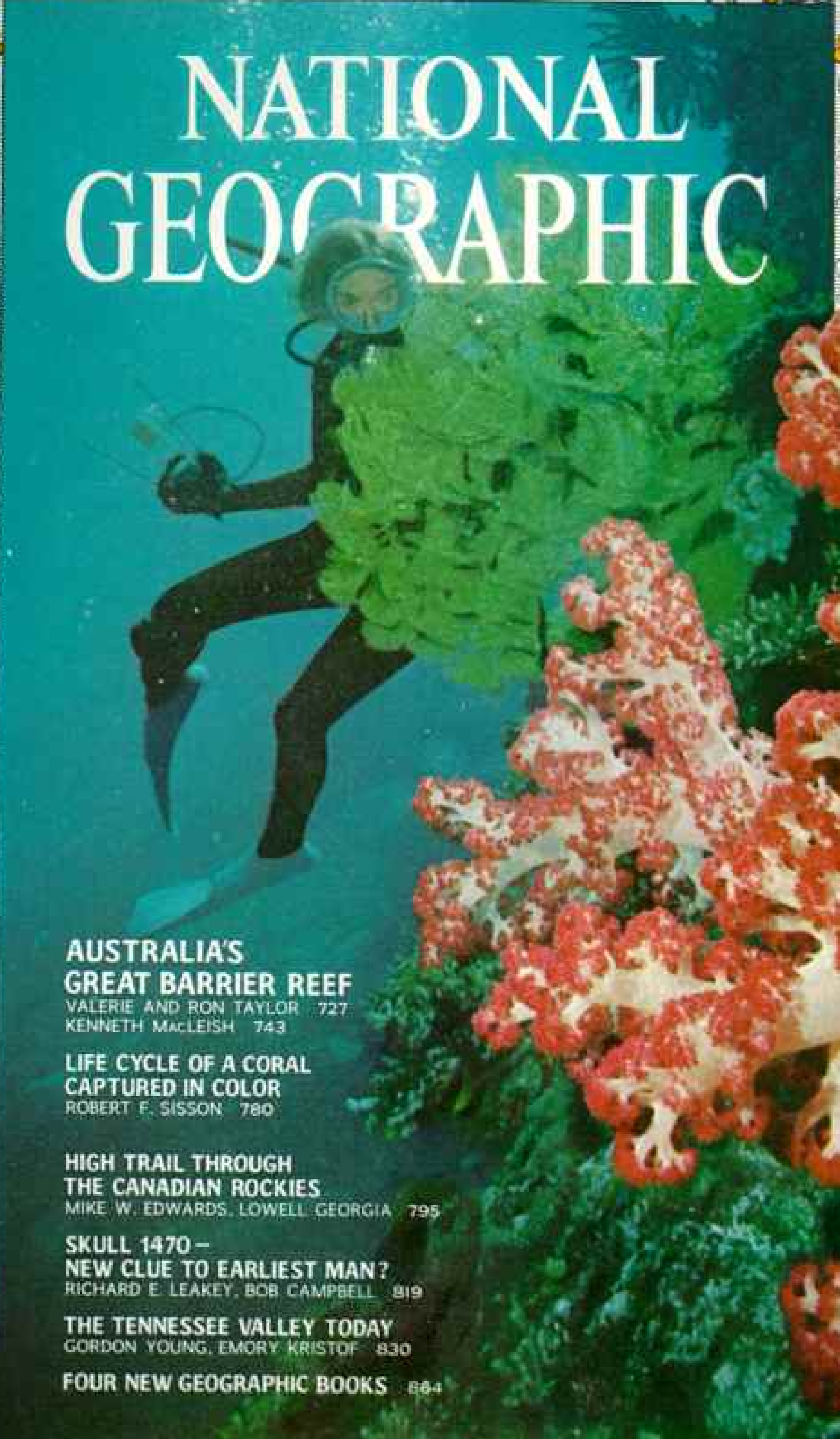


VOL. 143, NO. 6

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June 1973

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LEONA ANGELEFISH, *POMACENTRUS BERRICULATUS*, 18 INCHES, RON TAYLOR

An incredible
underwater
world of
bizarre life
and beauty,
the mightiest
structure on
earth built
by living
creatures . . .

THE distance from here, the sometimes humdrum world of man's making, to there, that unforgettable panorama of natural majesty, is about ten feet. That, at least, was my depth when I was stopped by an emotion that can only be described as awe: at the universe I had entered. I was diving near Heron Island, on Australia's Great Barrier Reef, through waters so clear they almost vanished. Like Alice's magic looking glass, they led me toward a realm enchanted—vast ranges and headlands of coral, shining with myriad rainbowed life.

For more than a thousand miles this testament to nature's prodigality fills the warm seas, a living rampart that dwarfs human works—yet it is fragile. Its existence hinges on the delicate balance of countless forces, all intimately related. The unabated attack of coral-eating starfish, the negligence or shortsightedness of man, all could upset the balance and devastate this noble work of nature.



TUBEWORM, *SPIROBRANCHIUS*, 1/2 INCH ACROSS LARGEST FAR, VALERIE TAYLOR

It was with particular satisfaction that I watched a talented staff create the articles that open this issue. Senior Assistant Editor Kenneth MacLeish takes us beneath the sea, into a region of incredible beauty documented by the photographs of Valerie and Ron Taylor. During years of filming and exploring, the Taylors have virtually become



BORDERIAN CORAL, *MURPHELLA*, VALERIE TAYLOR

citizens of the reef community.

A smaller world, one seldom seen even by scientists, delights us in *Life Cycle of a Coral* (pages 780-793), the brilliant work of staff photographer Robert F. Sisson. To enter this almost hidden realm, Mr. Sisson set up a thousand pounds of cameras and microscopes on Heron Island: there for long weeks, with infinite patience, he recorded the slow-motion miracle of growth.

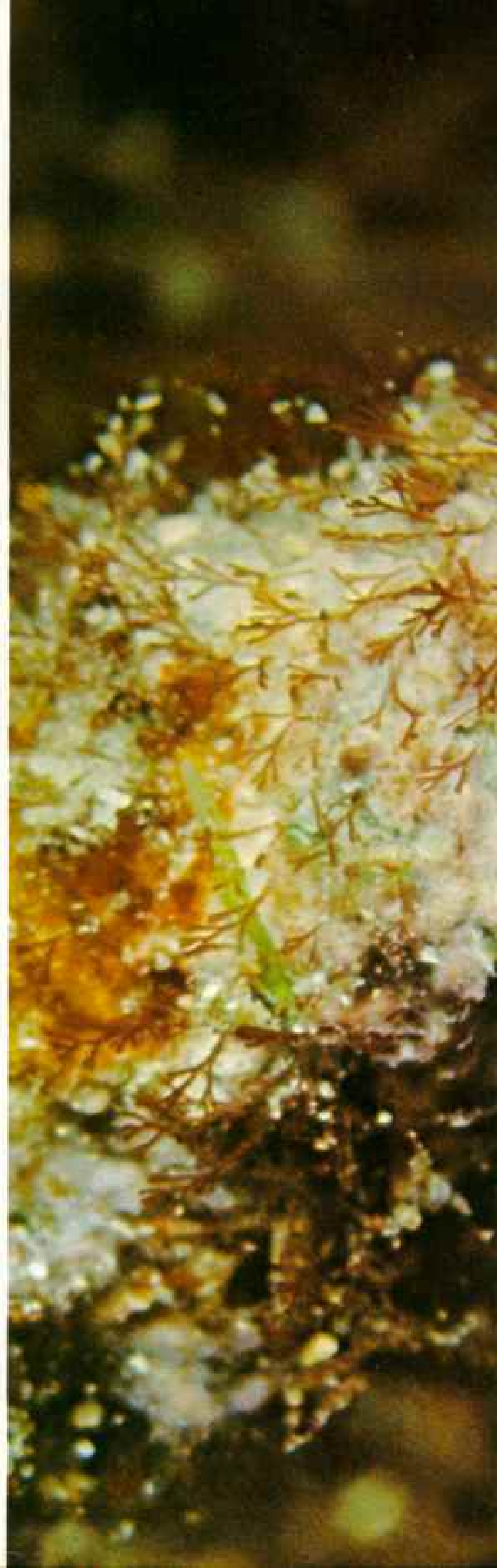
Together, these words and pictures transport us to one of the glories of our planet—a journey I know you will enjoy and remember.—THE EDITOR

Australia's Great Barrier Reef

PHOTOGRAPHS BY
VALERIE AND
RON TAYLOR

Grinning rogue of the reef, a blenny peers from a tubeworm's abandoned home. When hungry, the 2½-inch-long predator will venture out and hover motionless over the coral, waiting for another fish to pass beneath. Suddenly it will dart down, nip a bite from the unwitting victim, and streak off to ambush another.

