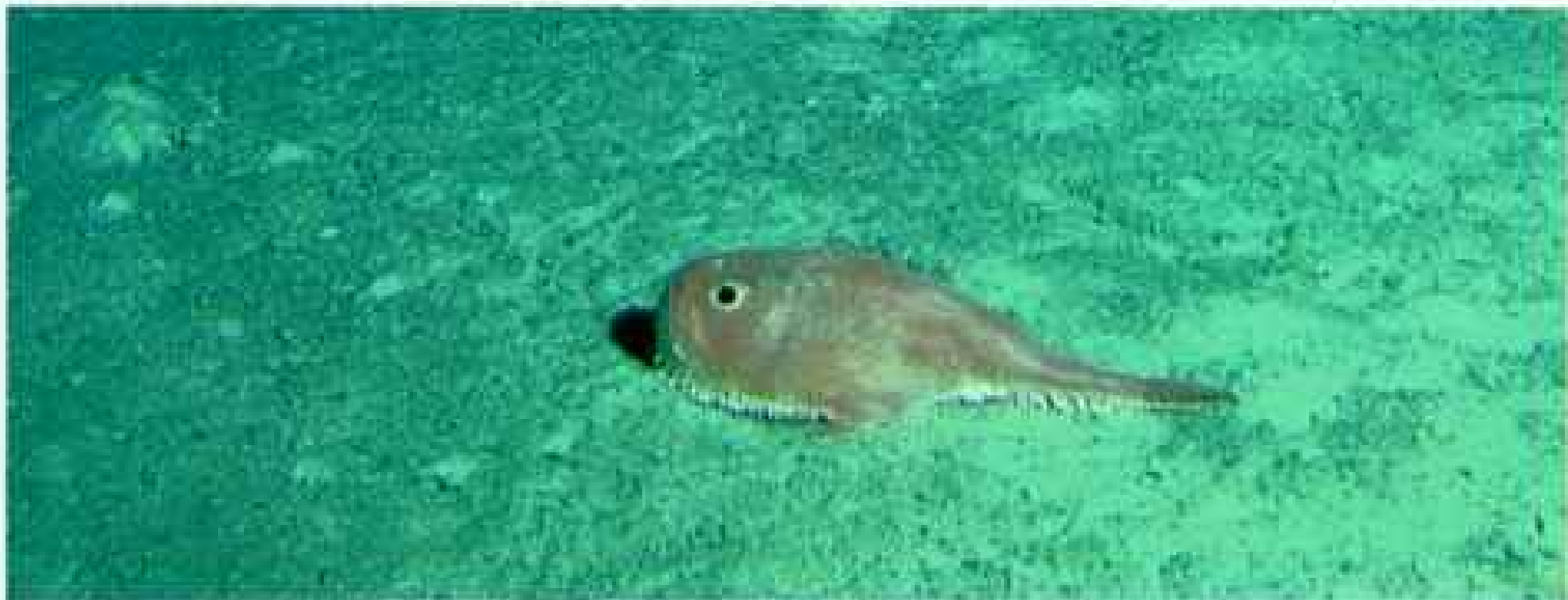
DEEP-SEA JUGGERNAUT, an eight-foot-long six-gilled shark slashes at the bait canister on the extension arm of a Perry submersible at a depth of a thousand feet. Emory Kristof and I had waited in the eerie glow of a chemical light stick for two hours when suddenly a huge

shape blocked the bubble window. We snapped on the floods, and there was the shark. We had observed sixgills—thought to be more primitive than the more often seen five-gilled sharks—at great depth off Bermuda a year earlier, but this is the first ever reported in the Cayman Islands.

In later dives to 3,200 feet as many as a dozen sharks circled

the bait station at a time. The largest was roughly 12 feet long, but I am sure there are others here even larger.

Certainly one of the oddest inhabitants we saw along the wall was a coffinfish (right) perched on its pectoral fins at 2,600 feet. A layer of tendrils forms an apron-like fringe around its midsection. □



EMORY KRISTOF (TOP); DENNIS BENSON





MISSION TO MARS

By MICHAEL COLLINS TRUSTEE, NATIONAL GEOGRAPHIC SOCIETY

Photographs by ROGER H. RESSMEYER STARLIGHT

Illustrations by
PIERRE MION and ROY ANDERSEN

THE BLUE-AND-WHITE EARTH is gone now, its remnant a mere pinpoint of light in their window, and dimmer than Venus. Their destination, out the opposite porthole, is a plump red beacon, larger and more inviting as the weeks go by.

The crew enjoy discussing these impressions with one another and with Mission Control, although with a ten-minute time-delay conversation with Earth is becoming increasingly stilted. Everyone is proud of the fact that—at the halfway point—they are all strong and well, physically and mentally. Even their plants seem to be thriving.

The decision to launch them had been long and tortuous, its roots as old as the telescope. For centuries astronomers had marveled at the fuzzy red ball in their eyepieces and lavished on it their most fanciful dreams.

Intelligent beings lived there, they theorized, digging long straight canals to bring water to cities hidden in desert oases. Later, when the likelihood of a lifeless planet crushed these hopes, there remained a special fascination with our planetary neighbor, in many ways the closest thing to an Earth twin in this solar system.

Unlike the other planets, such as the gaseous giants Jupiter and Saturn, Mars seems friendly, accessible, even habitable. As author James Michener put it: "Mars has played a special role in our lives, because of the literary and philosophical speculations that have centered upon it. I have always known Mars."

I grew up not only knowing the place but also wanting badly to

Blazing the trail for a piloted mission to Mars, a Soviet probe will reach 17-mile-long Phobos (left), larger of the planet's two moons, in the spring of 1989. Former astronaut Michael Collins describes a possible scenario for a U. S.-Soviet manned voyage in the year 2004.

PRINTING BY PIERRE MION

Tempting target for a Mars landing: Valles Marineris, the huge canyon system named for the U. S. Mariner spacecraft that spotted it in 1971. Stretching 2,800 miles along the Martian equator (facing page), it is ten times as long, as much as 24 times as wide, and three times as deep as Arizona's Grand Canyon. Nearby channels (below) show patterns that suggest colossal volumes of water once flowed on Mars—in an atmosphere and climate much closer to Earth's than the tenuous, Arctic-like conditions that prevail today.

Among the questions a scientific field trip might answer: When and why did the atmosphere change? Did life arise before the change occurred? And might remnants of that life be preserved in the planet's dry riverbeds?

go there. My trip to the moon in 1969 aboard Apollo 11 served only to whet my Martian appetite.

I felt a little bit closer to the red planet last July when I traveled to Baikonur, the Soviet launch site, to witness the lift-off of an unmanned craft to the Martian moon Phobos—the first of several such probes that will culminate in humans on Mars.

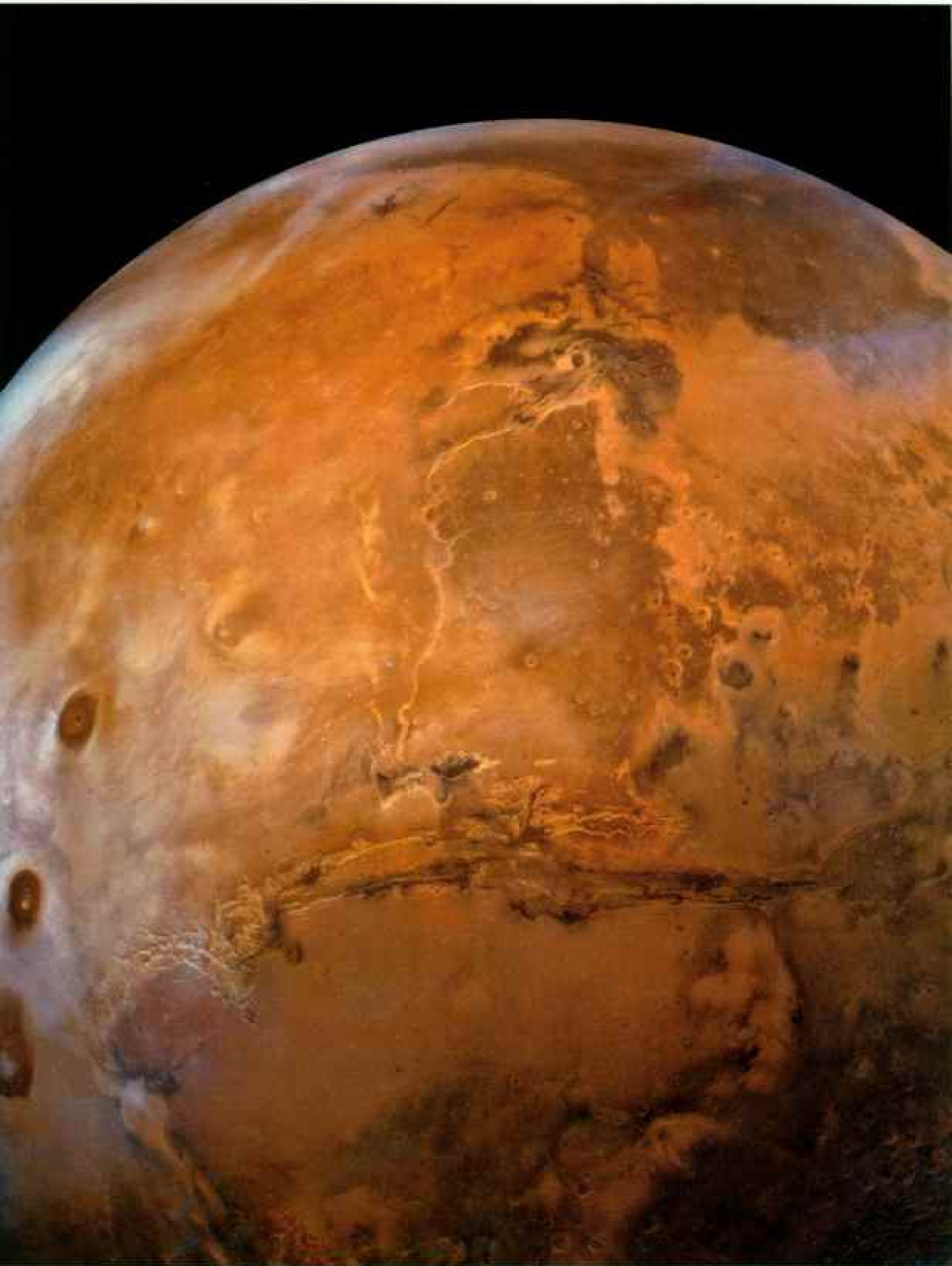
What would be involved in such a stupendous voyage? When and how might we reasonably expect to go there?

WE HAVE LEARNED MUCH about this seductive planet. Because Mars is half again as far from the sun as Earth, it is cold; surface temperatures may reach 30°F in midsummer but generally are in the cruel sub-zero range and dip as low as minus 200°F. Both poles are covered with ice caps that change size with the seasons. The ice, formed from both water and carbon dioxide, has been called “frozen club soda.”

The thin Martian atmosphere is equally harsh—almost all carbon dioxide, with just a trace of nitrogen, argon, oxygen, and water vapor. Its pressure is so low—the equivalent of Earth's atmosphere at an altitude of 100,000 feet—that human blood would boil. When our crew members eventually hike on the surface of Mars, they will be protected by pressure suits. They still may have to contend with high winds that produce dust storms lasting for months and creating a pale orange haze. Their mobility should be helped by the weak Martian gravity, in which they will feel only 38 percent of their normal weight.

Author MICHAEL COLLINS piloted the command module *Columbia* on the triumphant flight of Apollo 11 to the moon. A trustee of the National Geographic Society, he recently published his third book, *Liftoff: The Story of America's Adventure in Space*. ROGER H. RESSMEYER, founder of the San Francisco photographic firm Starlight, photographed the May 1988 article “Supernova—Death of a Star.” PIERRE MION and ROY ANDERSEN are frequent contributors of art to the magazine.





BOTH BY ALFRED MCINWEN, USGS FLAGSTAFF IMAGE PROCESSING FACILITY



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КОМПЬЮТЕРИ АВТОМАТИЧЕСКИ ТЕЛЕСКОПИЧЕСКИЕ СИСТЕМЫ - СЛУЖБА НАПОС





MICHAEL COLLINS (ABOVE AND LEFT)



JOHN SCHNEIDERMAN, NASA STAFF (ABOVE AND LEFT)

"We should go to Mars together," writes Roald Sagdeev (above at left), distinguished director of the Soviet Space Research Institute, who hails signs of a growing bond between superpowers in space. His colleague, Georgi Managadze, at right, is a principal scientist on the Soviet Phobos mission, which is being aided by a NASA tracking system in following the two experiment-laden probes. And last summer, in a cooperative gesture, the Soviets invited a small group of U. S. observers—including author Mike Collins—to long-secret Baikonur Cosmodrome in Kazakhstan to witness the Phobos launch.

Blasting off on July 7 (top left), the first of the two probes

soon began sending data to Flight Control Center in Moscow (left), while the second probe (top), mounted on its Proton rocket, was readied for launch on July 12.

Due to reach Mars in early 1989, the spacecraft will move on to Phobos several months later—eventually swooping to within 200 feet of the surface for a slow-moving pass. They will investigate, among other things, whether the moon is an asteroid trapped by Mars' gravity. Their array of equipment includes a laser to vaporize surface material for analysis and a lander, called the "Hopper," designed to conduct soil experiments, then leap some 65 feet to a new location.

They will find the topography of Mars not unlike the southwestern deserts of the United States, except that it is devoid of visible plant and animal life. The monotony of boulder-strewn flatlands is broken by spectacular mountains and chasms whose dimensions dwarf terrestrial features.

For example, Olympus Mons is the tallest volcano in the solar system, three times as high as Mauna Kea and covering an area about the size of Montana. Valles Marineris, a system of canyons near the planet's equator, stretches for ten times the length of the Grand Canyon. As on our moon, impact craters and volcanoes

dominate surface features, but unlike the moon, Mars shows clear evidence that copious amounts of water once flowed over its surface.

Scientists believe that at one time Mars had a warmer climate and much denser atmosphere, laden with water vapor. Running surface water carved out networks of channels, and the planet could easily have harbored life.

Later on the atmosphere thinned, and ice-age conditions prevailed. Today some water is frozen in polar ice caps and perhaps in ground ice. The whereabouts of water will be a prime concern of the landing crew.

Detailed knowledge of the red planet comes from data collected by two unmanned Viking spacecraft that mapped the entire surface from orbit in 1976. They also landed and analyzed a small amount of Martian soil. They found that the soil produced oxygen when water was added—a possible sign of dormant organisms coming to life. But scientists concluded that it was a chemical process rather than a biological one. If life exists on Mars, it probably is near the ice-covered poles or in hollows of dry riverbeds.

Some scientists feel that even failure to find life on Mars would be important. As astronomer Carl Sagan put it, "If Mars *is* lifeless, we have two planets, of virtually identical age, evolving next door to each other in the same solar system: life arises and proliferates on one but not on the other. Why?"

Our journey to Mars carefully considered the fact that Earth, closer to the sun, is orbiting faster than Mars and overtakes it about every 780 days. This interval determines when any mission departs



Earth for Mars (the launch window) and when it returns, in order to consume the least rocket propellant.

The minimum-energy path would have involved our crew in almost seven months of outward travel, a wait at Mars of a year and a half for the two planets to realign themselves for the return, and a six-month voyage home—a total trip of more than two and a half years. We have reduced this to less than two years by the stratagem of swinging by Venus to use its gravity as a slingshot to speed up the spacecraft, at a slight increase in fuel consumption (pages 742-3).

But far more than fuel is at stake in determining flight duration.

In an emergency, astronauts in Earth orbit can return to terra firma within an hour. Even the moon is no more than three days away. But a voyage of a couple of years imposes new standards of performance and reliability on both crew and machinery. No hospital, no repair shop or grocery store, just month after month of black sky and, at times, a face on the TV screen.

A little arithmetic demonstrates the enormity of the supply problem.

Each day the average man requires about 3 pounds of food, 5 pounds of water, and 2 pounds of oxygen for a total of 10 pounds. (Most women consume less, a point in their favor in considering any long-duration mission.) On a two-and-a-half-year trip eight men would require 75,000 pounds of food, water, and oxygen. And that includes only water for drinking, with no allowance for showers or laundry—clearly intolerable.

To avoid the weight penalty of dumping wastes overboard, our crew recycles all liquids. Wash water, cabin humidity condensate—even urine—are purified and used again for drinking.

Similarly, exhaled carbon dioxide is used along with sunlight and water to make food for plants, which help produce oxygen and food in return. Solid wastes serve as fertilizer. On this Mars voyage, however, the plants are only experimental; their health depends on the complex interaction of microorganisms whose behavior is far too risky for the first expedition.

SYSTEM BY SYSTEM the Mars spacecraft demanded a new standard of reliability. New ideas that offered to save weight or add performance were judged against old standbys. For example, new propulsion systems such as ion-drive engines have not yet proved themselves as dependable as liquid-fuel rockets. On Earth nuclear power plants can be shut down for periodic repairs, but such maintenance in space would involve formidable problems in shielding.

A spacecraft needs not only power to propel itself but also power to drive gyroscopes, pumps, lights, and other machinery. On the Apollo spacecraft we generated electricity by a clever device called



A Mars watcher at Lowell Observatory in Flagstaff, Arizona, keeps an eye on the red planet, visible through the dome's opening, with the historic 24-inch telescope (facing page) built for astronomer Percival Lowell in 1894. Based on his observations, Lowell theorized that Mars was populated by intelligent beings who built canals.