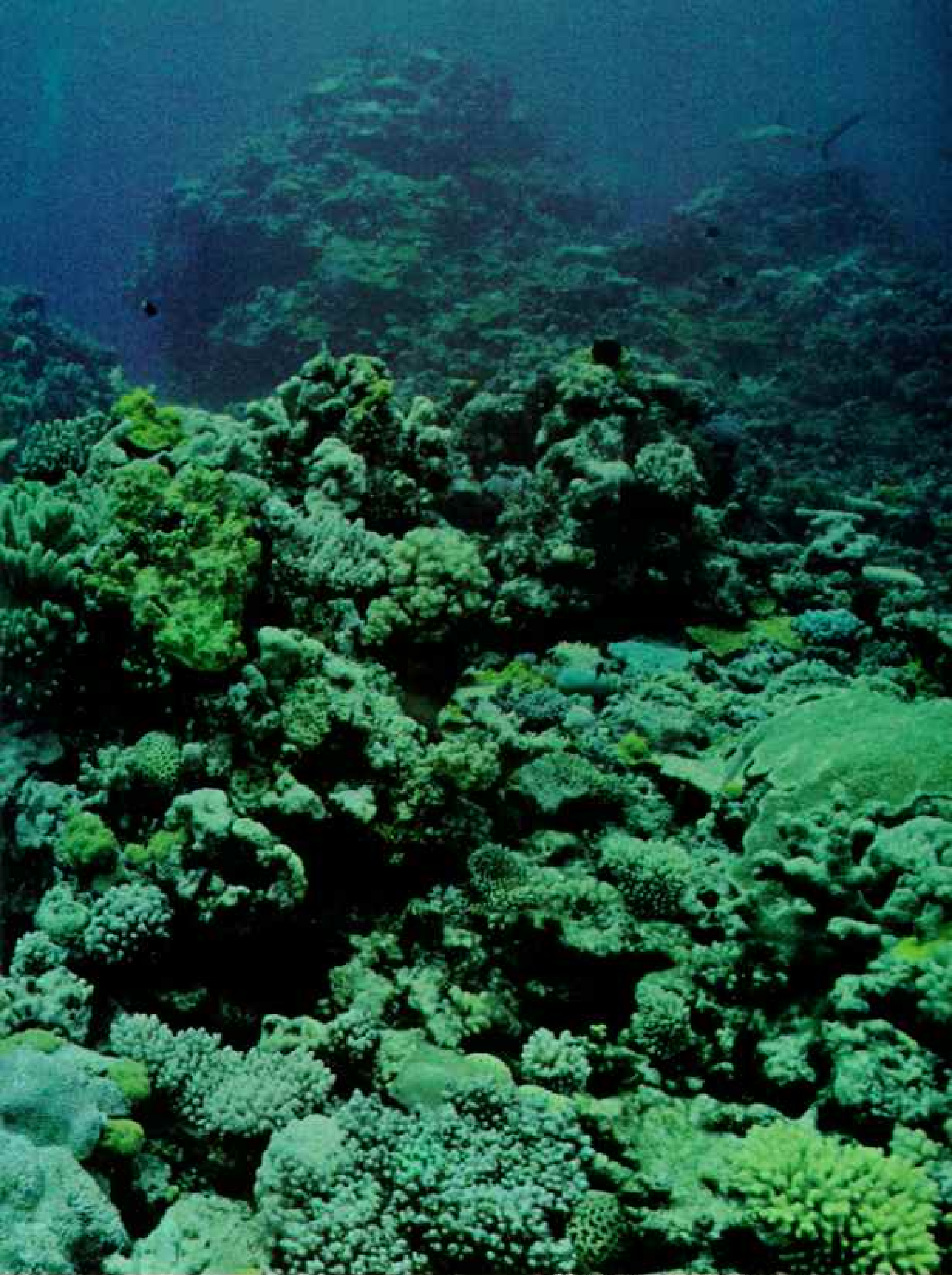
PLAGIOTRINUS, VALERIE TAYLOR







Twilight realm of a coral canyon envelops divers



NATIONAL GEOGRAPHIC PHOTOGRAPHER BATES LITTLEHALES

exploring an outrider reef in the Coral Sea



Plumed knight of coral nooks, a nudibranch
emblazons the reef with color



HEMEROTHA, HELENE TAYLOR

Charging across turf of green algae at the speed of its cousin the snail, a four-inch nudibranch, or sea slug, lowers sensitive horns

that help to detect prey. Feathery gills sprouting from the back give the creature its name, which means "naked gill."





CORAL, ANTIPATHES, BRITTLE STAR, AETHROBACHTHUS ADONISRAIS, AND LIENARDILLA FRAGILIS, VALERIE TAYLOR

Pigmy python in a filigree tree, a brittle star coils its five arms around a branch of black coral. The heavy glasslike coral is used to make costume jewelry.

As if meeting their mirror images, male harlequin tuskfish square off. When the photographer fed the near fish, a neighbor approached, only to be violently pushed away.

Dramas unfold in a watery arena



Like sunken amphorae, urn-shaped ascidians only



FAMILY SIPHONOCLEADIDAE, VALERIE TAYLOR

an inch and a half tall placidly filter plankton from the sea

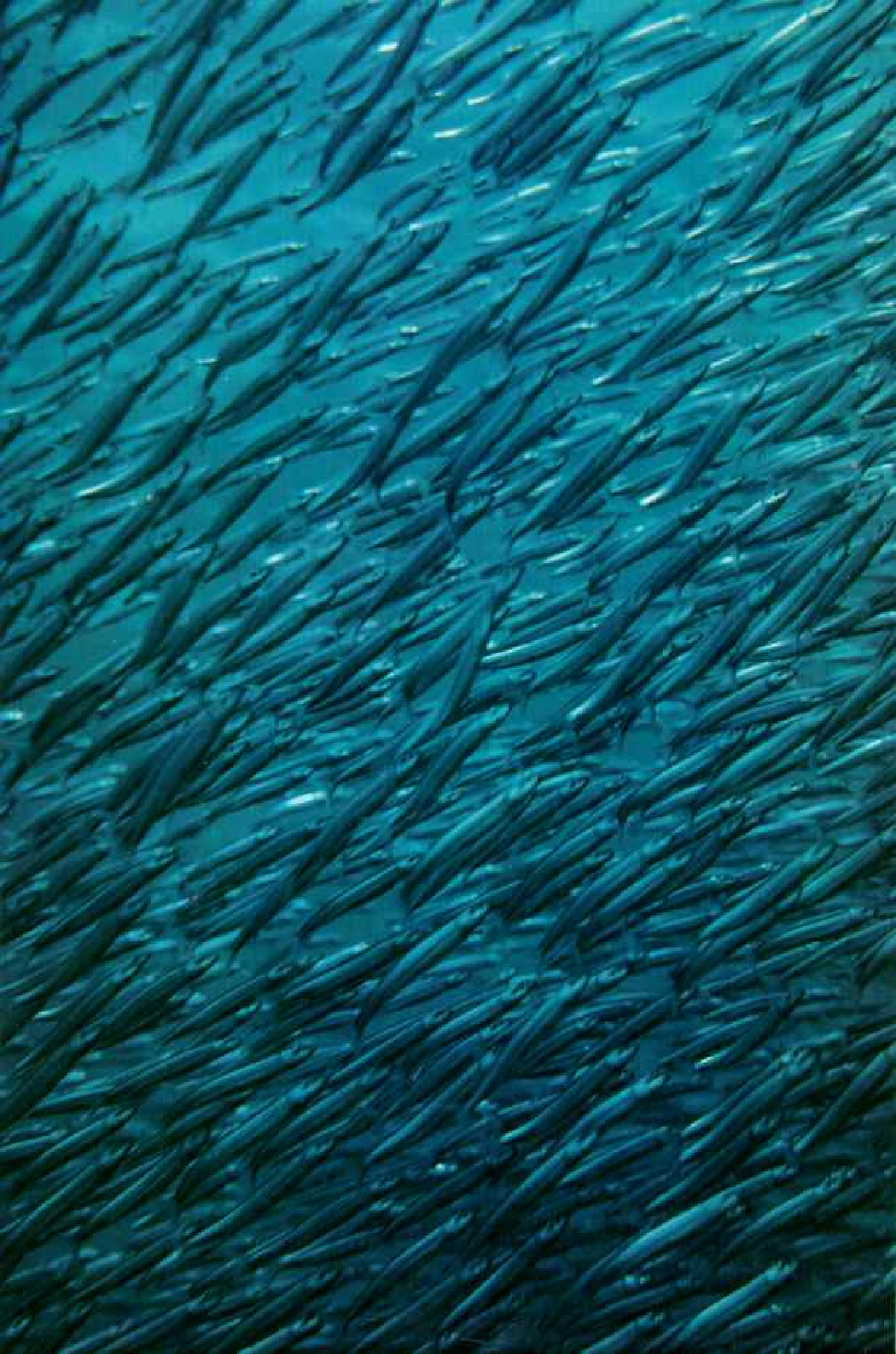


Artful camouflage, source of safety for many a



reef dweller, disguises a foot-long flathead

THYSANOPHYTES, BOB TAYLOR





“They blotted out the sun, swarming past for 15 minutes . . . all streaking in one direction, as if they had some place to go.”

Shimmering blizzard of three-inch-long sprats awed the photographer as she crouched beneath them. As they swam past, predator fish charged through them.

More than 1,400 species of fishes find homes on the reef, and collectors often discover new ones—some blending with the coral, others flaunting dazzling patterns, relying for safety on ready refuge in the reef’s nooks and crannies.

STOLEPHORUS, VALERIE TAYLOR



EVA CHOFF

A coral garden creates an underwater Eden off Gannet Cay in the Swain Reefs.

WE HAD LEFT THE COAST at midnight, traversing in darkness the region of dull sea and dimmed air that man and nature create along the limit of earth's landmasses. At dawn we had entered the water world of the planet's most marvelous complex of coral, Australia's Great Barrier Reef. We stood in the bow, photographer Bates Littlehales and I, old diving partners, staring 150 feet straight down into azure emptiness.

"You could lose your soul in that color," Bates said. "There's no blue like it."

"This is Coral Sea water," I said. "From here on out everything is ocean, or formed by the ocean and ocean creatures. Even the islands, like Fairfax there."

On the horizon lay a coral cay, sea-built of coral sand, forested by seeds brought by the wind, birds, and ocean currents. Like all islets at the southern end of the reef complex, it perched on a reef far greater than itself, an expanse of coral just awash at low tide. As we approached the reef edge, the bottom came up from 150 feet to 50. Bommies—coral heads—reared straight up to within a yard or two of the surface, amber brown, menacing. Coral clumps glowed blue and red and acid green. Fish flew like birds among their branches.

Every detail of the undersea landscape stood revealed. The water seemed to vanish. It appeared as inadequate as air to support our 20-ton fishing boat.

That staggering clarity graces the realm of the Great Barrier, as we would discover in the course of more than one hundred dives, by day and by night, along most of its 1,250-mile length.

We picked a coral pinnacle that rose 40 feet out of white sand for our first dive. We rigged up and went down to sense the atmosphere of the coral community, to feel the pulsing life of the reef and be part of it.

Suspended, freed from the force of gravity, we flew through water as a bird flies through air, soaring, plunging, turning. We circled the bommie's base. The bulk of our mesalike promontory was dead matter, either coral rock or detritus soon to be cemented by algal growth and chemical action into rock. But all its substance was the product of the live coral and other living things whose present generations adorned its surfaces and surroundings in greater numbers and wilder variety than

occur anywhere else on earth. No niche of nature is more exuberantly alive.

Shoals of glittering fry hung beside the coral cliffs, flashing in unison as they turned in response to some secret signal. They suggested molecules set in a crystal. Each shoal parted as we swam through. Schools of kingfish and bonito sped in, circled, and sped away. Blue-water wanderers, transients in the coral reef community, they wore unremarkable sea colors to hide where no hiding place existed.

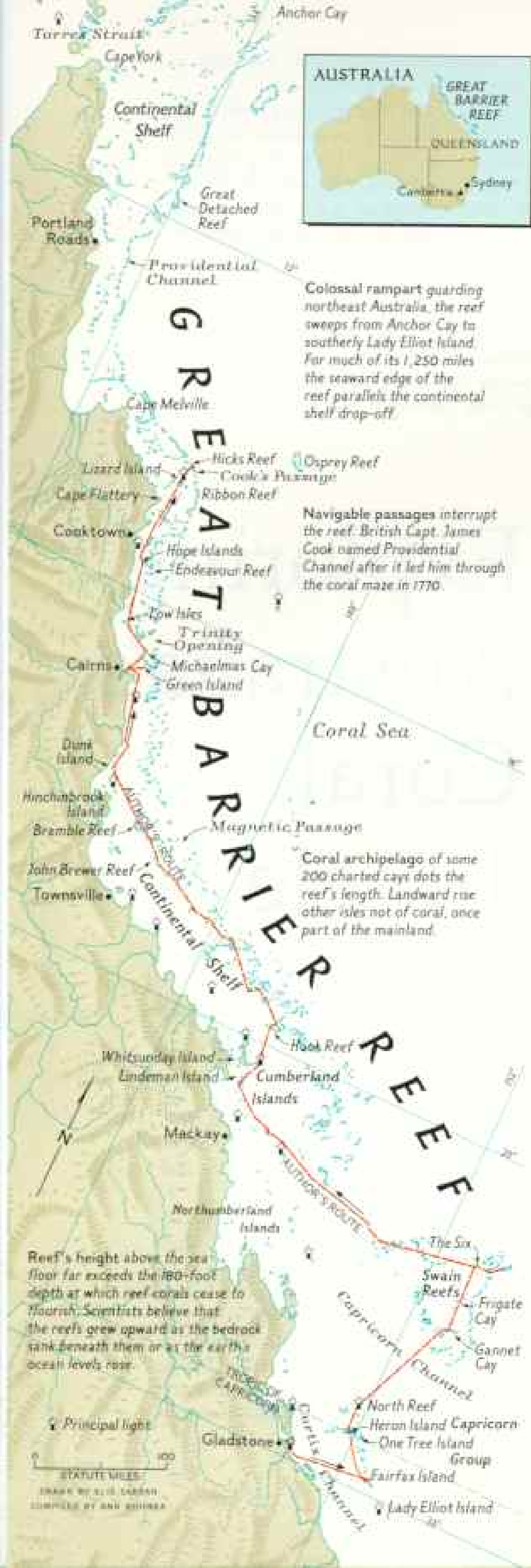
Not so the fish of the reef. As we coasted by the bommie's base, we saw dozens of large fish, strongly marked and richly

Exploring Australia's Coral Jungle

By **KENNETH MACLEISH**
SENIOR ASSISTANT EDITOR

hued: blue-spotted coral trout; surf parrots, pea green and pink; batfish, taller than long, vertically striped in black and bronze; and elegant angels.