To communicate with missions to Mars or other distant locations, NASA's Langley Research Center in Hampton, Virginia, tests a collapsible parabolic mesh antenna (above) that can be stowed away for launch, then unfolded and deployed in space.



the fuel cell, which combined hydrogen and oxygen to produce electric power, with drinking water as a by-product. But a Mars expedition requires many times more energy than an Apollo jaunt to the moon, and for much longer, beyond fuel cell practicality.

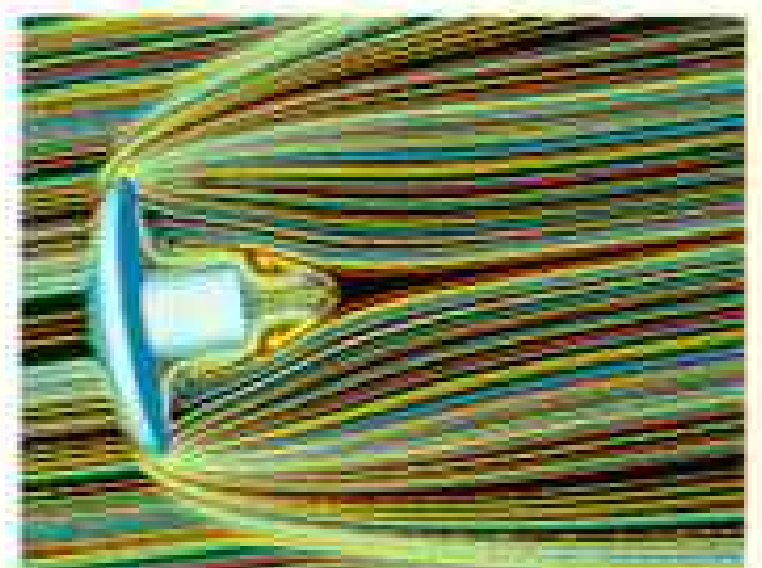
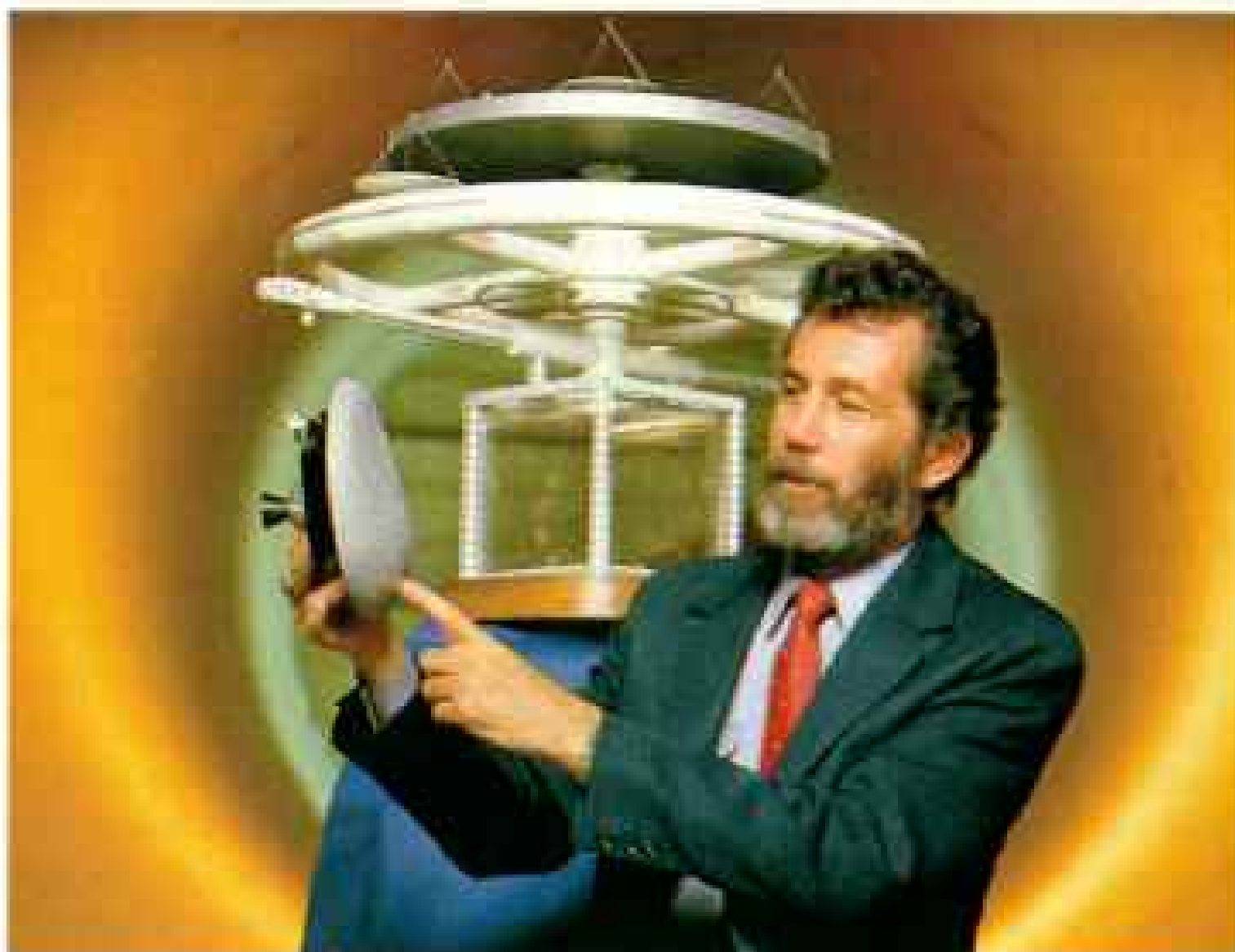
Solar energy presents similar problems. Solar panels, composed of many small photovoltaic cells, convert the sun's energy directly into electricity. They power most satellites. But on a trip to Mars, traveling farther and farther from the sun, the power produced by a solar panel would gradually be reduced by more than half. Consideration was given to using nuclear power to generate electricity before the final decision to stick with solar.

Such tricky problems are at least susceptible to engineering analysis. Not so the single most important component: the human body. In space the full range of health factors comes into play. Planners must consider not only nutrition and disease but also radiation, cardiovascular changes, muscular deconditioning, the psychology of isolation and confinement, and—perhaps most serious of all—a weakening of the bones known as demineralization.

Our crew members were subjected to the most exhaustive tests medical science could devise. But as Dr. Arnauld Nicogossian, NASA's director of life sciences, points out, "Never before has medicine been called upon to certify that an individual will be healthy enough to perform for two years after the examination." In

A key component of a Mars mission will be the aeroshell—a shield that slows the spacecraft by using atmospheric drag instead of costly fuel. Its oblate shape makes it easier to steer, says NASA's Paul Siemers (below left), who holds a small model of the craft to be tested on upcoming shuttle flights. A space station model sits behind him.

To study the vehicle's communications system, NASA's Tom Campbell positions a model in Langley's echo-free chamber (facing page). Supercomputers simulate flow patterns (below, top) and other effects of gases that would strike an aeroshell (bottom) in the Martian atmosphere.

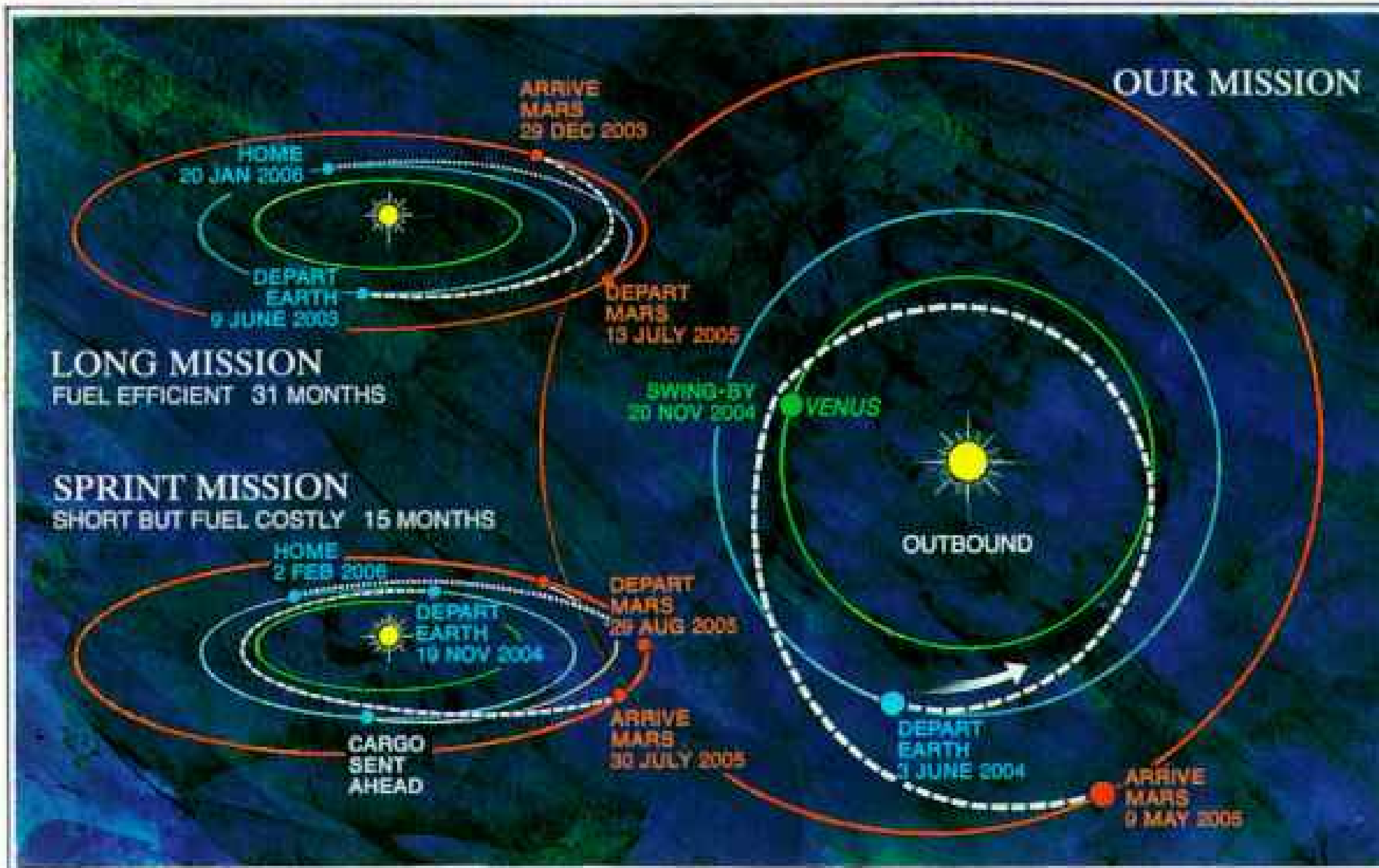


that time chances are that a case of appendicitis or a kidney stone may appear.

Once I asked Dr. Joseph Kerwin, a Skylab astronaut and physician, what he would have done if one of his mates showed signs of appendicitis. "Strap an ice bag on his belly, give him some antibiotics, and come on home," he replied. On a long-duration Mars trajectory, the ice bag and antibiotics might have to suffice.

Our craft has a well-stocked infirmary, but surgery will be limited to elementary procedures, and weightlessness could complicate those, such as stanching the flow of blood from an incision or wound.

(Continued on page 747)



Charting a round-trip: three options

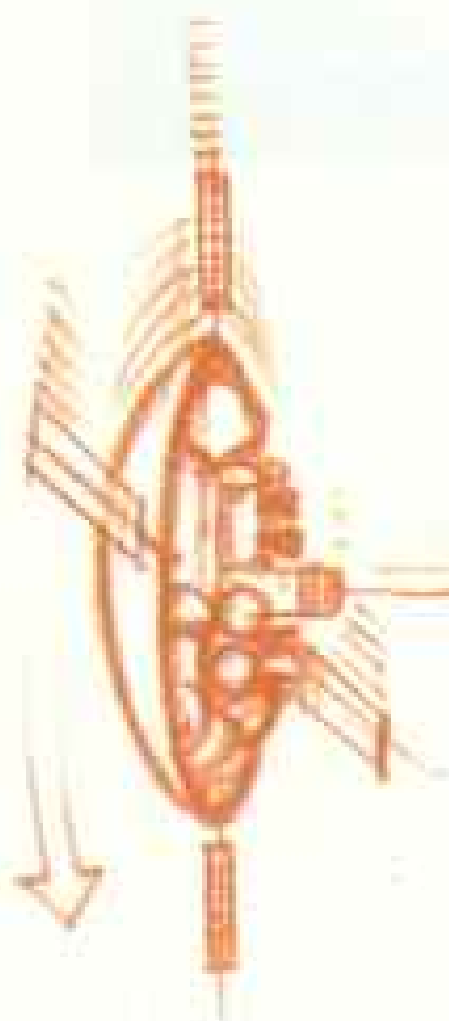
THERE ARE MANY WAYS to get to Mars," says author Collins, "depending on the position of the planets and how much fuel you're willing to haul along. If you drive your car at 65 miles an hour instead of 55, you get where you're going quicker, but your gas mileage drops. It's all a matter of trade-offs."

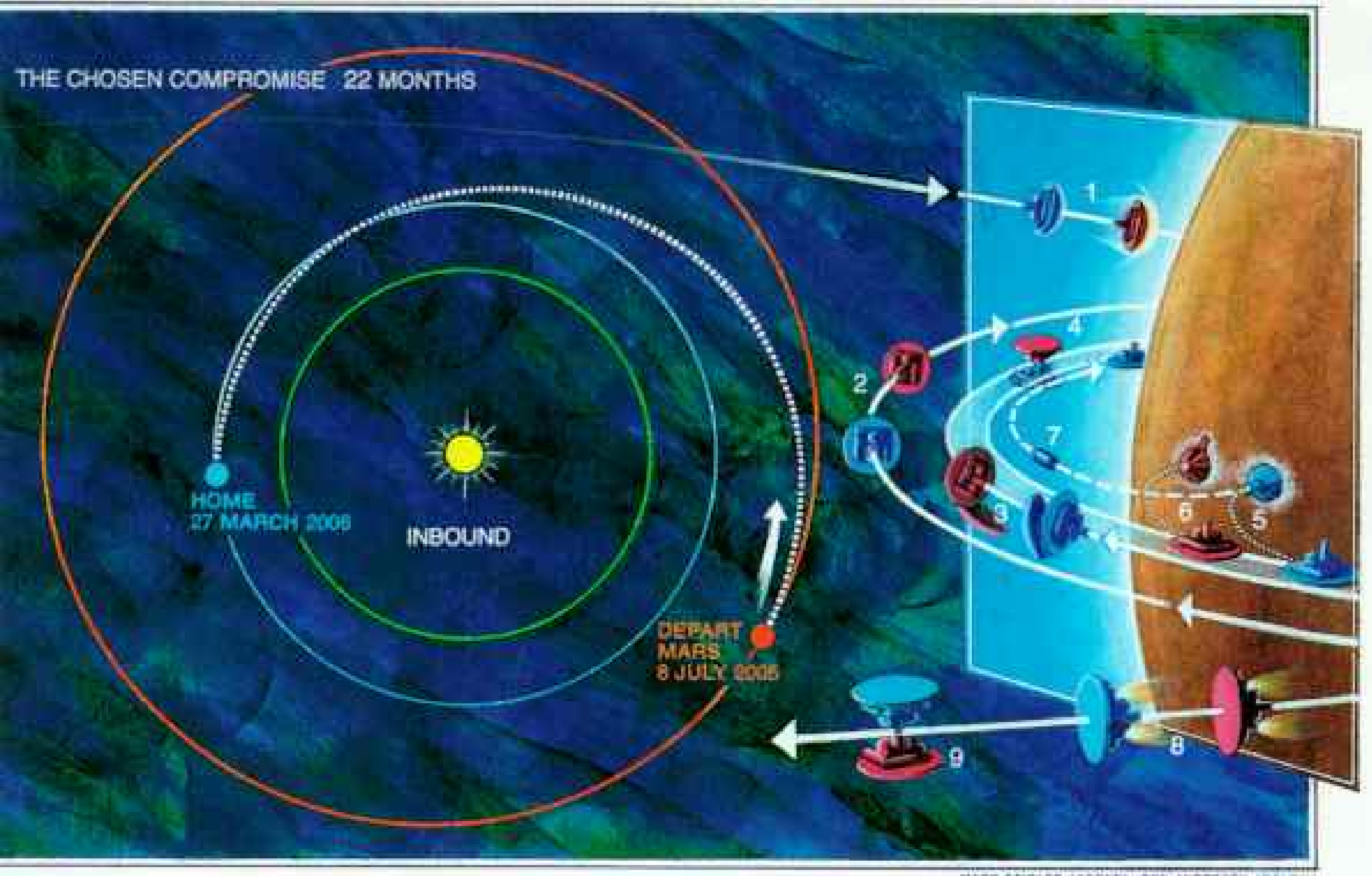
The most fuel-efficient route to Mars is a direct trajectory (top left) taking less than seven months each way but requiring a stay on Mars of a year and a half—a round-trip exceeding two and a half years. "A real ordeal," says the author. "It's also more of a gamble. The longer you're out there, the more bad things can happen."