These creatures did not hide in inconspicuous skins but proclaimed their presence to any searching eye, perhaps because their vivid adornment disguised their fishy form. Still more did the hundreds of species of little fish. Violent contrasts were common, brilliant yellow and matte black, white and orange, brown and green. Some were monotones—but what monotones—



blues so intense they set your teeth on edge, gold, scarlet. Markings? Every conceivable design. Shapes of a pencil, a coin, a new moon, a spindle, a flower in full bloom.

And these were only the finned residents of the reef. The crustaceans that crawled on it, the worms that burrowed into it, the gorgonians that waved upon it, the mollusks and starfish and urchins and cringing sea squirts that decorated it were even less inhibited in shape.

All these wonderfully contrived creatures, of course, are no more than tenants of a complex of superb structures built by one of the smallest and simplest members of the animal kingdom. The fish and lesser fauna moved among turrets and branches of living and dead coral. In this stone forest all found sustenance, and the safe refuges that allowed them to be gaudy in a fish-eat-fish world.

I couldn't count all the kinds of coral that lived upon the surfaces of the bommie (there are several hundred species on the reef), or list all the colors of each kind. Yet vastly as they varied, all were the creations and the present homes of flowerlike animals—polyps of the phylum Coelenterata—the minute and mindless builders of the reef.

Each polyp is little more than a pocket of protoplasm lodged in a limestone container of its own manufacture and equipped with stinging tentacles (pages 788-9). Individually, they build no more than shelters for their small selves. Collectively, they can create immense reefs—ranges and ramparts that are among the great geographic features of the earth. And the greatest of these coralline constructions is the one in whose waters we swam.

My turn around the bommie had reminded me of a central fact about the Great Barrier Reef. That living structure, 1,250 miles long, encompasses an area of 80,000 square miles. Its base is a limestone platform, and its seaward wall faces the full force of the Pacific Ocean. Had it been made of the toughest of continental rocks, it would have vanished eons ago. But soft and fragile as its substance is, the reef is practically indestructible. It regenerates and grows through the agency of the ultimate miracle, the miracle of life.

Now in the bright light of midmorning the miraculous reef builders were mostly



DAVID LIPSHALE

Her solitude shared by Sassie the heron, naturalist Julie Booth has studied the fauna of remote Fairfax Island for seven years.

in hiding. Only a few coral fronds were furred with tiny tentacles. But even those whose night-feeding polyps had retracted took their color from the animals' living flesh. I withdrew my gaze from this miniature world and returned to the air and sun of my own.

Fairfax Island shimmered half a mile away, a pretty beach-girdled tropic isle that owes little to the geological processes of the adjoining continent.

CORAL ISLANDS are few on the Great Barrier Reef (or better, the Great Barrier Reef Province, as some geologists call it, since most of its reefs are not true barriers). Ninety percent of the reef is underwater. Still, a few dozen square miles of the complex are permanently dry, and therefore serve as breeding centers for the reef's birds and turtles—sea creatures that use land mainly for egg laying.

Even small new treeless sand cays are aswarm with nesting terns and gannets in the Australian spring, now at hand. Forested islands, like Fairfax, harbor herons, shearwaters that make the night hideous

with their wailing, and frigate birds, those superlative fliers that can hardly walk and cannot swim.

Of human beings the coral isles contain almost none. Only two islands, in the reef's great length, house tourists: Heron, a day's run away and our next major port of call, and Green, 600 miles northwest. Between are groups of lovely coastal isles formed by the peaks of drowned continental mountains, where pleasant resorts entertain visitors by the thousands.

Other human companionship will be found only in a few scattered lighthouses and two or three outposts where some of the most dedicated observers of reef life make their homes. One of these sanctuaries was here on Fairfax Island, where my old friend Julie Booth had lived alone for most of seven years (left).

Julie's quonset hut stood as it was when I had passed this way five years ago, which was surprising considering the tropical storms (Australians call them cyclones) that had passed this way since. I waded ashore and gave a friendly yell. Out came a small noisy animal, closely followed by Julie.

"Good-day, Ken," she said, as if welcoming an old friend who'd been gone for a couple of weeks. "This animal you see is Lady Sula, and she is a dog-shaped bird. Dogs aren't allowed on this nature reserve."

"A bird with teeth," I noted. "Marvelous adaptation. Even barks like a dog."

Julie told the bird to shut its beak, and led me to the hut. Inside, the silvery material that had once insulated the corrugated iron roof hung in attractive tatters.

"Cyclones," Julie said. "They almost blew the lining out of the place. That rip over there was Daisy, that one was Emily. But the rest of the place isn't too bad."

The rest was, in fact, remarkable. Apart from her worktable and chair, Julie's furnishings were feminine, a chaise longue, shelves of cosmetics, a dressing table.

"I may be a recluse," she said, "but I'm a girl."

A young reef heron scampered across the concrete floor and bit me firmly on the finger. "That's Sassie," Julie said. "She's not used to strangers." Sassie hissed dismally and shot out the door. "She'll be back. She helps me knit. I had another heron named Sweetlip who used to help me read. He'd perch on a book, facing me,



Triumphant over the surging sea, tawny coral crests shelter labyrinthine reefs



SALESIE TAYLOR

off One Tree Island. Wave-crushed corals helped build the partly wooded isle.

and raise his feet to let me turn the pages. He preferred books with hard covers. They gave a bird something to get his claws into."

Julie collects specimens and observes reef life for the Australian Museum and other institutions. Most of the time she's alone—or rather, away from other humans. Yet she knows no loneliness.

"I'm in the sea every day doing my turtle study, painting numbers on them underwater so we can trace their travels. I've got some pets out on the reef, fish who know me. Here on shore I've got my birds."

Bates joined us with his cameras, and Julie led the way through wind-stunted pisonia trees to a scrubby section in the island's interior. Here brown gannets—boobies—sat on the sandy soil with pairs of eggs between their big webbed feet (below). They wriggled nervously, but most held still when Julie spoke to them.

We went on to the lee shore, where Julie told us to wait and watch. She walked out onto the beach and waved. At once birds by the hundreds appeared, soaring and circling above her.

"You see, they come to me," she said,



DAVID L. ARNOLD, NATIONAL GEOGRAPHIC STAFF

Standing her ground, a brown booby guards her nest on Frigate Cay, a rookery for the fish eaters.

"and when a storm's due, they fly round the hut and warn me with a special cry."

Later, we talked in the shade of the hut while Julie knitted and Sassie pecked at the flashing needles. When we left, Julie came partway down the beach and offered a quiet farewell. By the time we'd reached the water's edge, she'd vanished.

FAIRFAX ISLAND lies as near the southern tip of the whole reef complex as makes any difference (map, page 744). Thirty miles to the south, at a sand cay named Lady Elliot Island, the reef system ends where the water temperature drops below 68° F., the coldest water in which coral polyps can build reefs. Temperature is critical, as are light, salinity, and the nutrient and oxygen content of the water. Abundant and varied as they are, reef corals and their attendant organisms live within narrow environmental limits.

We therefore headed north, bound for Heron Island. Tourist center of the southern reef, the island has pleasant accommodations. Set apart is a marine research station operated by the 50-year-old Great Barrier Reef Committee and the University of Queensland, where scientists live and work. Here, through the committee's kindness, Geographic photographer Bob Sisson made the remarkable pictures of coral polyps on pages 780 to 793. Here, too, Bates and I received reinforcements for the long sea voyage ahead, consisting of the *Ideal Amateur* and the *Ideal Professional*.

No voyage of exploration can be perfectly manned without the fresh eye, excitement, enthusiasm of the former, the skill, wisdom, judgment of the other. Our new associates were both Australians, both from Sydney. Angela Packer is a courageous diver with almost no knowledge of the reef but an appreciation that never quits. Ron Taylor is one of the world's best underwater men, with many years of Barrier Reef exploration, photography, and film making to his credit. His wife, Valerie, also a renowned diver and photographer, would join us up the coast.

The bigger crew required a bigger boat. Mike Prior brought his 45-ton *Dolphin* out to meet us. She was a plain, strong, sea-kindly boat with a 1,500-mile range and room to spare for our compressors, generators, undersea lights, tanks, cameras,

and other gear. *Dolphin* was ideal for us. So was her skipper. Mike had learned the still-uncharted contours of the remote reefs the hard way, fishing from a dory.

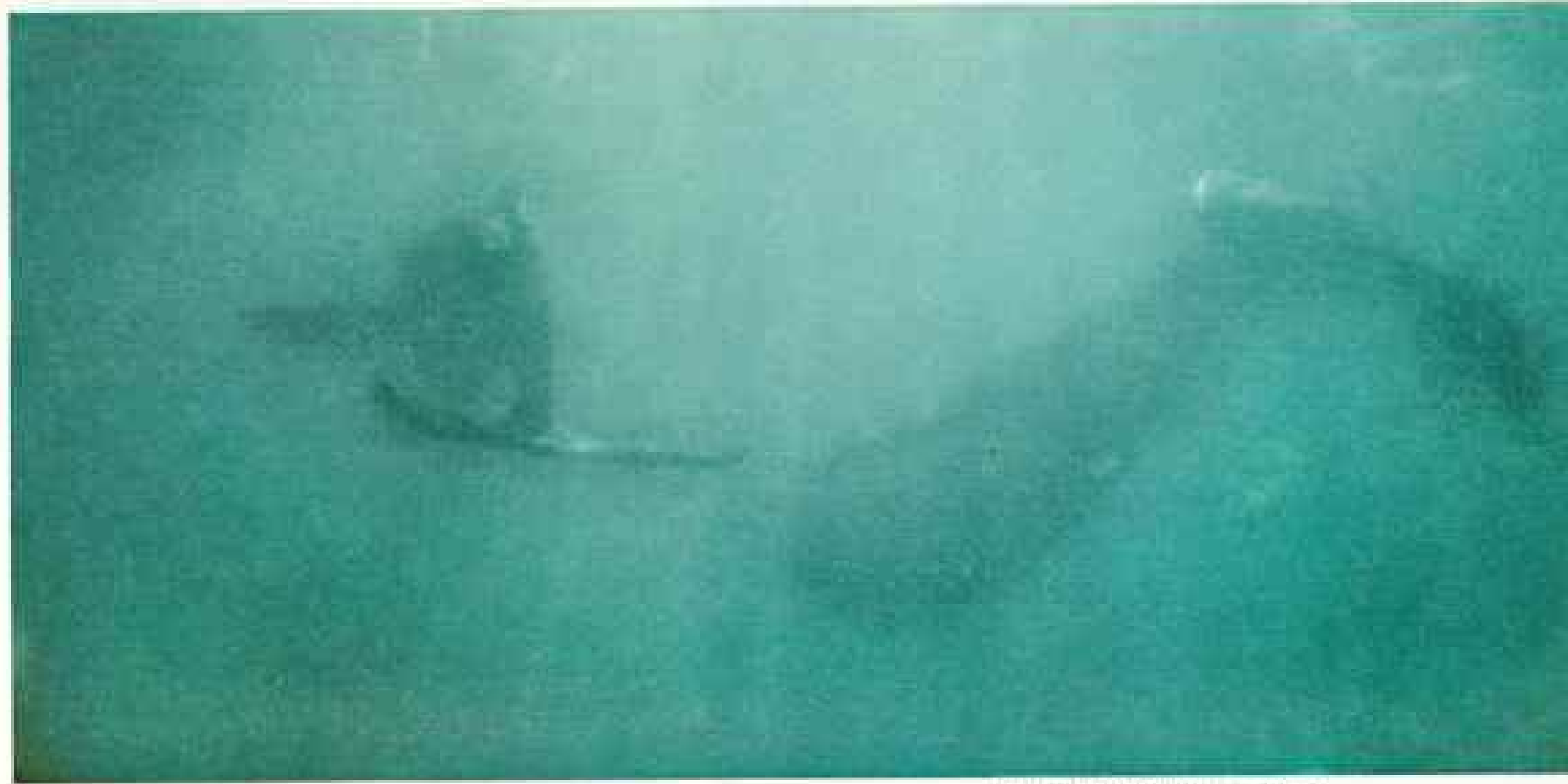
Heron Island offers its visitors both above and underwater views of the reef. Non-divers walk out on the flats at low tide to see the rich array of creatures caught in the tidal pools. Snorkelers and scuba divers usually favor a clump of coral heads known as the Big Bommie, where fish, not only protected but often fed, exist in extraordinary numbers.

The Big Bommie is a fine, unspoiled piece of coral country. On a clear, dead-

"Humpbacks," Bates decided. "Mother and calf. She's about 45 feet long, the little one 20. She could cut this boat in two with a blow of her flukes, but she won't."

We slid over the side, leaving the dink at rest on the glassy sea, and finned out in front of the oncoming humpbacks. I ducked down. No bottom was in sight, no reef near, just open water. A man can feel like a minnow in water like that, and just as vulnerable.

Beside me, Angela pointed and grabbed my hand. The dimness ahead darkened and took form—two great roundish forms. They looked more like places than faces.



MELAPTEIA WONGSAMOLIAI, WIM TAYLOR

Giant flukes waving good-bye, a humpback whale and her calf, left, turn tail to the camera. Once abundant, the huge mammals have nearly succumbed to whalers.

calm morning, we weighed anchor off Heron's lee and ran up there for a day of diving. As we approached, two long black mounds rose glistening out of the water and sank again with hardly a ripple.

"Whales!" Bates hollered. "Get the dinghy!"

"Whales!" said Ron, who never hollers except across wide bodies of water. "I haven't seen one here in ten years."

We three and Angela grabbed fins, masks, snorkels, a couple of cameras. No time for other gear. The huge beasts eased along, dead slow by whale standards (above). With our little outboard flat out, we managed to pass them and pull ahead.

They were about 30 feet away, coming straight on. Angela's wide round eyes eloquently asked, "Now what?"

The whales answered her unspoken question. They swapped ends so smoothly and swiftly that I couldn't see how they did it. Then, in place of the two huge heads, two majestic pairs of flukes rose and fell before us, flashed their white undersides in leisurely farewell, and vanished.

And so back to the bommie. Descend into its small universe. Refocus your eyes and your mind for little subjects now. Fly around a bit first, up the walls, over the tops, down to the bottom. Staghorn forests on the upper slopes. Dim gray rubble

Elegant but armed, a lion-fish glides on fins whose spines can inject painful poison. Saltwater aquarists prize the ten-inch lions.



PIERRE VULTUREL, BEN CROFF



PHOTOGRAPHY ABOVE, WIN TAYLOR, BRUCE LITTLEWALLS

"Tame as my cat," attests Valerie of a huge moray eel that gently accepts tidbits with jaws that could crush her arm. A wrasse steals a morsel tucked in her glove.

Afoot in coral country, two collectors, or fossickers, explore the Swains. Low tide line limits the reef's upward growth.

bottom at 60 feet dropping off seaward. Bright sand patches between cliffs coated with sponges and coral clusters. At the base of each pinnacle, caves where the big predators rest—coral trout, wire-mesh cod, Maori rock cod, a groper or two.

One cave has lion-fish in it, resplendent with their feathery fins (left). Gentle, but poisonous. There are spines in those feathers. Enter this cave carefully. In a dark lair lurks a moray, thick as a leg and a lot longer (below left). He's stronger than any man and has toothy jaws that won't let go, but he's not aggressive. Under a ledge lies a wobbegong shark, frilled and lumpy. Think of him as a living bear trap. You can approach him in safety. Poke him and he snaps. His teeth are terrible.