The fastest route is a sprint mission, which reduces the round-trip to about 15 months

but greatly increases the fuel load. To minimize fuel weight, a cargo vehicle would be sent ahead on a more efficient route. But because of the celestial timetable, astronauts would be limited to less than a month on the surface of Mars—a relatively small payoff for the 50- to 100-billion-dollar price of a Mars mission.

Blasting toward Venus to rendezvous with Mars, the 22-month journey preferred by the author would combine advantages of both scenarios. By using the gravitational field of Venus to "sling" the Soviet-American spacecraft toward its destination, the mission would achieve necessary velocity while conserving fuel. And the landing crew could spend about 40 days on the surface of Mars before taking the "long" route home.





MARK SCIDLER (ABOVE); RYAN ANDERSEN (BELOW)

While en route the tandem spacecraft would probably be joined at the docking port (right). Another plan: swing the ships around each other on a tether (bottom) to provide artificial gravity for their crews during the long trip.

vehicle's built-in ascent stage (7) to rendezvous with their crewmates in the orbiting mother ships. The craft blast out of Martian orbit separately (8), then redock for the nine-month journey home (9),

Nearing Mars (above, far right) the Soviet and U. S. ships separate, then "aerobrake" to reduce speed (1) and enter an elliptical orbit around the planet (2). Maneuvering into circular orbits, the ships jettison their aeroshells (3), recouple (4), and target the landing site. After separating again, the crew's landing vehicle descends to the planet's surface (5), to be followed by the electronically guided, unmanned lander (6) containing supplies and equipment. After their 40-day stay, the crew launches the landing





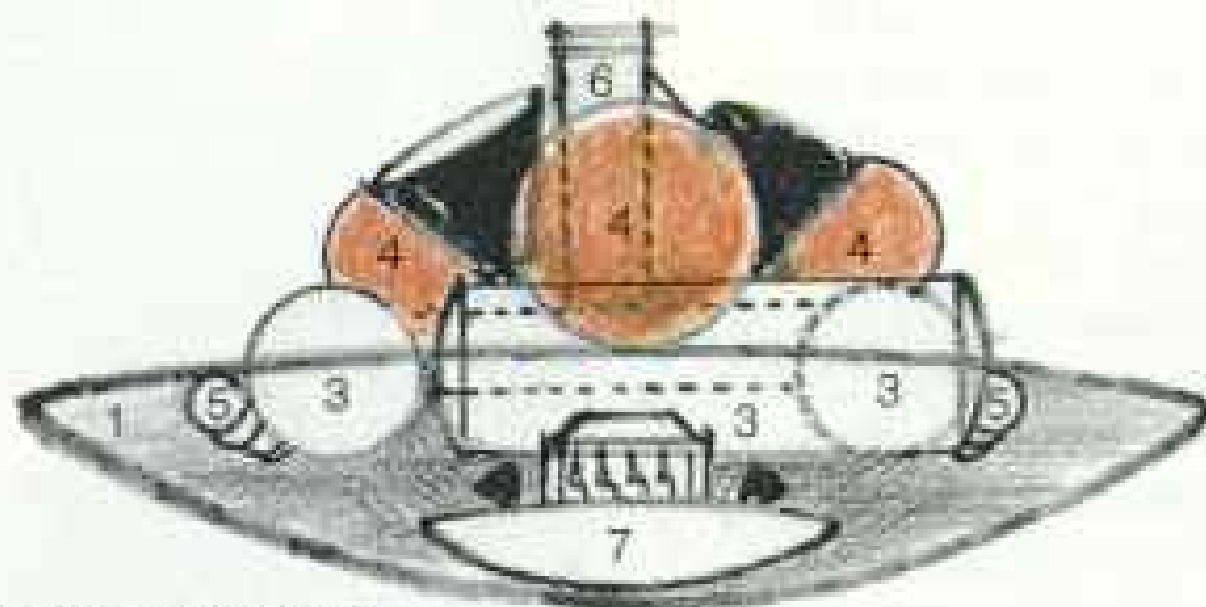
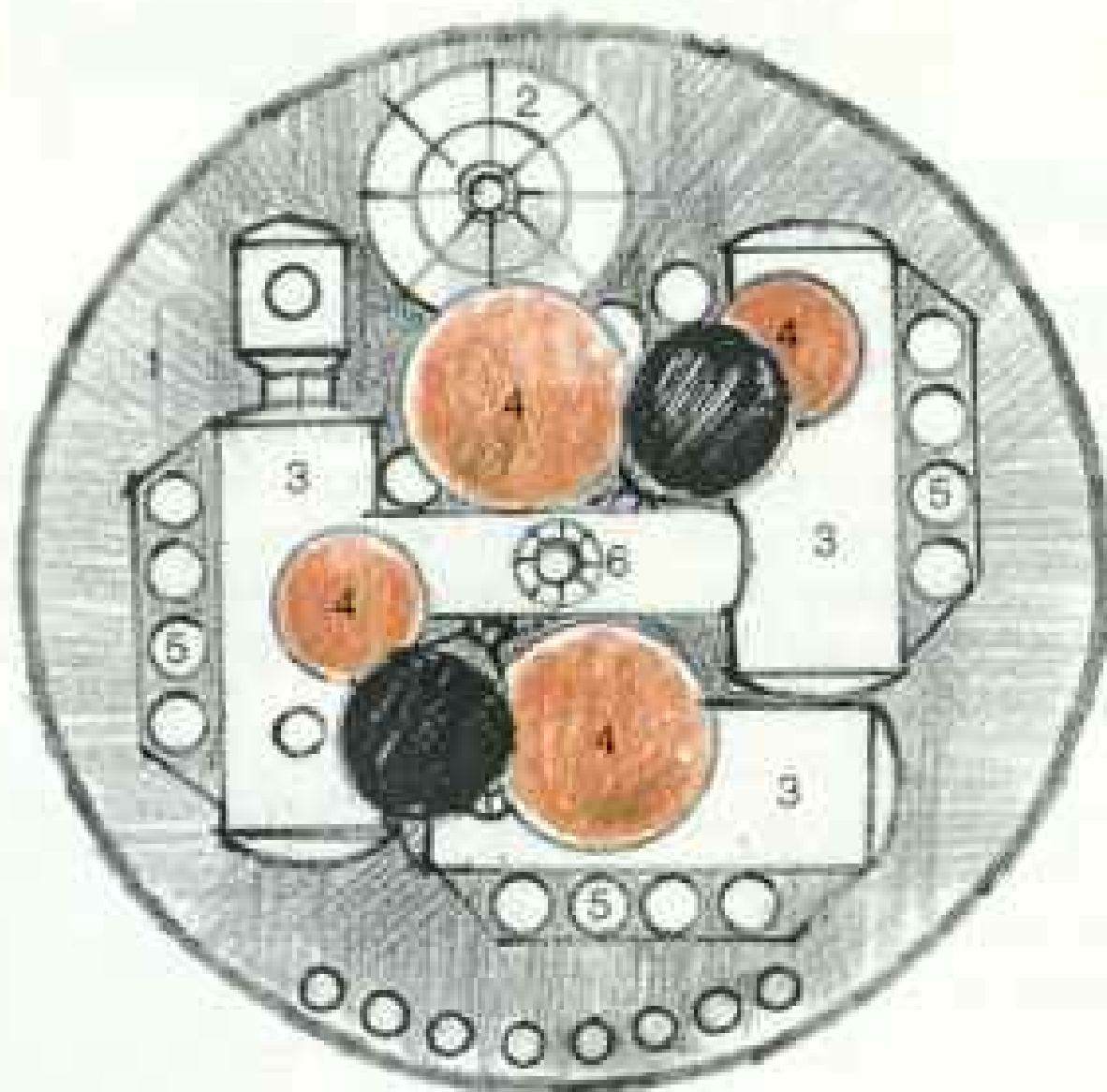
Escape from Earth orbit

RIDING ATOP a pair of escape rocket stages, the spacecraft (left) envisioned by Mike Collins and other experts would be launched from low Earth orbit, rather than from the surface, because of its size. Seen at far left in different phases leading to countdown—perhaps as soon as 2004—the 500,000-pound spacecraft would be assembled at a space station, at left, from equipment ferried aloft by unmanned heavy-lift vehicles.

Beneath the spacecraft, each escape stage is protected by an aeroshell and will be retrieved for reuse. A similar Soviet spacecraft, launched from their space station, would rendezvous

and dock with the U. S. ship some ten days into the journey.

The spacecraft (below) includes an aeroshell 90 feet in diameter (1), a landing vehicle for descending to the surface of Mars (2), habitation modules where the crew lives and works (3), tanks for fuel storage (4) and water (5), a docking tunnel for mating with the Soviet spacecraft (6), and, at bottom, an "Earth-capture vehicle" (7) with its own aeroshell. This smaller ship would be used as a storm cellar against radiation from solar flares and to reenter Earth orbit at journey's end, after the eight crew members have left their mother ships.



PIERRE NICH (LEFT); ROY ANDERSEN



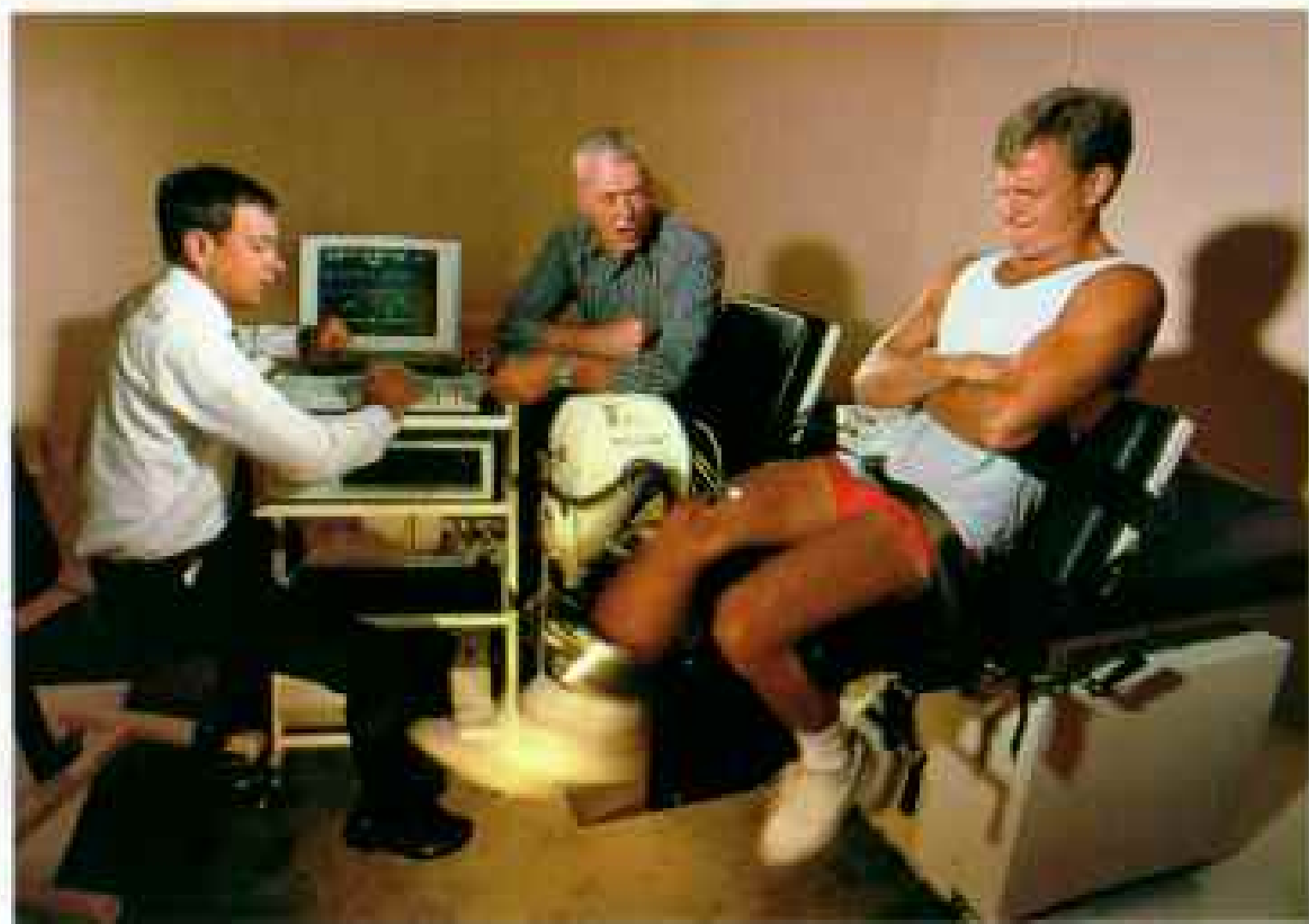
Hazards of a long voyage

THE WORLD WITHIN the spacecraft may be the ultimate frontier on a Mars mission. "It would be an enclosed life-support system," says the author, "where nearly everything is recycled, so the crew would be vulnerable to any organisms that run amok."

Personnel choice would also be critical. Collins suggests a crew of four married couples, assembled from around the world. They would face problems ranging from deadly bursts of solar radiation to the more subtle effects of "space stress," such as irritability and depression. Both might result from boredom, isolation, confinement, or the homesickness of seeing Earth as a mere speck millions of miles away.

Experiments are under way to have the crew decorate their own living quarters, sleep in hassle-free restraining sleeping bags, and work and eat at stations custom-made for the "neutral body position" of weightlessness.

The medical effects of prolonged weightlessness are cause for concern. The Soviets, who have logged more than 15 man years in space, believe that exercise can minimize two known effects: calcium loss in bones and muscle atrophy. Another recently detected problem—a possible





HOY ANDERSEN

weakening of the immune system — might leave the crew vulnerable or impaired in accomplishing their mission on Mars.

At NASA's Kennedy Space Center, scientists study the merits of "normal" exercise (below left) versus electro-muscle stimulation (below) — a passive technique that could save electrode-wearing astronauts hours of drudgery on a treadmill or rowing machine.



THE MARS SPACECRAFT was assembled in factory "clean rooms" that filtered out dirt and dust. However, microbes pervade all equipment, and undoubtedly a colony of them has accompanied the crew on the voyage. Presumably no virulent strains found their way on board, but it is even possible that in the alien space environment some genetic mutations may develop and produce new forms of bacteria the crew has never encountered before.

The crew's diet, essential to health, has been carefully planned. Because of weight limitations the mission relies on the old standby, dehydrated, prepackaged food.

Radiation poses a major concern. Human response to harmful radiation can range from nausea and vomiting to fever and death. Long-term effects, which may not arise until years after exposure, include cataracts, tumors, and leukemia.

Galactic cosmic rays, high-energy particles that probably originate in exploding stars called supernovae, constantly bombard the spacecraft, but the amount of radiation reaching the crew is not expected to exceed an acceptable level. More threatening, solar flares sporadically belch out from the sun. Their radiation could kill the crew, if unprotected, within a couple of days. Engineers designed the spacecraft with a protective storm cellar, shielded by the vast stores of water, oxygen, and propellant on board — all of which are good energy absorbers.

Another problem, though considered remote, is posed by meteoroids, which might be lurking near Mars because of its proximity to the asteroid belt. Spacecraft shielding would stop sand-grain-size pellets, and our eight voyagers have been carefully trained to patch holes made by larger ones.

Perhaps the greatest threat lies in the debilitating effects of weightlessness on the human body. On Earth our bodies fight against gravity: Muscles strain as we walk up stairs, and bones maintain their strength to support the weight of our bodies. On the trip to Mars, floating free, the crew's bodies have changed, responding to an environment unlike anything our ancestors met in millions of years of evolution.

At the earliest onset of weightlessness their body fluids, which on Earth are drawn by gravity toward the feet, migrated toward the upper body. Neil Armstrong and Buzz Aldrin looked different to me on our flight to the moon: Extra fluid reduced their facial wrinkles and made their eyes look squinty and crafty. With no gravity to compress our vertebrae, we grew in height by perhaps two inches.

Although it didn't happen to us, weightlessness makes about half of all space travelers feel sick for the first couple of days. The symptoms are similar to seasickness, with loss of appetite, nausea, and sometimes vomiting. We still don't know why this happens, and ground tests are not accurate in predicting who will or will not be susceptible.

Other changes are equally mysterious. The body mistakenly interprets increased fluid in the thoracic region as an increase in total blood volume, and initiates a complex process to get rid of it. There is an initial decrease in blood plasma volume, perhaps due to hormone secretions, which might also have a diuretic effect. The body seems to sense that the new blood volume is too rich in red blood cells and sets about curtailing their production in the bone marrow.

Muscles atrophy if not used, and without exercise our crew's leg muscles would wither during the long voyage. With no gravity to pump against, the heart grows lazy and shrinks in size.

Exercise does not eliminate the most serious health problem—loss of bone density, especially in lower back, legs, and feet. Just as the marathon runner may not need the heavy bones of a weight lifter, so the space traveler can function with a skeleton much lighter than that of his earthbound twin. The body responds to weightlessness by excreting calcium and reducing bone density, at a loss rate that has been calculated at one-half of one percent a month.