In the open water between the crags are gentle moon-eyed batfish, hovering like dark clouds. Sparkling, shifting veils of infant fish. Parrots, wrasses, surgeons, butterflies, too many kinds to count. In the special neighborhoods of the coral community—say the condominium of the staghorn thicket—variety is even greater.

Rise out of those stone trees and fly down to the big simple shapes and dim colors of the deepest rocks. Fish are scarce there, but out of the seaward twilight a great dark beast comes to meet you, flying like a slow gigantic bird. The manta closes in, peers with a large mild eye, banks away with a display of white underside, banks again to swim with you. You join him, turning as he turns until he tires of the game and wings away. You watch him go, wondering at the cruelty and stupidity of men who harpoon these gentle animals, simply because they are big.

We could well have worked the bommie for a week. But we had hundreds of miles to go, so we set out for North Reef, our departure point for those most oceanward segments of the Barrier Reef, the Swains.

Boats bound for the Swain Reefs must cross the wide Capricorn Channel—a nine-hour run—so as to come in to the ill-charted reefs when the sun is high enough that they can be seen—that is, after 9:30 in the morning. The trip must therefore be begun at night. But to start at night, one must be clear of all coral banks.

North Reef, on the outer edge of the Capricorn Group, fills the bill. The sun

(Continued on page 767)





Saucer-eyed squirrelfish, night hunters of the reef, huddle by day in a coral



Holocentrus ruber, Valerie Taylor

cave. Thick-growing staghorn coral spreads a brilliant lawn for these timid eight-inchers.





Velvet-lined vise of a giant clam cradles a cuplike siphon, one of a pair that perform the clam's breathing, feeding, and excretory functions. The polka-dot mantle will withdraw into the zigzag $3\frac{1}{2}$ -foot-wide shell before it shuts. Often spanning 4 feet and exceeding 500 pounds, the powerful clams could easily trap a diver's foot. This specimen rests on Endeavour Reef, named for the ship of British Capt. James Cook, who discovered the Barrier Reef in 1770 by running aground on it in his bark. TRIDACNA BIRAE, DON TAYLOR

Elephant-trunked cone shell (below), about three inches long, carries a barbed venomous dart that paralyzes prey and may even be fatal to humans. Golden horns adorn a three-quarter-inch wentletrap (**bottom**), whose name comes from the Dutch word for "spiral staircase." The carnivorous sea snail feeds on corals.



CONUS STRIATUS, VALERIE TAYLOR



EPITONIDUM, VALERIE TAYLOR





HEXABRANCHIUS FLAVIVULATUS, BEN CHOFFY



EURYPHELLA, LEFT; *CHROMOGORIS* DOO, ABOVE; *GALEA* TRIFLOR

Nudibranch: vivid and venomous. Agleam like a jeweled tiara (left), an inch-long sea slug waves a battery of hypodermics that sting predators on contact. Born defenseless, this nudibranch acquires its toxin by eating poisonous anemones and incorporating their armaments.

Swirling its skirtlike mantle, a foot-long Spanish dancer swims slowly upward (top). An elegantly attired 1½-inch-long nudibranch ambles sedately across a sponge (lower).



BEHRODREPHTHA, ABOVE, RON TAYLOR; *DISTICHOPIRRA VIOLACEA*, BELOW, PAVITIS, RIGHT; AND MERTENSII SOFT CORAL, OPPOSITE, VALERIE TAYLOR

Like a budding tree, a soft coral from 70 feet down sprouts hairlike polyps (left). Unlike the hard corals, whose limestone skeletons steadily build the reef, leathery soft corals decay after death. This species adds a little to the structure by secreting limestone spicules, supports for the stalk, seen here as white splinters.

Pompon polyps cluster on another soft coral (opposite), found at 100-foot depths. Retracted coral polyps show fluorescent, star-shaped mouths (twice life-size, below).

Fiery-pink hydrocoral (lower left) decorates a giant cave near Heron Island. Tentacles of these two-inch-high candelabra can inject enough poison to give divers a tingling sensation. Deep-blue sponge grows at the base.







Betrayed by its beady eye, a scorpionfish lurks almost invisible among corals. Striped mouth and ribbed fins take form with the help of a diagram (left) that penetrates the frilly camouflage.

The lethargic carnivore waits for fish and other organisms to



wander by, then drops open its large lower jaw and sucks victims in. Approached by a diver, it menaces with fins whose poisonous spines can cause excruciating pain. Photographer Valerie Taylor found she could lift the fish with a bare hand under its belly; thereafter

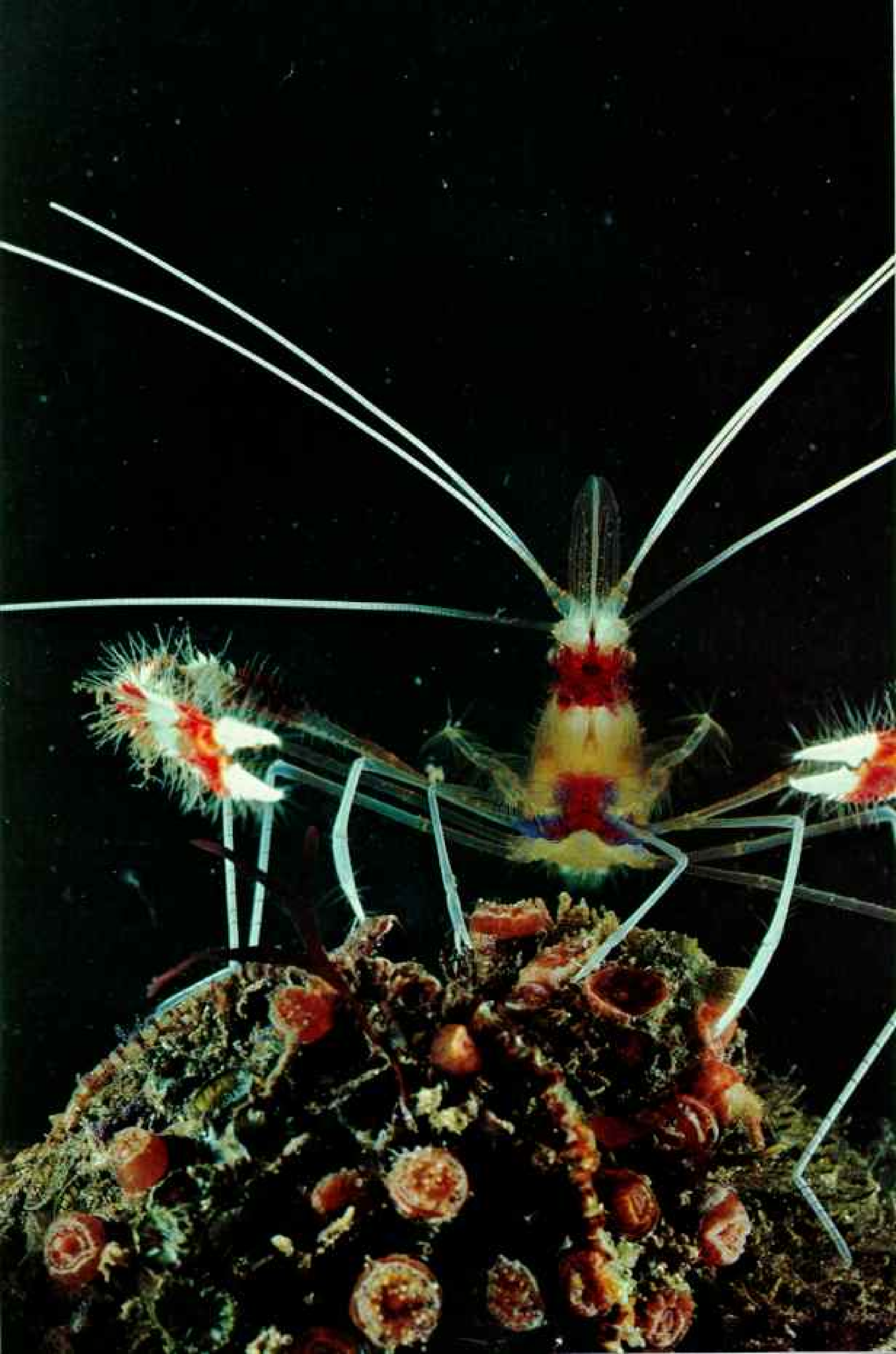
it would flutter away a few feet to settle again.