Bones become brittle and begin to fracture easily when their mineral content is reduced by 25 percent, which might take five years in weightlessness. Tests of bedridden patients on Earth suggest that bone damage may be irreversible after a year. Calcium in the urine may also lead to kidney stones, a painful and disabling ailment to encounter months away from a well-equipped hospital.

Muscle and bone problems are the result of the condition—weightlessness—not the location—space. If artificial gravity can be introduced in space, they should disappear. It is possible to use the centrifugal force of a rotating spacecraft as a substitute for Earth's gravity. How-



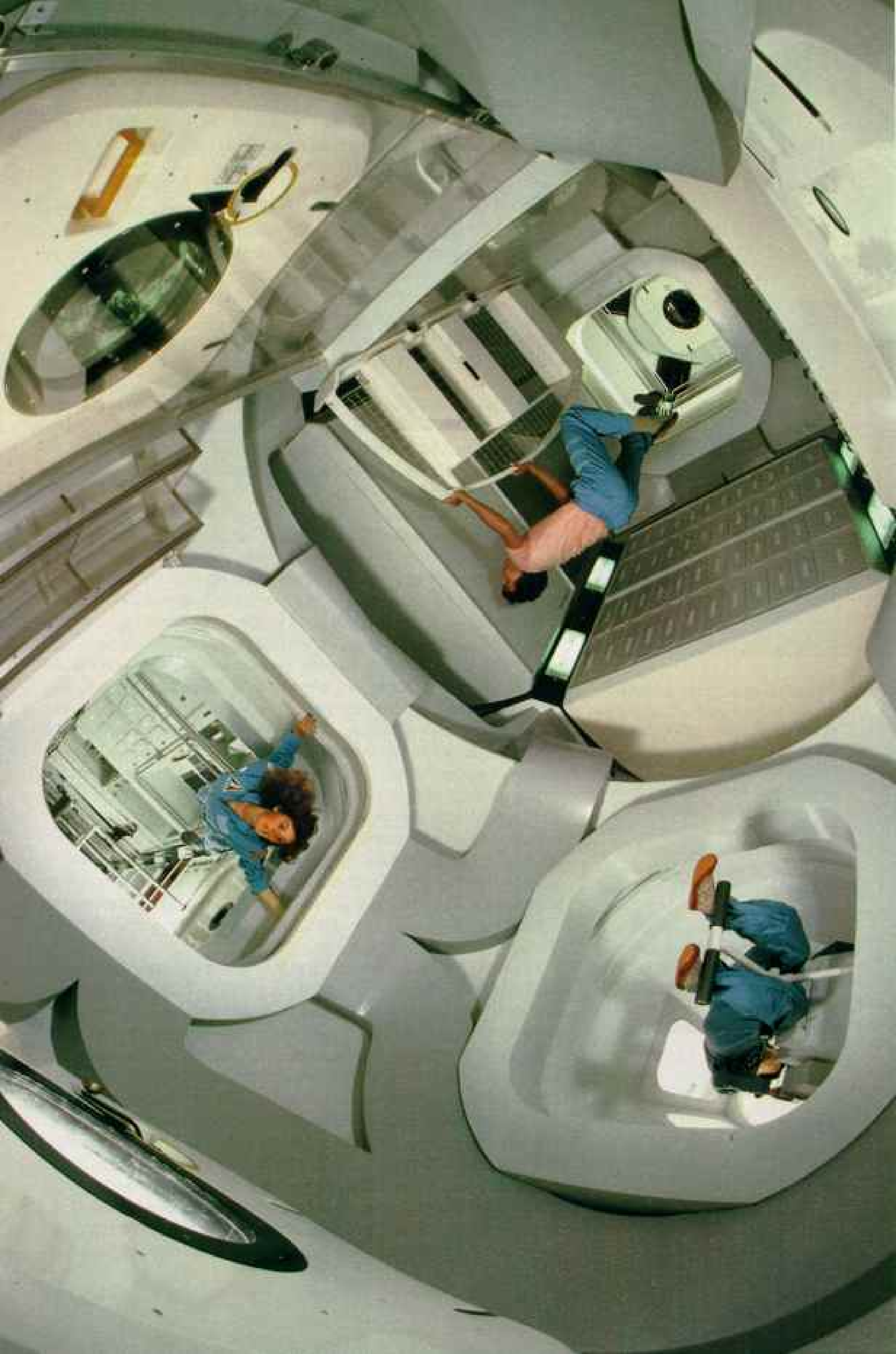
Home is a habitation module (above) to technicians demonstrating training in the space station mock-up at NASA's Johnson Space Center in Houston. Designed to accommodate eight crew members in a pressurized, shirt-sleeve environment, this prototype links habitation, laboratory, and other modules using an interconnecting node (opposite). To make space travelers—who only appear weightless here—more at home, architects plan modules with an artificial "up and down" orientation.

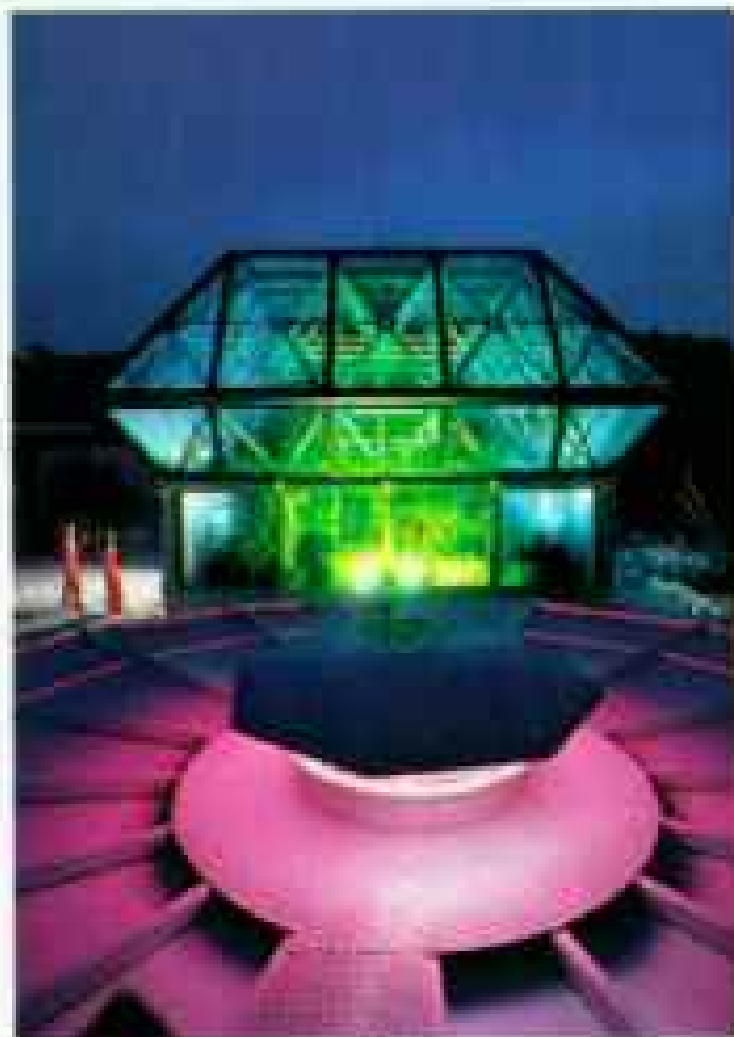
ever, spinning a habitat may create engineering and physiological problems. It consumes fuel to initiate or terminate and it may be difficult to stop a craft from nutating, or wobbling like a top. Communications and navigation become harder. The radius of rotation may have to be large, perhaps a hundred feet or more, or the spinning might cause dizziness and loss of balance.

AMARS CREW FACES one final hurdle: the psychological double whammy of prolonged isolation and confinement. Isolation from all they have known before: no family, no trees, no valleys, no waterfalls. Out of the windows, month after month, the same black velvet dotted with unblinking stars; only the almost unmeasurable change in sun, Earth, and Mars as the mission unfolds.

And confinement: No way to escape from the cloistered daily life of the spacecraft. No way to avoid looking at the same walls, no way to escape from the same repetitive tasks—or from other crew members. The interaction between individuals may be the most crucial factor of all, as months of boredom create frustration and hostility, followed even by incapacitation or violence.

Perhaps the closest analog on Earth is wintering over at an Antarctic research station. For the scientists and their supporting staffs the problems often result in "cocooning," a form of withdrawal.





To supply enough food, water, and oxygen to support an astronaut indefinitely, scientists at the Kennedy Space Center experiment with crops grown in a hydroponic environment inside a sealed chamber (opposite). The search goes on, says project scientist Bill Knott, standing, but so far dwarf wheat looks promising. "It's productive, fast growing, and short."

In 1990, eight volunteers will go behind sealed doors for two years at Biosphere II (prototype above), a private research project in Oracle, Arizona, exploring closed life-support systems.

Cases of violence have been reported. Under such conditions, organization and compatibility are of paramount importance.

Similarly, reports from long-duration Soviet space flights tell of tiffs between crew members, with participants in two-man crews pouting at either end of their space station.

THE SOVIET UNION has made an impressive long-term commitment to space exploration, with a steady, aggressive, well-funded program that includes going to Mars. (See NATIONAL GEOGRAPHIC, October 1986.)

As part of the program, cosmonauts have systematically extended their orbital flights. Ten years ago they surpassed our Skylab record of 84 days. In 1984 three weary cosmonauts, including a doctor, returned to Earth after 237 days aboard the Salyut 7 space station. At this writing a two-man crew on the Mir station should be well on the way to breaking the duration record of cosmonaut Yuri Romanenko, who spent nearly all of 1987 in orbit.

What have the Soviets learned so far? First, in the broadest sense, the flights have been successful, and many Salyut and Mir cosmonauts have gone up again.

On the other hand, it hasn't been easy. Romanenko's performance degraded toward the end of his flight, and his workday was reduced to 4.5 hours. Upon landing, cosmonauts have had trouble standing up and are scooped from their spacecraft in reclining chairs as a precaution. After seven months in space, Anatoly Bere-zovoi told me that he couldn't walk properly for three days, and he thinks a Mars trip is impossible without artificial gravity.

The Soviets are trying various countermeasures to protect the body from weightlessness: exercise on a stationary bicycle and treadmill for at least two hours a day (Romanenko reportedly did as much as four hours a day); special clothing that simulates the role of gravity in sustaining muscle tone; a diet of 3,200 calories a day plus calcium supplements and vitamins twice daily. All these measures are designed to minimize bone demineralization and cardiovascular and muscular deconditioning.

Romanenko's 11-month stint in Mir is a big step toward certifying the human body for a Mars mission. He appeared to rebound quickly, more so than earlier crews, and was healthy enough to greet his family on his feet. He said that he went for a brief run the day after he landed, and his condition compared favorably with his 96-day flight of a decade earlier.

But many questions remain. Exactly how much was his skeleton weakened? Was this damage permanent? How much variation between individuals is there? Are women more susceptible to brittle bones? Will Romanenko's heart return to its preflight norm? How serious was the loss of muscle mass in his legs? If he had landed on Mars, would he have been incapacitated for a day or so? In all likelihood the methodical Soviets plan to answer these questions by tests of increasing duration aboard the continuously manned Mir.

While expanding their human presence in space, the Soviets have not overlooked the machinery a Mars mission would require.

The first need is raw rocket power, and the U.S.S.R. has recently unveiled the Energia, a giant booster in the same class as the U.S. Saturn V moon rocket, which last flew in 1973. The Energia can propel payloads of approximately a quarter of a million pounds into

Earth orbit and 60,000 pounds on a trajectory to Mars. It will be many years before the United States can duplicate this Soviet heavy-lift capability.

As preliminary steps to a piloted mission, the Soviets plan to send a series of unmanned probes into Martian orbit. The thunderous blast-off of a Proton rocket that I observed last July at Baikonur sent the first of these to the Martian moon Phobos.

During the next decade the Soviets will send several spacecraft to map the Martian surface, along with robotic rovers that will analyze soil and rock samples and ultimately return them to Earth.



Coupled with a vigorous research program aboard Mir, these missions should clear the way for sending people to Mars.

The exploration of space has increasingly become an international venture, and the Soviet Union has often used joint space missions to promote friendship with other countries. I have discussed the matter of a Mars expedition with half a dozen cosmonauts, and all agree that our two countries should work together on such a complex and expensive undertaking.

A possible schedule has been proposed by Roald Z. Sagdeev, director of the Space Research Institute: "We should go to Mars together. First, by 1994, we should cooperate in landing a mobile, unmanned space vehicle on Mars. Later, by 1998, to bring samples back to Earth. We could try to cooperate in landing men on Mars, maybe by the year 2001."



Simulating weightlessness in a 40-foot-deep water tank, space-suited NASA engineers at Huntsville, Alabama, test hardware designs and assembly procedures by building the primary framework for the planned U. S. space



ROGER BEALMEYER WITH KENJI TAMAGUCHI, NASA STAFF

station. In space, astronauts will strap into basket-like platforms, then maneuver themselves and their equipment around the station's framework to connect the plumbing and electrical systems.

Showering in space will keep the Mars astronauts in good humor, predicts test subject Sue Eley (facing page). She tries her hand at NASA's new zero-g shower aboard an aircraft flying 30-second parabolas to achieve weightlessness. The device runs on a gallon and a half of recycled water.



Working 25 feet underwater, engineers at Johnson Space Center assess the performance of the ZPS Mark III, a new pressurized space suit designed to help astronauts avoid hours of "prebreathing" to prevent the bends.

In this country there have been similar proposals, some pointing out that 1992 is both the 75th anniversary of the Russian Revolution and the 500th anniversary of Columbus's discovery of the New World—an auspicious year to begin, perhaps by testing in Earth orbit the first components of a Mars spacecraft.

The U. S. and U.S.S.R. flew together in Earth orbit in 1975, when a U. S. crew of three docked with a pair of Soviet cosmonauts in a goodwill mission called the Apollo-Soyuz Test Project. Now that President Reagan and General Secretary Gorbachev seem to have established a mutual goal of easing superpower tensions, a

joint flight to Mars might make political as well as technical and financial sense.

On the other hand Apollo-Soyuz was child's play compared with the extraordinary complexity of a Mars mission. I recall from early Apollo days that it was sometimes hard to get two or three American contractors to work together harmoniously. Imagine bringing together technicians with very diverse cultural backgrounds, no common language, and not even the same units of measure! Also, what about the Japanese, Europeans, and Third World countries—can they be left out? Should not a Mars expedition, especially the first one, represent all mankind, not just the two superpowers?

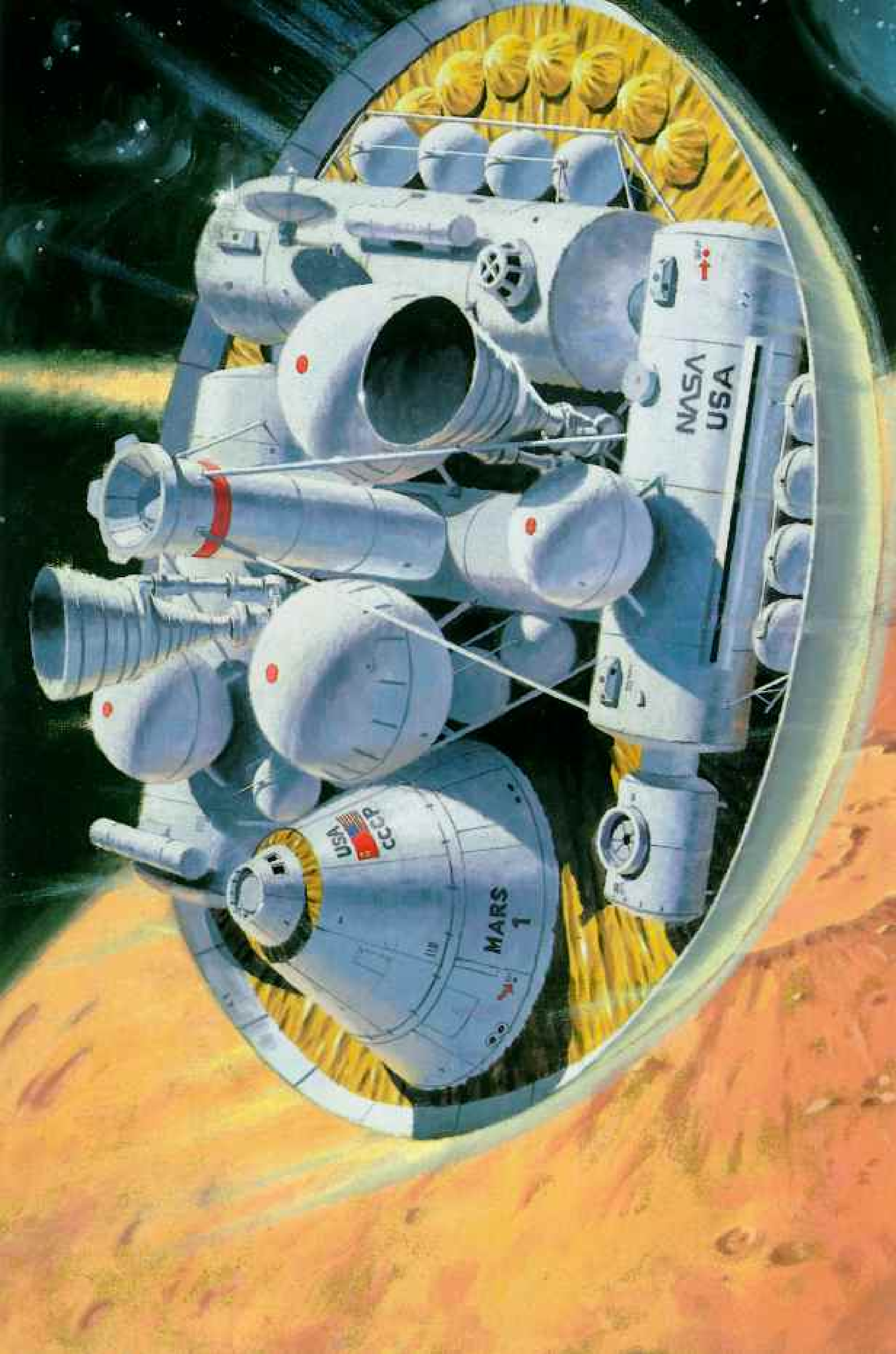
Cosmonaut Vladimir Dzhanibekov, a veteran of five space missions, described to me how international problems could be minimized by separating flights into national modules. For example, a joint sample-return mission could be put together so that one nation would provide a one-way trip for the robotic surface rover, while the second would be responsible for collecting the samples from the

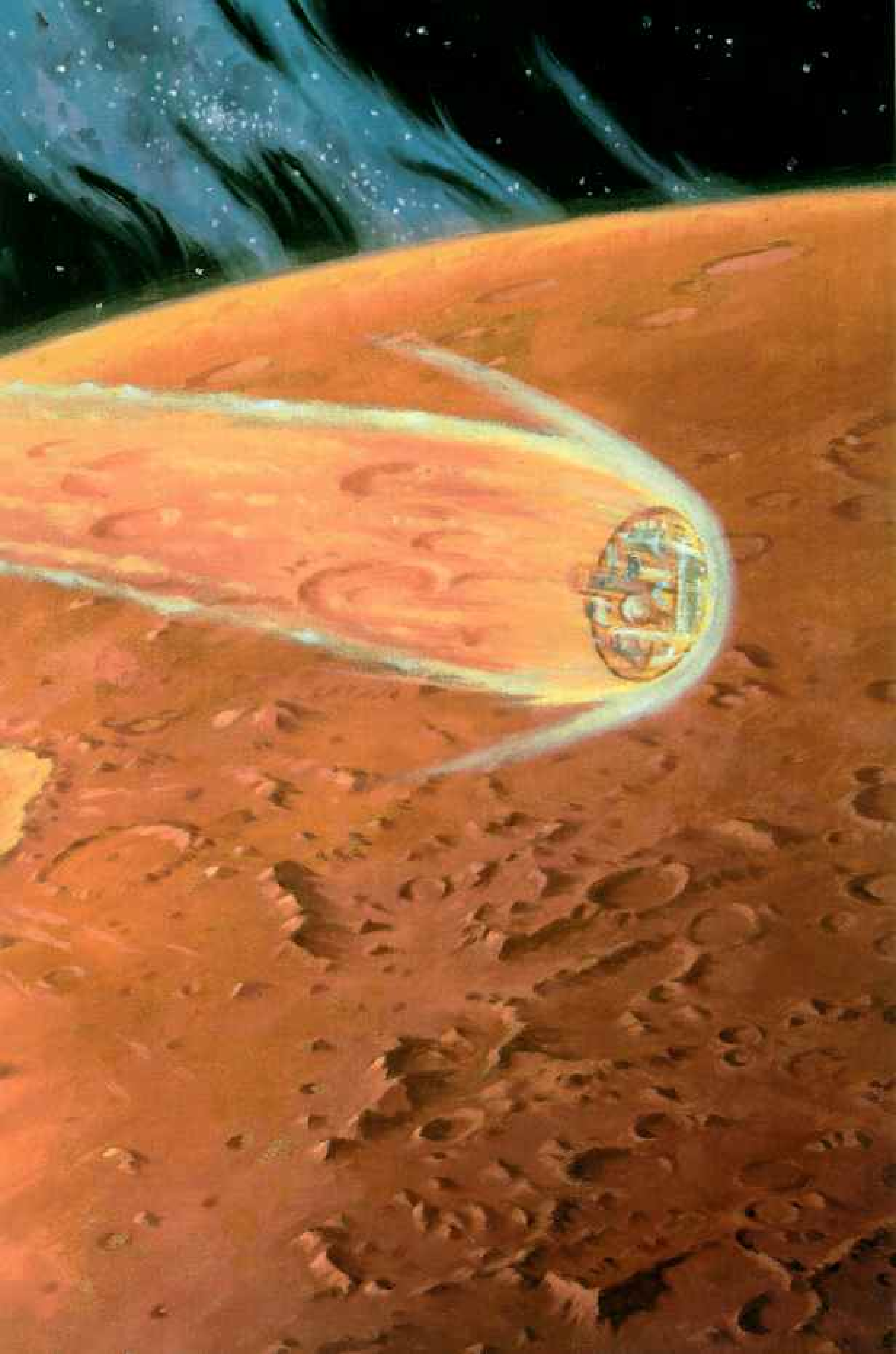
rover and returning them to Earth. In similar fashion a human expedition could be divided into logical national components, with attention to parity in responsibilities.

How close is this nation to undertaking a Mars voyage with or without the Soviet Union? In 1992 NASA expects to launch the Mars Observer to map the planet, measure its gravitational field, and study its atmosphere. Beyond this, plans for the red planet are vague.

The 1986 report by the National Commission on Space, chaired









ROY ANDERSEN

Firing retro-rockets to slow the descent, the crew of the landing vehicle become the first humans to touch down on the dusty surface of Mars. A possible landing site: the eastern Mangala Vallis (facing page, below), where ancient river channels, lava flows, and impact craters are clustered.

The explorers may wobble as they feel the tug of gravity for the first time in nearly a year, although Mars' gravity is only .38 that of Earth's. They set up an inflatable habitat and plant electronic beacons to guide the cargo lander, carrying a small nuclear power plant, to their camp. To explore Mars, they might use a Soviet-made rover similar to this remote-controlled one (facing page, top).

< Plunging into the Martian atmosphere with their aeroshells forward, the Soviet and American ships use friction rather than fuel to reduce speed and enter an elliptical orbit around the planet.

PIERRE HUIJN, PRECEDING PAGES

by former NASA administrator Dr. Thomas O. Paine, looks 50 years into the future and sees "pioneering men and women from many nations working and living throughout the inner Solar System. Space travel will be as safe and inexpensive for our grandchildren as jet travel is for us." The report predicts the first human outpost on Mars in the year 2015.

In 1987, as a member of the NASA Advisory Council, I chaired a small working group that recommended to NASA that the human exploration of Mars should be the agency's primary goal. Shortly after, former astronaut Sally Ride directed a much more extensive study within NASA. Her report endorsed the long-range goal of Mars but with qualifications: "Settling Mars should be our eventual goal, but it should not be our next goal."

Dr. Ride believes, as do a lot of other experts, that the best way to get to Mars is by way of the moon. A lunar outpost would allow a stair-step approach to Mars, wherein we could learn how to survive on another planet while venturing only three days from Earth. This makes sense, but I disagree: I believe the moon is an unnecessary detour that would delay our colonizing a much more interesting place. Besides, I think NASA needs one major goal, not two.

Perhaps my thinking is clouded by the fact that I have been to the moon and don't want to go back. But on one thing Dr. Ride and I agree: The exploration of Mars should not be a dead-end, one-shot spectacular but rather an orderly progression from the first landing to a small outpost to a Martian colony.

WHAT WOULD a Mars program cost?

Roald Sagdeev estimates that the initial phase, including a Mars rover, would be one billion dollars; a sample return, less than five billion dollars; a manned expedition, 50 billion to 100 billion, based on today's dollar. A knowledgeable American group, the Planetary Society, estimates 80 billion dollars to put four people on Mars for 30 days.

A sensible cost estimate requires that we have a rough mission profile. What trajectory, what size crew, how heavy a spacecraft? What equipment can be borrowed from other programs?

Wernher von Braun, the great rocket engineer, envisioned two ships carrying a dozen people. He stuck to the basic minimum fuel trajectory, calling for more than a year on the Martian surface and making the round-trip a 32-month ordeal.

Dr. Maxime Faget, the designer of the Mercury spacecraft, agrees that the way to go to Mars is in a small fleet. "A single ship is too risky; to make it adequately redundant would be too complicated and too expensive." Faget compares the Mars voyage with that of Christopher Columbus, who used the *Niña*, *Pinta*, and *Santa María* for safety. Faget would send 12 people in three or four ships.

Innumerable studies have investigated how best to reduce trip times. For example, more propellant must be burned to shorten the trip, adding to weight and costs. But it also means the crew will be breathing, eating, and drinking in a space environment for a shorter time, so human logistics are simplified. A shorter trip reduces exposure to danger and wear and tear on the body.

After listening to the experts, I picked a mission profile that includes the most advantages, as I see them, for our crew.

The mission, an international one, sent eight people on a 22-month journey, with a swing by Venus on the way out and six weeks on the Martian surface.

Making the voyage are two similar spacecraft, one built by the Soviet Union and one by the United States. The Soviets launched theirs in pieces with the Energia and assembled it at the new space station that replaced Mir. In similar fashion a new U. S. heavy-lift launch vehicle delivered components to this country's space station, which became operational in the late 1990s. It took a total of ten flights to assemble a million and a half pounds of machinery in low Earth orbit.

Because of the difficulties inherent in creating artificial gravity, our crew travels in a weightless environment (although future research in Earth orbit may establish the feasibility of artificial gravity).

The functions of the Soviet and American spacecraft are almost identical, although each nation's engineers arrived at separate solutions to many of the same problems. An equipment breakdown in one will require only that the crew double up, resulting in a severe inconvenience rather than an outright catastrophe.



COURTESY SPACE RESEARCH INSTITUTE, ACADEMY OF SCIENCES, U.S.S.R.



USGS PLAYSTAFF IMAGE PROCESSING FACILITY

Each of the two nations picked four crew members, two men and two women, coordinating closely to cover all vital scientific, medical, and technological disciplines needed. The four couples are U. S., Soviet, European, and Asian. English is the official language. As a concession for its use, a Soviet commands the mission. The four to descend to the Martian surface will be Soviet and American.

Once the two mother ships were assembled, the crew members were delivered to their space stations by the U. S. shuttle and its Soviet counterpart. Amid intense international fanfare the two spacecraft departed Earth orbit separately, then approached and docked for their historic trip.

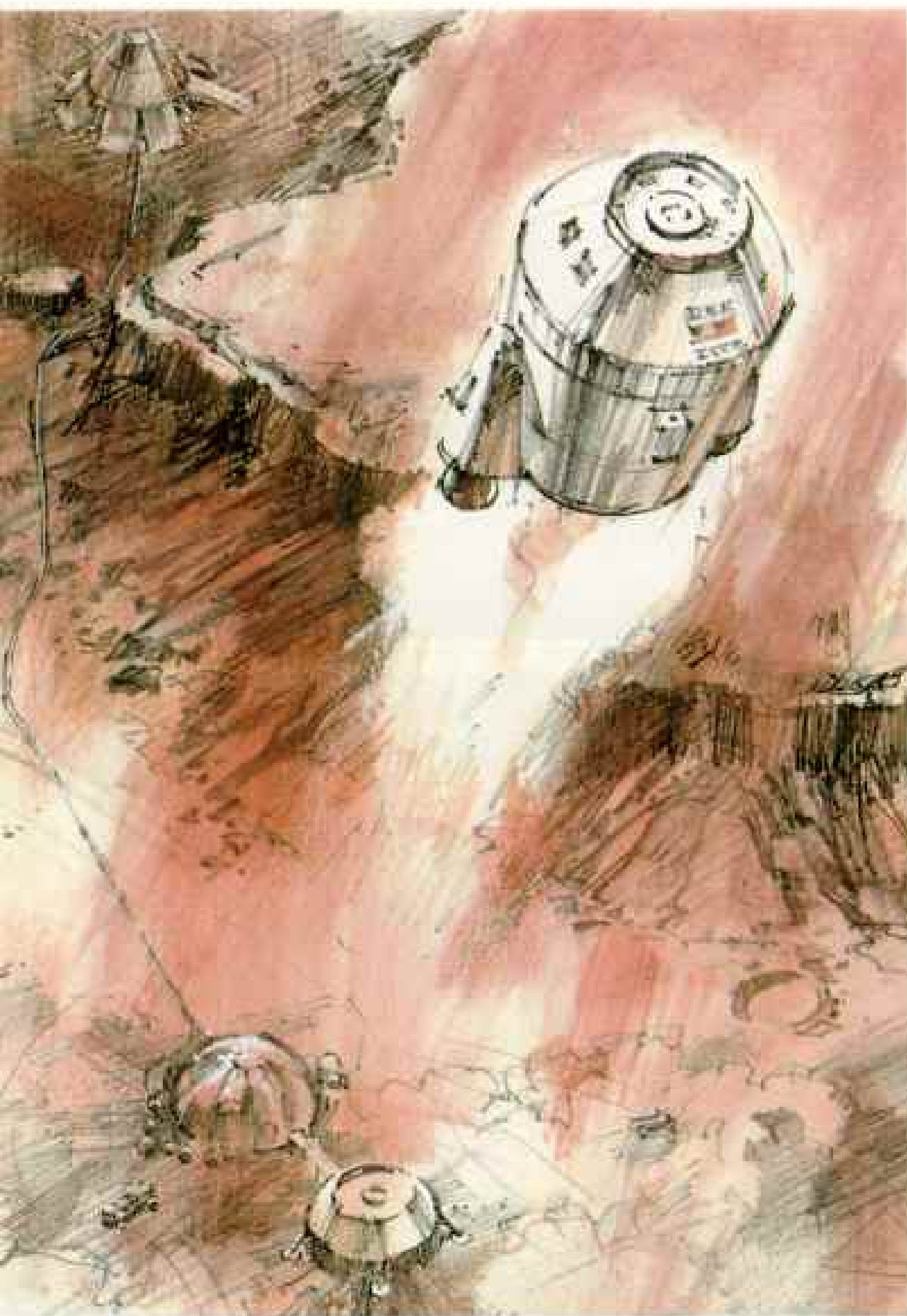
What is it like for the crew? The habitat modules, huge by present spacecraft standards, are cramped nevertheless, because of the space devoted to fuel, water, and other expendables, as well as to hardware. The crew's careful training, the sense of purpose, the interest of the world audience, the honor of representing the home planet, the clearly defined goal and timetable: All these combine to ameliorate what otherwise would be a terribly confining 22 months.

The crew spends a lot of time on scientific observations, along with exercise, engineering checks, and household chores. Keeping the supply inventory current is a time-consuming job (Skylab carried hundreds of washcloths, color-coded so each crew member could recognize his own supply). The cooks (French astronauts?) must plan, prepare, and clean up after 15,000 meals. Exercise is serious business for everyone: two hours a day of workouts on bicycles, treadmills, and other resistance machines.

Swinging by Venus on the outward journey five and a half months from Earth provides a

welcome break in the monotony. Crew members plaster themselves against windows like eager tourists to photograph the planet's veil of swirling butterscotch clouds.

Tension rises among the crew as the home planet becomes increasingly remote and the unknown perils of Mars more imminent.



ROY ANDERSEN

They spend a great deal of time studying and simulating future phases of the mission. To keep skills honed, they occasionally connect the control instruments into a computer that has been programmed to simulate various emergency conditions. Taped lectures help. An entire geology course, given by the crew geologist, engrosses those who will make the landing.

Despite all these activities, boredom remains a problem that will not go away. Television buffs among the crew have the easiest time of it because programs are beamed from Earth, not to mention the hundreds of movies stored on board. Even the news is at most only a quarter hour behind Earth schedule. Games and friendly competition help keep the eight voyagers interested and alert. The Soviets are the undisputed chess champions, while the Americans excel at inventing—and winning—new video games. Dart throwing and card playing (tricky in weightlessness) are popular.

Gardeners among the crew grow vegetables and a few flowers, not as a necessity but as a dietary supplement and a hobby. Applause greets the occasional appearance of fresh potatoes and beans on the dinner table—symbols of well-being and success.

The crew's life-support system is a hybrid, with a closed loop for recycling water and oxygen but not food and solid wastes. It was regarded as technologically risky to attempt to recycle solid wastes—a loop easy to visualize, but, oh, so difficult to keep working efficiently year after year. Thus some wastes go overboard, to mystify intergalactic travelers who might stumble across them centuries later.

ON APPROACHING MARS the two mother ships will separate and point their saucer-like shields toward the thin Martian atmosphere. In this way atmospheric drag can be used (instead of fuel) to slow the vehicles, a concept called aerobraking.

Once the two vehicles rejoin in orbit around Mars, the first duty will be to make the final landing-site selection for the base camp, one that not only is safe for landing but also provides interesting terrain for prospecting in the rover. Then the landing team—the two Americans and two Soviets—will abandon the luxury of duplicate facilities, and for six weeks they will rely on one landing vehicle, one surface habitat, one rover, one ascent stage.