Visitors trespass warily on the reef, knowing that amid its awesome beauties lurk many that can be lethal—sea snakes, cone shells, and the dreaded stonefish, among the ocean's most poisonous creatures.

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SCORPAENIDAE, VALERIE TAYLOR; DRAWING BY JOHN W. LUTWICK



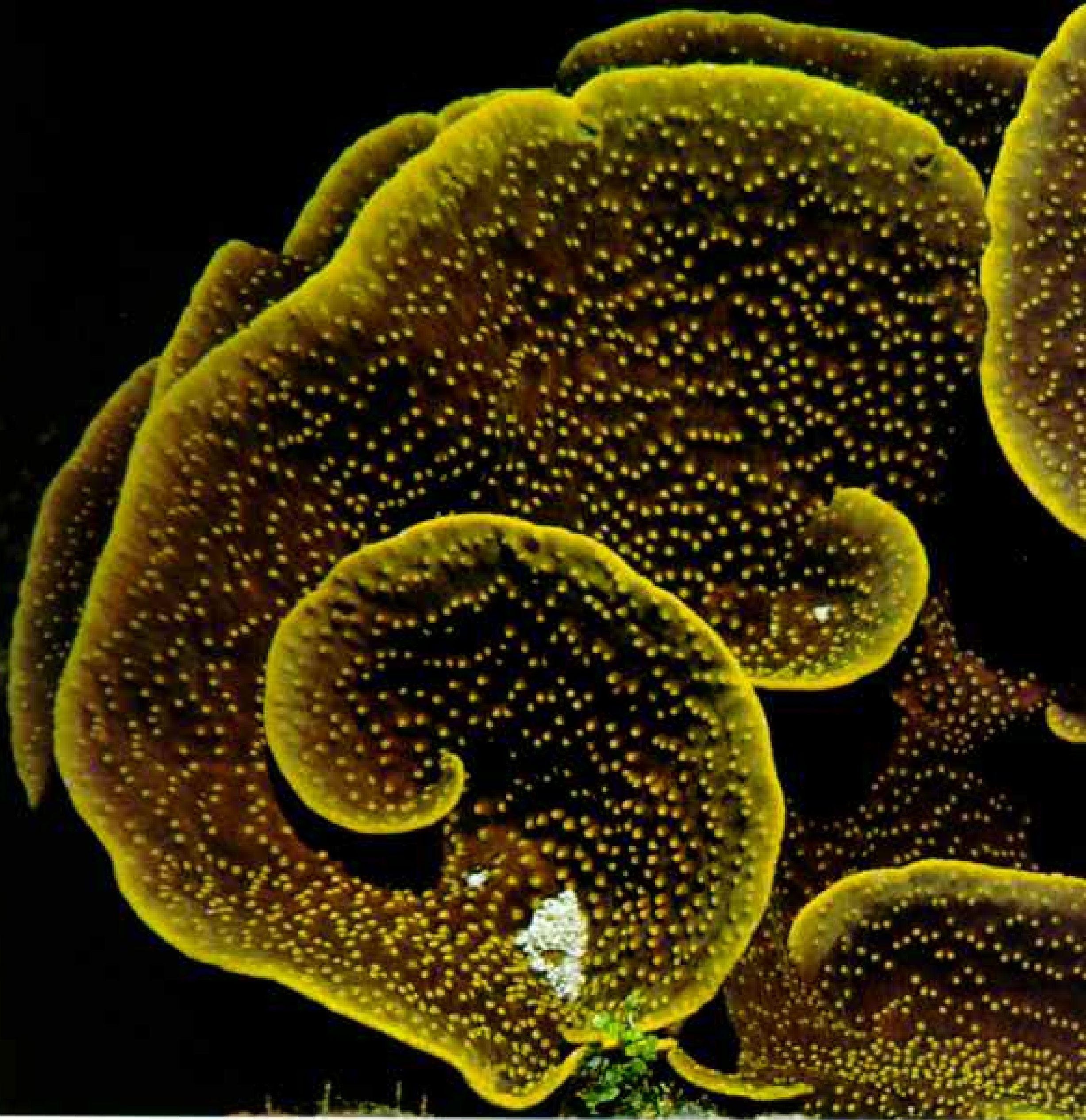




SHRIMP, *STENOPUS HISPIDUS*; CORAL, *CELASTRA*; WALTER DEAN; BLENNY, WIN TAYLOR, ABOVE

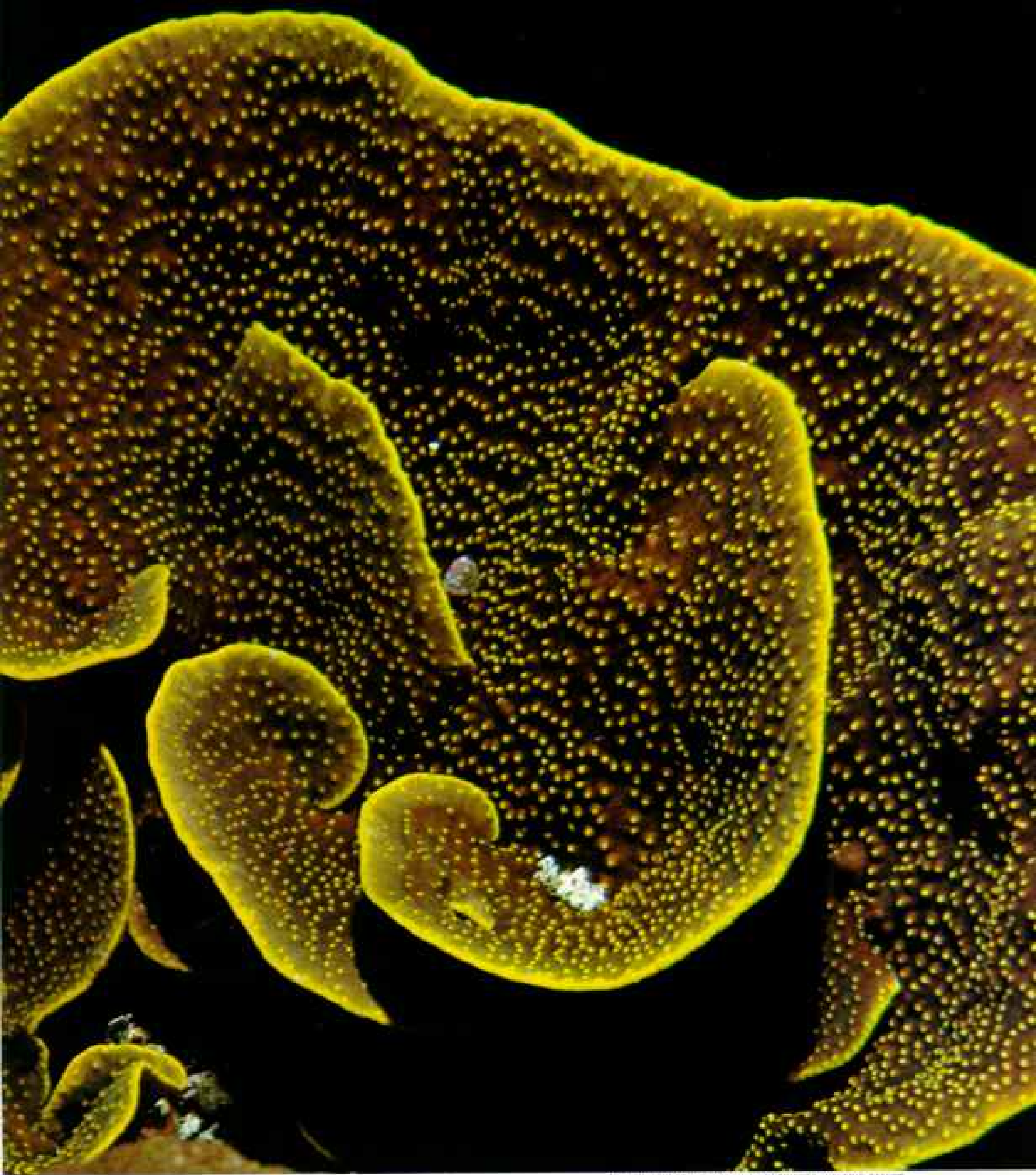
With woeful mouth and wizened horns, a three-inch-long blenny caricatures a disconsolate devil. Most of the numerous blenny species sprout a variety of headdresses, or cirri.