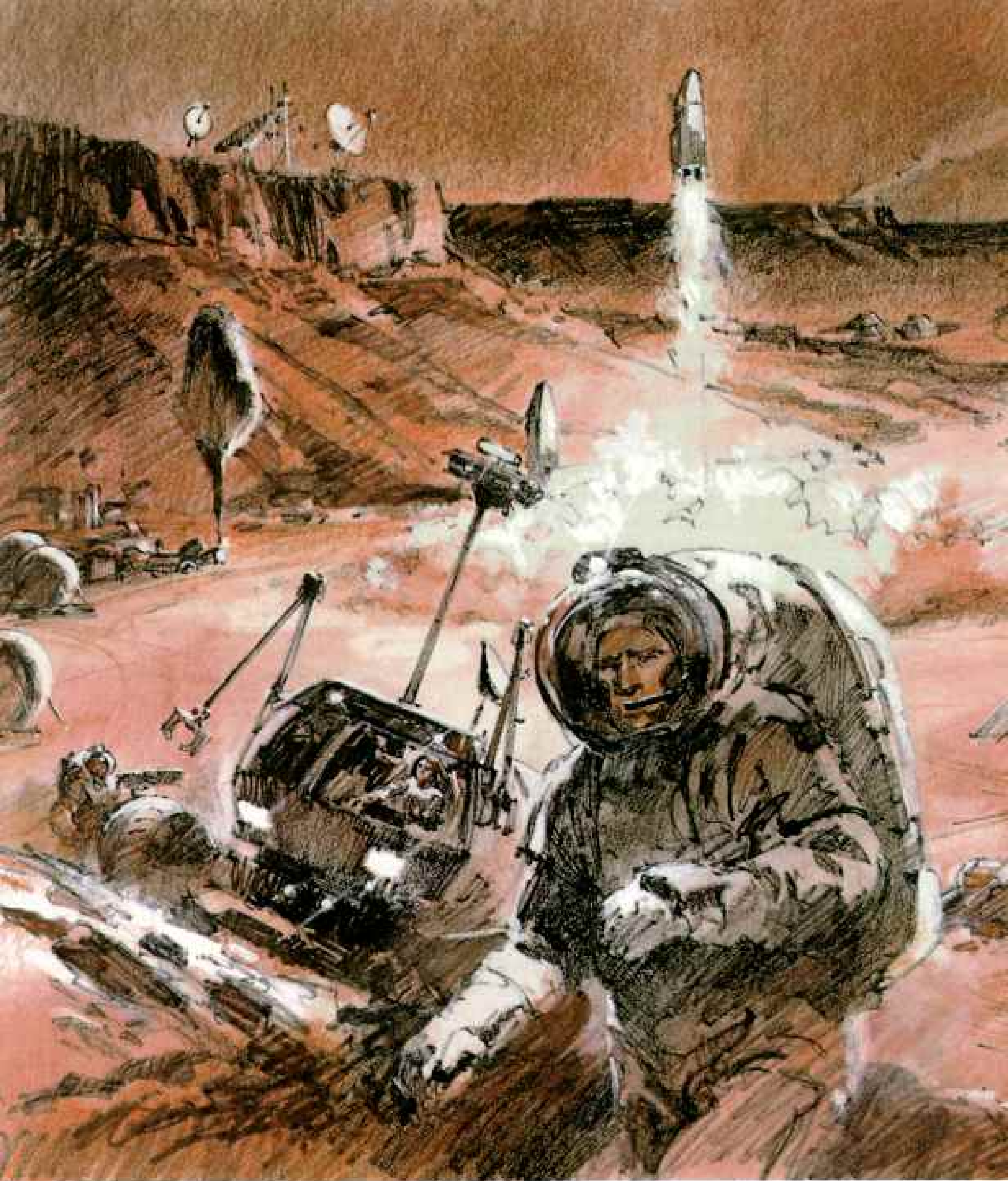
Of course, each of these machines has redundant components where possible. But just as the Apollo ascent stage relied on a single engine to take off from the lunar surface, so weight restrictions in the Mars mission dictated similar tough design decisions.

Fortunately the new technology needed to produce these units is well advanced, including the descent stage, which again will employ aerobraking. After this has done its job, parachutes will deploy, and then a rocket motor will cushion the final descent to a vertical landing.

On the surface the team's first task will be to ensure the proper functioning of the surface habitat, an inflatable structure (left) that will be connected to its own small nuclear power plant. Then two at a time they will venture forth in the rover to explore and to gather samples. They will avidly scan the surface for evidence of life, past or present—such as fossil remains in eroded sedimentary rock or any sign of living bacteria colonies. *(Continued on page 764)*

Leaving behind a base camp for future explorations (opposite), the Mars crew lifts off in the landing vehicle's ascent stage to rejoin the orbiting mother ships. Battened against the planet's dust storms, the inflated habitat, connected to the lander by a tunnel, stands near the Mars rover.

Buried for safety beneath the cargo lander, upper left, the camp's nuclear reactor will continue to power experiments, beacons, and communications—a lone electronic sentinel holding the fort until the next visitors arrive from Earth.



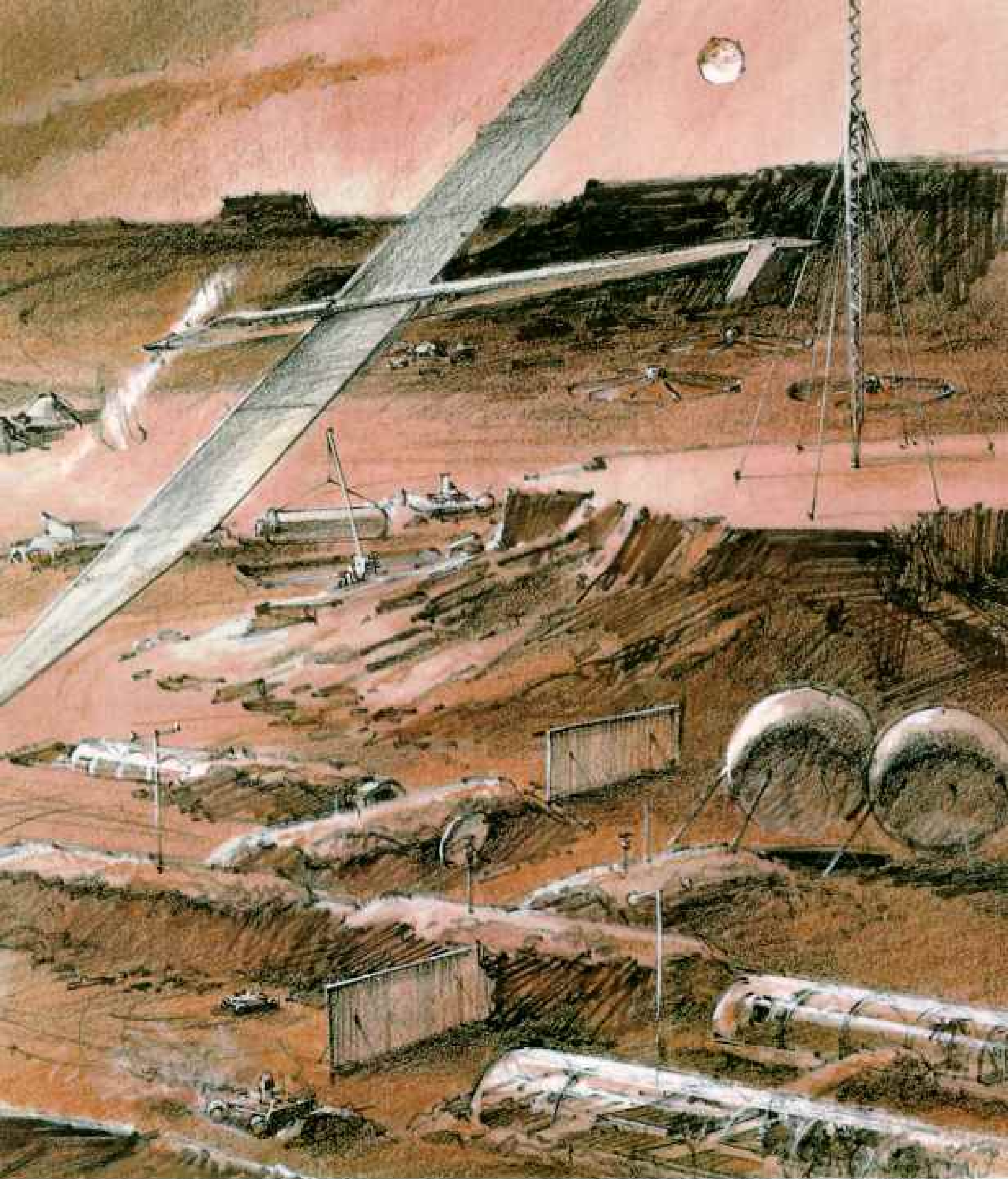
Mars Base 2050

A COLONY ON MARS by the year 2050 is feasible, according to some experts. If so, a collage of activities at this far-flung outpost would be a study in human ingenuity.

In the planet's thin, carbon dioxide atmosphere every breath

would represent a small miracle of technology, with oxygen drawn from CO₂-recycling greenhouses. Water would come from Martian polar or ground ice, melted and filtered.

To survey the planet's rugged topography, a Mars colony would be wise to send out



ROY ANDERSEN

mechanical scouting devices—a video-equipped helium balloon to wander the planet, perhaps, or an ultralight robotic plane for long-distance exploring, mapping, and prospecting.

Advanced rovers might allow a colonist to perform outdoor tasks without a space suit. But

even a short stroll outside, under creamy orange Martian skies, would mean coping with an environment more hostile than Antarctic winter: solar radiation, temperatures as low as minus 200°F, blood-boiling atmospheric pressure, and corrosive dust as fine as smoke.

Meeting Mars on its own terms will be a challenge for the next generation. For ours, the year 2004 is some 15 years away. But there's an optimistic saying gaining momentum in the U. S. space program: "Is there life on Mars? Maybe not, but there will be."

THE TRIP BACK TO EARTH will involve fewer tensions but will be even more tedious. Crew members will count the days and hope the machinery holds together, spending more time in their tiny sleeping compartments, reading and daydreaming in privacy. The commander will have to be extraordinarily skillful in using crew meetings and individual contact to keep the group functioning as a happy, cohesive unit. Mission Control could face difficult choices: Does it reveal bad news, such as a death in the family, or try to cover it up until the mission is completed?

Back in Earth orbit, once again after aerobraking, they will be examined aboard a space station to make sure it is safe for them to resume a gravity environment and that neither they nor their cargo is harboring dangerous pathogens. Then they will be shuttled back to Earth and pick up the threads of their terrestrial lives amid the most tumultuous global welcome ever given to returning heroes.

Our tired but triumphant travelers will be followed to Mars by others who will add to their tiny outpost. The emphasis in subsequent missions will shift from getting there and back to making the planet more habitable. To assist, crew specialties will expand to include biology and agronomy.

A first step for the new pioneers will be to burrow underground and create habitats easy to pressurize and heat and protect from radiation. They will tap Martian resources. Water, obtained from ground ice or polar ice caps, will be electrolyzed to produce oxygen to breathe. The hydrogen component of this process could be combined with atmospheric carbon dioxide to produce methane, a fuel suitable for rockets, rovers, or habitat heating.

With sufficient water, plants might be grown in the Martian soil in greenhouses. The first settlers will be primarily vegetarians, but animals could be raised later for added protein. The Martian soil might also yield cement, glass, and metals for construction.

Little by little the first mission's inflatable habitat will be replaced by a village of underground dwellings and extensive greenhouses. A happy milestone will be the birth of the colony's first baby. Reared at one-third Earth gravity in a biologically isolated environment, this delicate child might not be able to survive a visit to filthy, bone-crushing Earth.

In discussing the future, such as our Mars journey, one must be careful to differentiate between what *can* be done and what *will* be done. We *can* embark on an expedition to Mars on June 3, 2004. But to do so will require far more than scientific curiosity and technological capacity. It will require a grand political decision, a global version of John F. Kennedy's nationalistic march to the moon.

And it will involve danger, no matter how carefully undertaken, because of the vast distances involved. In 1910 Englishman Robert Falcon Scott and the Norwegian Roald Amundsen set out for the South Pole. Scott's team faced one disaster after another, until the last men finally froze to death. For Amundsen, who had been meticulous in his preparations, everything went well.

Regardless of when we go to Mars, and we should be preparing now, may the spirit of Amundsen be with the first intrepid crew. □

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THE POWER IS ON

Pandas in Panama?

THE NATIONAL GEOGRAPHIC SOCIETY

GEOGRAPHY CAN BE FOUND in the strangest places. While in London not long ago, I came across an open produce van parked at a curb and was intrigued by the variety of fruits and vegetables it was carrying. There were onions from Spain, strawberries from Kenya, cucumbers from France, tomatoes from the Netherlands, grapes from South Africa, and bananas from Belize—all waiting to go into a restaurant. "Here's a pear from Cyprus," the driver said, pulling a beauty from a box.

It struck me that his van was bringing the world to the restaurant's doorstep. In every bite the customers would be able to taste the breezes of Normandy, the sunshine of the Mediterranean, the tropical showers of the Caribbean. And as they did so, they might also sense a geographic truth: We are all interconnected on this planet.

This fact has been lost on many Americans, who possess a woefully poor sense of where they are—much less any knowledge about the rest of the world. One in seven—some 24 million people—cannot find their own country on a world map. More than half don't know its population. These and other sobering statistics emerged from an international survey conducted for the Society by the Gallup Organization. The most disturbing finding: In a survey of 18-to-24-year-olds from nine nations the United States scored dead last in general geographic knowledge. A few said they thought pandas come from Panama, kangaroos from Lebanon, and the Summer Olympics were to be held in Nigeria. And these were the most recent graduates of our high schools and colleges.

To find out what American 12th graders do or do not know about the world, the Society has commissioned the National Assessment of Educational Progress—also known as the Nation's Report Card—to administer a program of tests. The results, due in early 1989, will establish a benchmark for future progress. Fortunately there are signs that the educators are now taking this problem seriously. In a recent survey of top state officials in public schools, 84 percent said they believed a greater emphasis will be put on geography in the coming years.

The U. S. Congress has kept the ball rolling by designating November 13-19, 1988, as Geography Awareness Week. In celebration of this the Society is sending thousands of lesson plans, posters, and other activities—under the theme "Geography: Passport to the World"—to social studies teachers across the country.

We're also gearing up for an exciting contest next year: the National Geography Bee. Fourth- to eighth-grade students in 82,000 schools in the United States and its territories have been invited to compete during the week of January 9, 1989. As many as 53 finalists will be brought to Society headquarters in Washington, D. C., for the national championship to be held on May 18 and 19. First prize will be a \$25,000 scholarship; second prize, a \$15,000 scholarship; third, a \$10,000 scholarship.

I can't say if any of the questions will concern fruits and vegetables of the world. But if I were a young competitor, I wouldn't rule anything out.

Silbert H. Browner

Only half of U. S. adults know that the nation where Sandinistas and contras have been fighting is Nicaragua. Among the guesses: Norway and Australia.

Twelve million Americans do not know that their nation's capital is Washington, D. C.

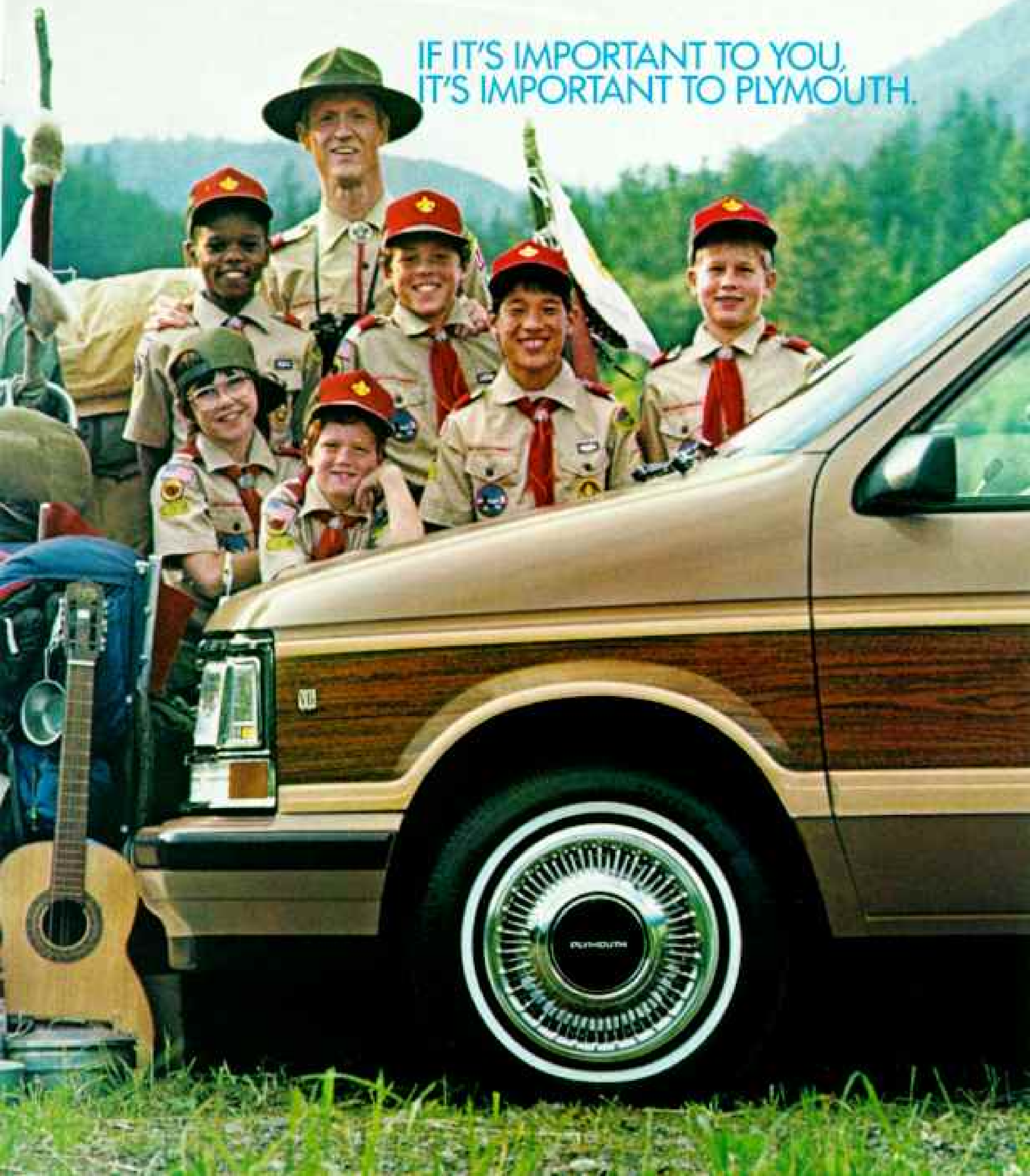
People in Sweden, Japan, and Canada are more likely to know the population of the U. S. than are Americans.

Despite heavy U. S. involvement in the Persian Gulf, three-fourths of Americans cannot find it on a world map. Two-thirds cannot find Vietnam.

More than half of U. S. adults have forgotten that Columbus was hoping to find Asia when he discovered the New World.

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Chile

During a month-long visit my wife and I saw a very different Chile from that described in the July 1988 issue. Nobody claimed Pinochet was an angel, but everyone we spoke with, from a greengrocer in Santiago to an elderly man gathering seaweed at the shore, was happy with the advances Pinochet has brought and disturbed that the U. S. had sent a million dollars for his opposition and had cut Chile from the preferential tariff list.

R. L. KRANKER
Stockholm, New Jersey

Except for minor references to the continuing Chilean horror, the article mainly provides excuses for Pinochet repression and right-wing ideology, distorts recent and current Chilean history, and underplays the U. S. government's role in producing the Chilean misery of the past 15 years. It replays the now tired and discredited story of a society forced to choose the evil of right-

wing capitalism because of the greater threat of left-wing communism.

ROBERT ELIAS
*Center for the Study of Law
and Society
University of California, Berkeley*

As a Chilean I enjoyed Mr. Boraiko's article. But the accompanying photographs did not do justice to the country. The poverty and politics depicted are a reality, but so are other aspects of our life: middle-class Chile, tourist Chile, professional Chile, and all the other facets of what is often called the Switzerland of South America.

HEIDI DE GRUMBLING
Chicago, Illinois

The Yaqui of Mexico, the Guaicuru and Mbaya of Paraguay, and the Patagonian tribes of Argentina might dispute your claim that the Mapuche were "the only Indians in the Americas to resist the Spaniards successfully throughout the colonial period." None of the above groups were effectively subdued until the introduction of the repeating rifle, years after the Spaniards had left the scene.

THOMAS WHIGHAM
*Department of History
University of Georgia, Athens*

Your reports on Chile and Guatemala (June 1988) provided effective coverage of the human rights concerns expressed by the United Nations and the



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organizations speaking out against the violent repression that the governments practice against their own people.

In Chile we are concerned about the current escalation of harassment against people from many walks of life, including nurses, actors, trade unionists, political activists, human-rights workers, and student leaders. There have been frequent reports of disappearances, torture, and death threats that have been carefully documented.

JANET KILGANNON
Amnesty International
Ottawa, Ontario

Kourion Earthquake

As an American born in Cyprus, I commend David Soren for his efforts in presenting the history of Cyprus through archaeological excavations. His article (July 1988) is highly informative. It would have been gratifying if a similarly unbiased endeavor were made toward finding a viable solution to the political problem of that hapless island.

NICK C. LOUIS
Orlando, Florida

The photograph of the doomed family holds a personal poignancy for me. In 1979 my husband and son, then a toddler, huddled in a closet with me as our home was demolished by a tornado. I can imagine, all too clearly, the terror felt by those ancient earthquake victims.

LISA GUNNELL
Wichita Falls, Texas

If local villagers identified the items on page 47 as lacemaking bobbins, take their word for it, even if the artifacts are over 16 centuries old. Although bobbin lacemaking reached its heyday in the 1500s, evidence of bobbin lace has been found in Coptic tombs in Egypt.

SALLY KATHRYN NUTTALL
Glen Ridge, New Jersey

Atlanta

This native Atlantan thanks you for your exceptional article (July 1988). Chances are one of the mansions you drove by in Buckhead was home to the Southern Writers Theatre, where I am artistic director.

JIM DORSEY
Atlanta, Georgia

Author Eria Zwingle has exhibited myopic vision in her thumbnail assessment of Smyrna as "red-neck." We have no more pickup trucks, baseball caps, or ignorance per capita than anywhere else. I know, for I have lived and operated a business here for more than ten years. If Ms. Zwingle had experienced our beautiful Jonquil City, she would know of the community involvement, exciting business opportunities, and proximity to the finest shopping

and recreational facilities. Our school system is one of the best around. We have more than 40 churches, varied cultural events, libraries, and the usual blessings of an erudite population. NATIONAL GEOGRAPHIC has been remiss in allowing this type of slur to go unchecked. My neck may not be red, but your collective face should be.

LINDA P. FARMER
Smyrna, Georgia

It is, and we accept the advisory of Smyrna's public relations director Kathie Barton, "We would like to be called 'hometown folks.'"

Frankly, my dear Zwingle, not all Atlantans agree with Mayor Young's "get rich quick" intentions. And those "overwrought Southernisms" have allowed for an element of internal humanism not found in many cities. The scars Atlanta bears are not from Sherman's destruction but from super development and financial greed.

MARY MCDANIEL
Atlanta, Georgia

On pages 22-3 the young runners' shorts appear to be made from the American flag. Title 36, Section 176 of the U. S. Code says "The flag should never be used as wearing apparel. . . . No part of the flag should ever be used as a costume or athletic uniform." Patriotism is evident in the picture, but the young men should be made aware of the code.

ROBERT L. GARNER
Rome, Georgia

Moors in Spain

Powerless, we watch how Granada's most typical areas are being used for tourism and how the Alhambra has been rented for a film stage. I hope that articles like yours (July 1988) will help the authorities realize how necessary it is for all of us to keep our land's identity.

PAU BERMUDEZ ACKERMANN
Barcelona, Spain

A slight error on page 93: logarithm was not named for scholar al-Khwarizmi but was coined by inventor John Napier from the Greek words *logos* (ratio) and *arithmos* (number). Al-Khwarizmi's memory still lives in two books. From his book about arithmetic his name comes to us as "algorithm." His second book, *Kitab al-jabr wa al-muqabalah*, gives us our word "algebra."

DAVID F. ANDERSON
Department of Mathematics
University of Tennessee,
Knoxville

The frequent use of the word "reconquest" suggests that the struggle for supremacy on the Iberian Peninsula was one between a monolithic, indigenous Christian people and foreign Muslim invaders from Africa. How long must invaders inhabit a land before they may be considered indigenous? The Muslim presence in Spain lasted over 800



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years, some 300 years longer than the European Christian presence in the Americas.

ALI GALEDARY
Los Angeles, California

True, the Moors conquered almost all the Iberian Peninsula but never the rough mountainous region of Asturias. There they met defeat at the hands of Asturian Don Pelayo. This is why the region is referred to as the birthplace of the Reconquest, La Cuna de la Reconquista, of which Asturians are very proud.

CESAR V. RODRIGUEZ
San Juan, Puerto Rico

The fountain surrounded by 12 lions (page 100) is

inconsistent in an edifice whose Muslim builders abhorred any representation of man or beast, until one discovers that the work was designed in the 11th century for a fortress-palace built by a practicing Jew, Joseph ibn Nagdilah. To him the lions represented the 12 oxen in King Solomon's Temple in Jerusalem.

RABBI STANLEY RABINOWITZ
Washington, D. C.

Dying Palms

Congratulations on a splendid article on palm trees (July 1988). In the 1950s what was popularly called the rhinoceros beetle attacked the coconut palm in Sri Lanka, devastating the estates in



the south in a few years. A strong soap solution was used to control the epidemic—effectively.

G. T. YOGANANDAN
London, England

(The following letter came to us as a tape recording from a 71-year-old reader who had heard the article on a Library of Congress recording for the blind.)

When I was a landscape gardener in Key West in the late 1950s, I found the first dying palm to hit the coast of the U. S. on the Casa Marina Hotel grounds. I suspected something serious but couldn't get anyone to listen. I found maggots in the bud, and it smelled like a garbage can. Eventually, at my own expense, I took down 10,000 dis-

eased palms and had them burned. I think birds feeding on those maggots spread lethal yellowing.

CHARLES WARDLOW
Key West, Florida

Experts tell us that after the lethal yellowing disease sets in, rotting tissue attracts flies whose maggots draw the birds.

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



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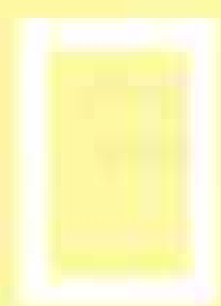
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Drought Helps Uncover Life on the Mississippi

This year's severe drought has been the bane of Mississippi barge traffic. But record low levels of the river and its tributaries have been a boon to archaeologists as the remains of old boats—from Civil War gunboats to commercial craft—have come to light. One such burial ground lies opposite Memphis, where sunken boats from the turn of the century were exposed and archaeologists could simply walk up to the wooden wreckage (right).

Leslie Stewart-Abernathy, of the Arkansas Archeological Survey, says the jumbled remains come from at least eight boats. They include several barges and a stern-wheel steamboat. "Nothing fancy," he says, "just plain workboats."

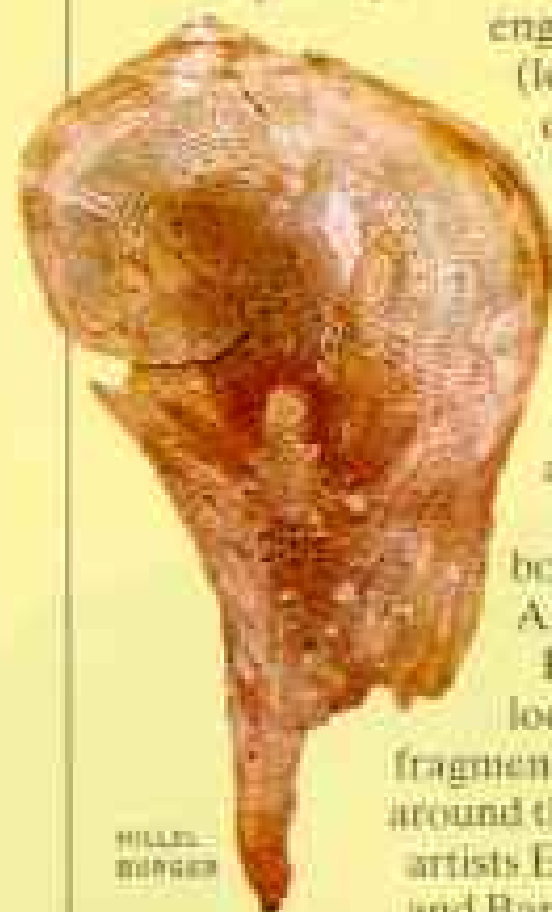
But, the archaeologist adds, that is the best thing about studying these boats: "We're getting insights into ordinary behavior on ordinary barges and steamboats, an everyday way of life that existed nowhere else, and now it's completely gone."

Piecing Together an Indian Heritage

During the 1930s looters dug up thousands of artifacts from the Spiro Mounds (A.D. 1100-1500) in eastern Oklahoma, including embossed copper plates, textiles, decorated pottery, stone implements, and engraved seashells

(left). Fragments of broken shells were sometimes sold separately to collectors at the site.

Researchers at Harvard University's Peabody Museum of Archaeology and Ethnology have located shells and fragments in collections around the country, and artists Eliza McFadden and Barbara Page have made rubbings of the fragile pieces on tissue paper. Rubbings assembled from as many as six different collections have often revealed complete shells.



HILLER BURGER



DAVE DARRELL © MEMPHIS COMMERCIAL APPEAL

A six-volume study, *Pre-Columbian Shell Engravings from Spiro*, published by the Peabody Museum, provides researchers with information once assumed forever lost.

Raptor Nursery Raises Birds for the Wild

Falcons, eagles, hawks, and owls—some tottering at the brink of extinction—have found an ally in the wildlife biologists at the World Center

for Birds of Prey outside Boise, Idaho. Opened in 1984 as headquarters of the Peregrine Fund, formerly at Cornell University in Ithaca, New York, the center studies the behavior, diet, and genetics of birds of prey. In the captive-breeding program eggs develop in specially designed incubators, and chicks dine on quail. Sturdy young birds are released in carefully selected habitats where their species once thrived. The fund has also cooperated on raptor projects in 34 countries.



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ERIC L. WILLIAMS, NGA STAFF

Citizens Join Together to Save Their Environment

When residents of Scientists Cliffs, Maryland, heard that forests and abandoned farms surrounding their homes were to be sold, possibly to developers, they bought the land. A tract of 436 wooded acres near the Chesapeake Bay became the American Chestnut Land Trust.

Peter Vogt, a government geophysicist who spearheaded the drive, never thought of saving the whole expanse when he started the movement in 1984. "But there was a lot of interest," he says. "Three hundred people have contributed. My share could have bought a new car." So what might have become a housing development or a golf course remains home to Maryland's only known colony of sweet pinesap and a single American chestnut, a species decimated by blight. Buoyed by its success, the trust hopes to help preserve the adjacent estuary of Parker Creek, where bald eagles circle and great blue herons stalk the salt marsh. Inquiries are welcome: ACLT, Box 204, Port Republic, Maryland 20676.

Celebrating Peoples of the Bering Strait

Crossroads of Continents: Cultures of Siberia and Alaska, a joint Soviet-North American exhibit, will be at the Smithsonian's National Museum of Natural History, Washing-

ton, D. C., from September 23 through April 2, 1989. Kayaks, harpoons, ivory carvings, headwork, masks—592 artifacts in all—demonstrate the culture and history of Siberian, Aleut, Eskimo, Athapaskan, and Northwest Coast peoples. The exhibit will later travel to Seattle, New York, Indianapolis, Anchorage, and Ottawa, and from 1992 to 1994 in the Soviet Union.

School Field Trip Yields Prehistoric Bone

At first it appeared to be nothing but an old tin can. But the cylindrical object discovered near Washington, D. C., by a ten-year-old schoolboy turned out to be exciting news for paleontologists. On a field trip from Polk Elementary School in Alexandria, Virginia, Colin McEwen found a vertebra of a plesiosaur, an extinct marine reptile with a long neck and paddle-like limbs that lived 65 million to 210 million years ago. The fossil is important evidence that the creatures lived in the area, then a subtropical seashore.



SUSAN STEINBERG

Colin found the fossil in Largo, Maryland, where earth had been dug up to lay underground utilities. "I wanted to find some shark teeth," he said. "I was climbing a pile of dirt when my toe hit the edge of the fossil."

Colin donated the bone to the Smithsonian's National Museum of Natural History. In return he will receive a plaster cast of his find. "I've wanted to be a scientist for a long time," Colin added. "Now I'd like to go to more digs."

Lonely Rocks Important to Japan

In a remote expanse of the Pacific Ocean 1,800 kilometers (1,118 miles) southwest of Tokyo in the path of typhoons, two rocks barely pierce the water's surface. But because they do, Japan claims exclusive fishing and undersea mining rights over a 400,000-square-kilometer (154,452-square-mile) area.

Rich deposits of cobalt and manganese may underlie the seabed around Okino Tori Shima—Island of the Offshore Birds. This and the voracious Japanese appetite for seafood make the area a prized part of the country's economy.

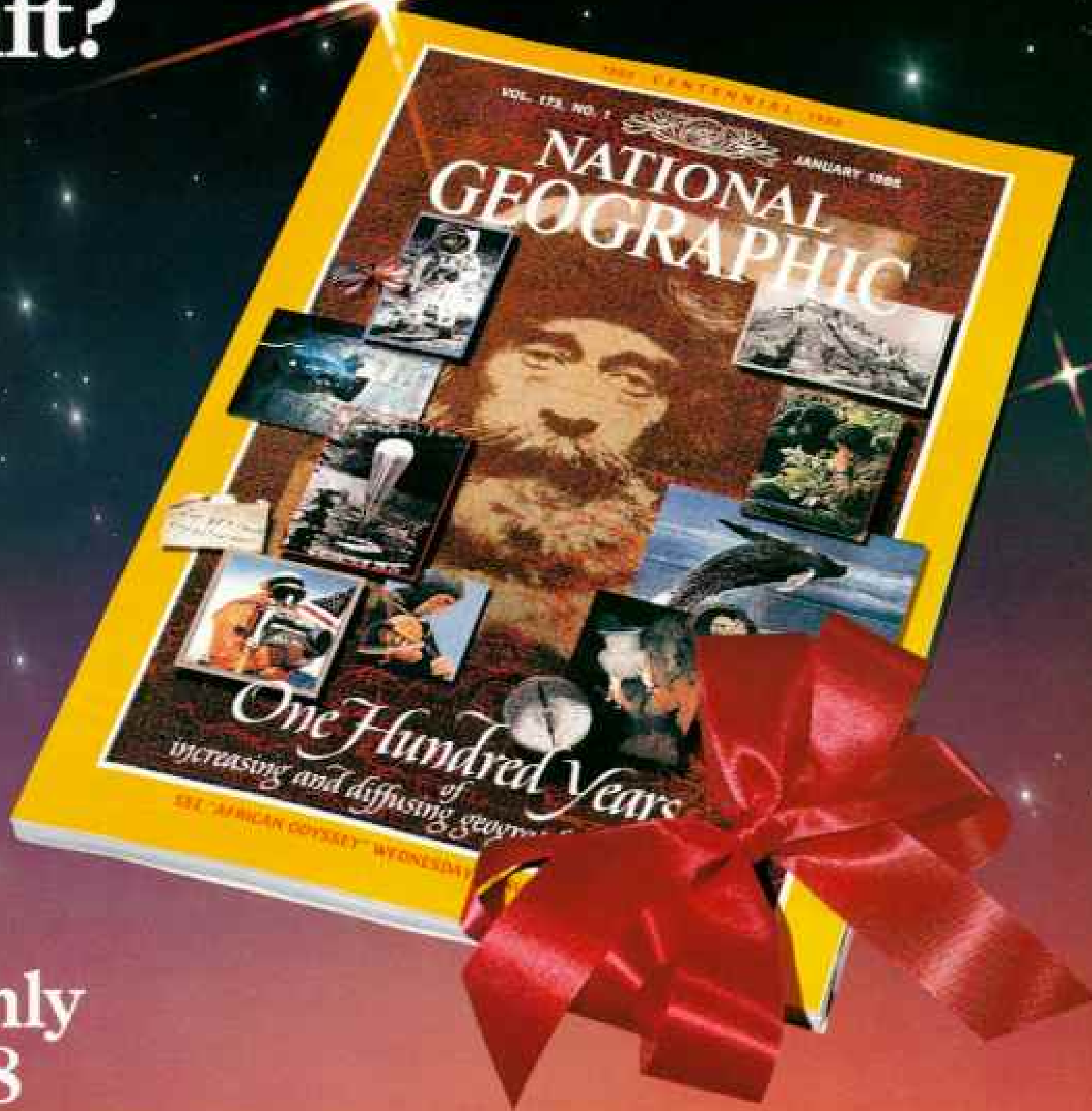
While low tide reveals a reef of coral and limestone, at high tide Okino Tori Shima almost disappears, shrinking to two rocks a mere 70 centimeters (27 inches) above the sea. Pounding waves threaten to erase them altogether.

The Law of the Sea states that an island must be above sea level at all



times. Therefore, the Japanese government embarked on an ambitious multimillion-dollar construction project hoping to halt erosion. Last April ships, helicopters, and several hundred workers converged on Okino Tori Shima and began to encircle the outcrops with walls composed of thousands of cast-iron tetrapod forms and concrete. By March 1990 the wave-absorbing barrier will guard Japan's southernmost point from disappearing under the unrelenting waves.

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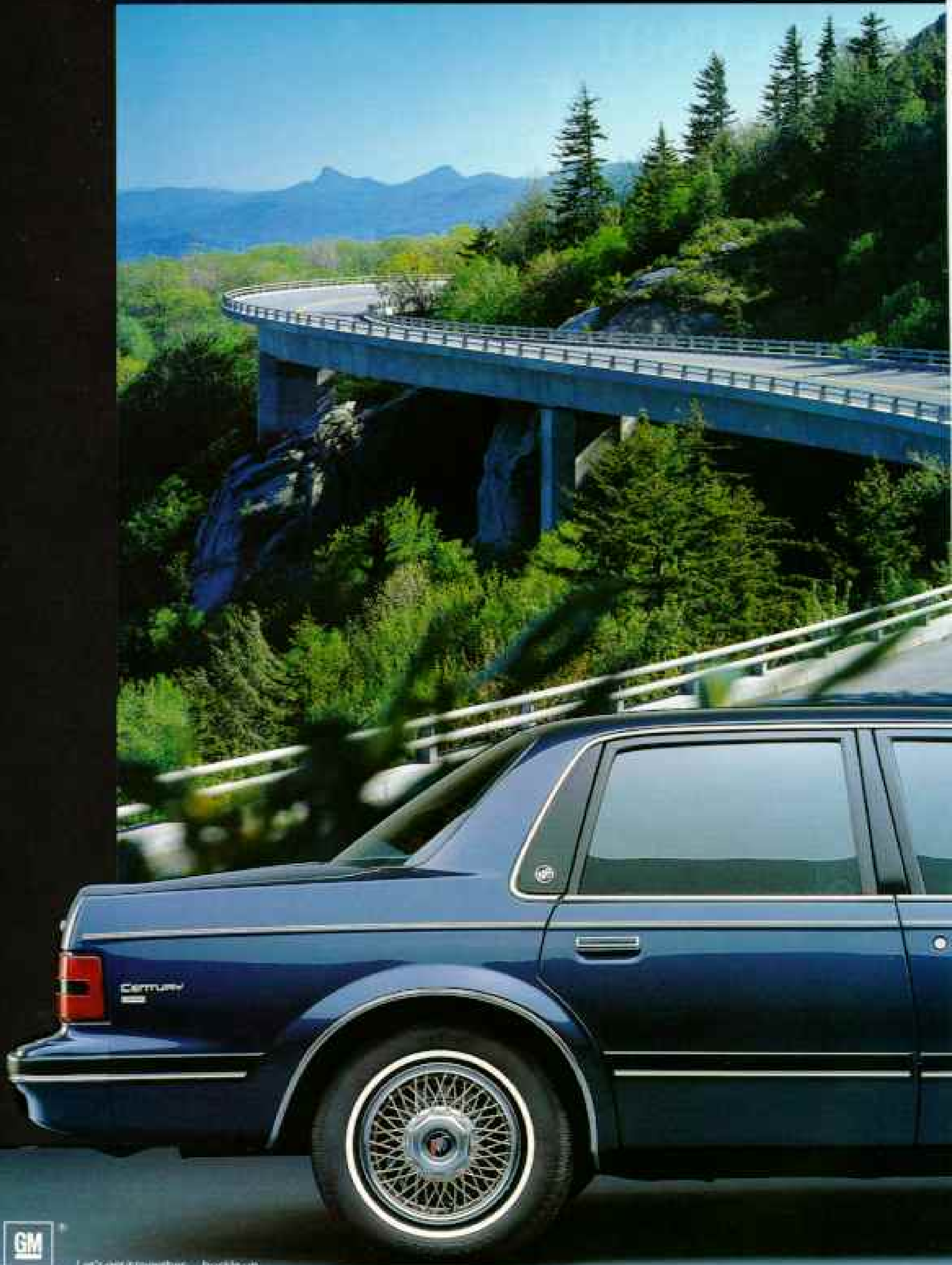
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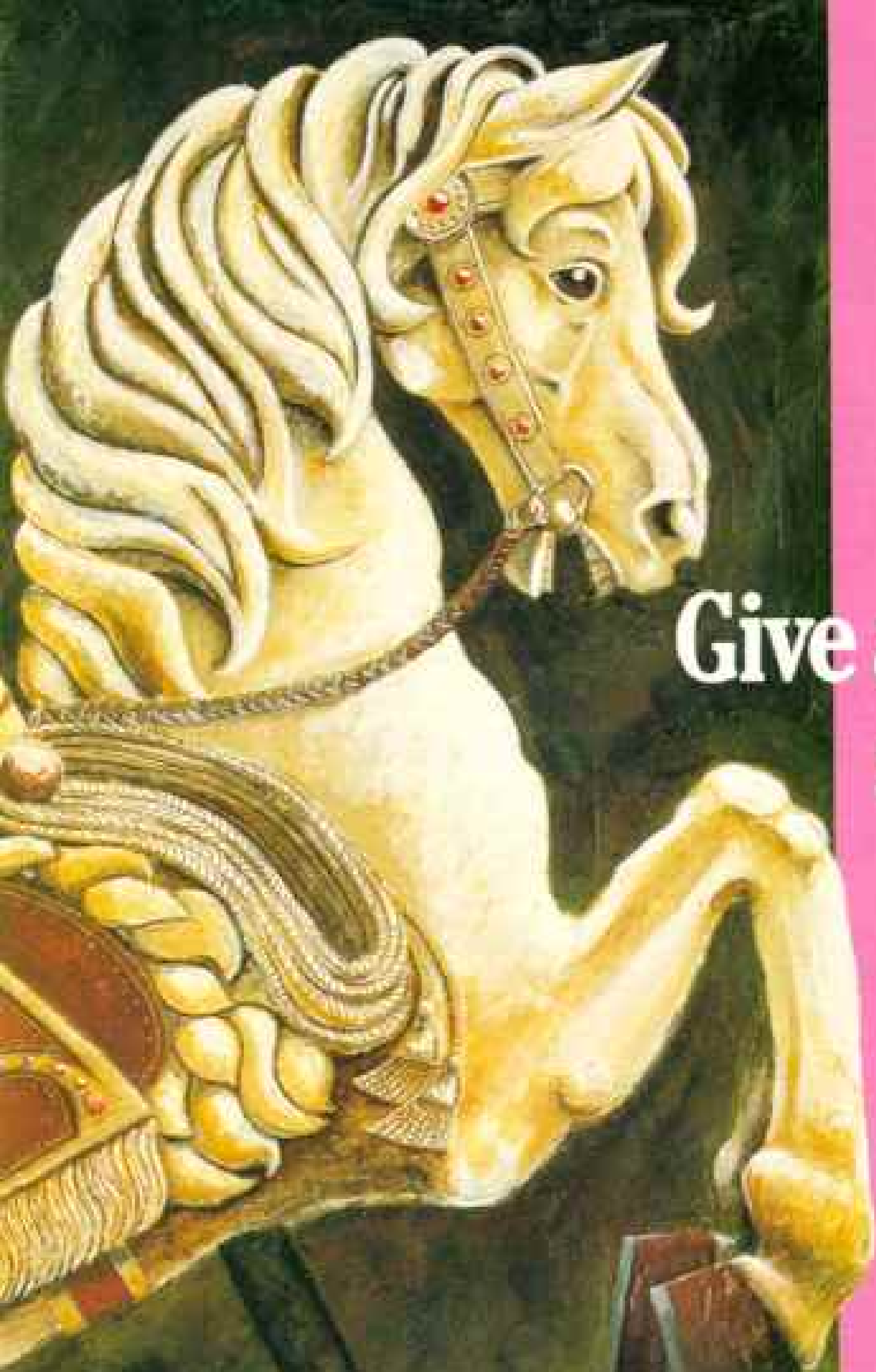
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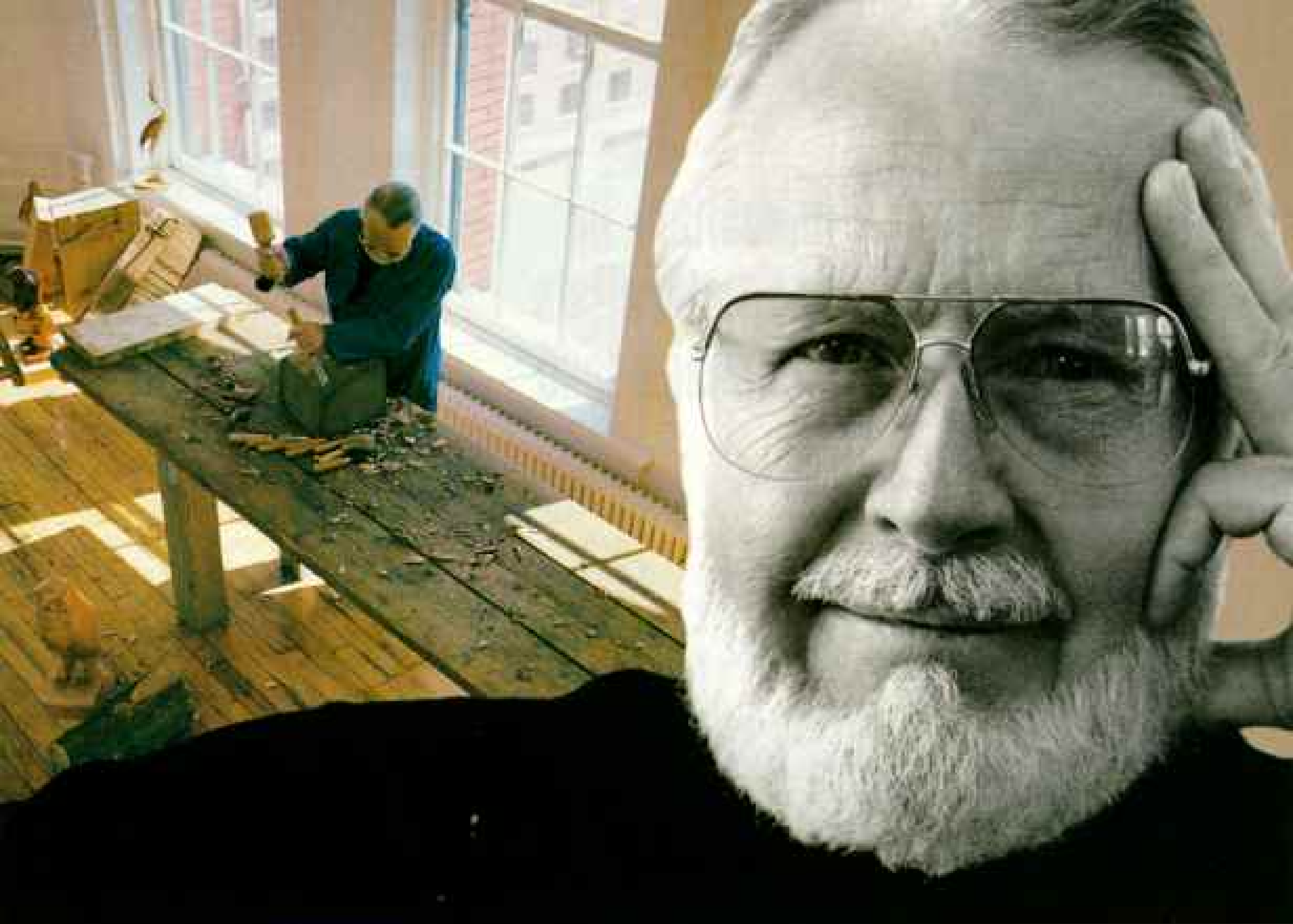
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NATIONAL GEOGRAPHIC, "Any question you ask about nature's possibilities may have an answer in Madagascar."

Among the creatures arousing wonder are chameleons. Half the known species of this Old World lizard, including the largest and smallest, are found there. Like the Parson's chameleon (drawing), they have evolved highly specialized features.

Most people are aware of the chameleon's ability to change color in response to light, temperature, and aggression.

Equally curious are chameleon eyes. Each rotates independently to seek out prey; both focus together to gauge distances



island was wrenched from the African Continent by tectonic forces.

Scientists have been enthralled by that wildlife. "Nature seems to have retreated there into a private sanctuary, where she could work on different models from any she has used elsewhere," a French naturalist wrote in 1771, calling Madagascar "the naturalists' promised land. . . . There you meet bizarre and marvelous forms at every step."

Zoologist Alison Jolly agrees, writing in the February 1987

ahead.

Then with uncommon accuracy the lizard's sticky tongue flicks out to snare insects or, in the case of large chameleons, hatchling birds.

Equally unlikely are chameleon feet. The toes are positioned so that all four legs can grasp a slender branch below the body. Chameleons walk with a hesitating gait, giving rise to a Madagascar proverb: "The chameleon counts his steps wherever he goes."

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Feria de Abril: Springtime in Seville.



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On Assignment

“GOING DOWN THE ROPE required Zen concentration,” says ERIC VALLI, here beginning a cliff descent (right) to photograph Nepalese honey hunter Mani Lal at work. “There were so many bees I was afraid I might freak out. But I knew if I did, I would be dead. So I took a deep breath and relaxed. Getting stung would be better than finding myself at the bottom of the cliff.” His honey-hunter series won a first prize in the 1988 World Press Photo Foundation competition.

The former cabinetmaker from France and his wife, Diane Summers, a lawyer from Australia, met on a bus in Nepal five years ago. Now living in Kathmandu with their daughter, Sarah, they have produced four books and a film. Both speak fluent Nepali. “Going into the mountains to meet different peoples isn’t our work,” says Diane. “It’s our passion.”

Obtaining unobstructed views of the Mount Everest region through this optically correct window of a Learjet, free-lancer WILLIAM THOMPSON felt he was living a photographer’s dream. “It was the chance of a lifetime. Here I was on top of the world. The air was crystal-line, and we could see from Tibet to India. I had an incredible sense of serenity.”

In contrast, flights in a high-altitude prop plane were downright frightening. “One day we plunged a thousand feet in a downdraft. My camera lenses went flying out the open door; Barry Bishop was thrown to the bulkhead and almost knocked unconscious. It was incredibly wild flying.”



JOHN LEWIS (TOP); BARRY C. BISHOP, NGE STAFF



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