King of its coral mountain, a banded coral shrimp (left) flexes fuzzy pincers. The crustaceans, along with the cleaner fishes, set up stations for plucking parasites from finned customers, signaling with their semaphore antennae when ready for business. This shrimp perches on a mound studded with non-reef-building corals.



Like a monstrous lichen, a plate coral, seen from above, blankets a five-foot stretch of the Swain Reefs. Polyp centers spangle its convoluted skeleton. Thriving in the depths, plate corals sometimes spread as wide as 12 feet. Some giant flabby leaf sponges take almost identical shapes, although they lack the corals' armor.

Star sapphires of the plant world, spherical algae, shown twice life-size, adorn a reef flat. Each globe represents a single massive cell that, if punctured, expels a jet of water.



LOBOPHARIA, APODO, VALZANIA, VENTRICOLA, VALANIS, TAYLOR





(Continued from page 750)

was high when we dropped anchor, so we went diving in search of the big green turtles that mate in those waters.

We spotted several singles in the first few minutes, then, in the distance, what appeared to be a mating pair. We swam closer. Mating they were, but pair they were not. Three turtles were involved: a big female who did all the swimming, topped by a male, topped by another male.

As the sun set we went in to greet the keepers of the North Reef lighthouse and watch them light a little kerosene vapor lamp that, magnified by marvelous lenses and prisms, sends a powerful beam far to sea. Toward midnight the big light winked at us familiarly as we headed out to the Swain Reefs, 80 miles away.

The Swains form a huge half-charted maze. Our target, Gannet Cay, lay deep within it. A scrap of sand covered by birds and little else, Gannet's reef is one of the most beautiful coral displays anywhere. All morning we passed between yellow-brown banks, through deep-blue cuts where tide rips scarred the tormented water. Every channel turned and twisted. One reef edge looked like another. But not to Mike.

"I used to troll along these reefs in a 15-foot dory, picking up coral trout and sweeties [sweetlips]. At night I'd bring them in to the mother ship. Hard work, my word, but you could make a quid. Ah, but the sharks. Two of us, two dories, one man in each, shot 220 bronze whalers in one ten-day trip. Had to. They'd take our trout quick as we'd get them hooked."

As the enticing edges of the coral wilderness passed close aboard, Ron and I waited with mounting eagerness to get down into that undersea world. Ron reminisced about some of the curious sights he'd seen in the coral jungle.

"You know those little blue streaks, the cleaner wrasses?" he asked. I did. I had watched them often, flitting in and out of the open mouths and gills of big predators that normally prey on fish their size (right). They go into a little gymnastic routine as the big fish arrives, thereby apparently establishing their identity, then pick off the carnivore's parasites and dead skin.

"Well, the wrasse is pretty interesting

in his own right, the more so since females of the species can turn into males, if other males are removed, and fertilize eggs.

"But there's a fish that's even trickier," Ron said. "He's about the same size as the cleaner fish, same color, same shape. And he does the same gymnastics. So the big fish opens his gills, and then the little rascal gets stuck into him and bites out a lump of flesh. Because he isn't a cleaner wrasse at all, he's a mimic blenny. He's got himself designed to look like the cleaner fish.

"With all the competition down there, I doubt that there's a single means of survival that isn't being used by somebody. Take the trumpetfish [below]—the long fellow

Hitching a ride or seeking concealment, an elongated trumpetfish (**below**) nuzzles a Maori rock cod. Mouth agape, a coral trout (**bottom**) gets groomed by a cleaner wrasse.

BLASTOMUS CAHEROE OVER EPINOTHELLUS UNDELABESTRATUS, WALTER BEAN



LARMIERUS BREVIVIRGATUS CLEANING PLECTROPODUS MACULATUS, BEN DUFFY



Staring through periscope eyes, a hermit crab guards her turban-shell home.

DAVID HULL, VALERIE THYLIAN



ANEMONE, VALERIE TAYLOR, TOP AND ABOVE; BOB TAYLOR, MIDDLE

The partners: Seeking protection from predators, the clown fish lives unscathed (top) among stinging tentacles of the anemone, and even nibbles on its host. Fed tidbits (middle), the clown placed them in the anemone's tentacles (bottom), as if repaying its protector.

with the small mouth. You've seen them steal a ride on a trout's back? Well, the trout eats bigger fish than his friend does. Little animals don't fear him. So the trumpetfish uses the trout to sneak up on his own prey, then he grabs them.

"Some creatures get along by fencing out the rest of the animals, instead of tricking them. Gall crab, for one. The female sits on a coral branch and lets the coral grow around her until she's trapped. Can't get out. But nothing else can get in, either. Except her mate, who's a tiny thing, and enough water to bring the plankton she needs. She's imprisoned. But she's safe. There are bivalves, too, that dig into coral rock, dissolving it with acid until only their edges show."

Other creatures take refuge within the weaponry of harmful species. I'd watched fish hiding among the spines of sea urchins, and the gaudy clown fish nestling among the stinging tentacles of those giant polyps, the sea anemones (left), to whose poison they are immune.

Gannet Cay appeared ahead: an islet on a crescent-shaped reef whose tips trailed to leeward, away from the prevailing southeasterlies. Within its sheltered semi-circle was a depression about sixty feet deep in the middle and ranging up to about eight feet around the edges. Angela and I went down to explore it.

The deep hole was sand floored, though dotted with coral growth; but the whole curving side was crowded with delicate stony growths of many species, notably the branching acropores, in unbelievable colors: tawny, sea blue, sky blue, grass green, pink, violet, clear red (page 742). We savored the visual symphony that no woods on dry land could have created.

There were fish, of course, most of them familiar. Along the bottom large blue-green venus tusks forage (right); picking up branches of dead coral, for all the world like dogs, piling them in little heaps and then fanning the exposed sand with powerful pectoral fins to expose small crustaceans and other delicacies. While they worked, coral trout cruised alongside, ready to attack small fish brought in by the lure of the fresh excavations.

Here and there, in small sandy patches, were little holes beside which pallid gobies rested, propped on their pelvic fins,

watching like guard dogs while the occupants of the burrows, a kind of snapping shrimp, trundled back and forth excavating new tunnels in the bottom. As each shrimp worked, it uncovered tidbits of interest to the goby, which signaled the arrival of intruders by sticking its tail into the shrimp's burrow and wagging it briskly. When danger pressed too close, the goby would turn and dart down the burrow, thus preventing his nearsighted roommate from emerging.

Everywhere reef creatures went about their business, so that the whole coral citadel shimmered with motion and color. An occasional ear-jolting thump signaled the lunging attack of a predator.

AGAIN the westering sun sent us hurrying in search of overnight shelter in this all-but-landless sea. Mike guided *Dolphin* through two narrow, tortuous channels into a sanctuary in seemingly open sea where a full gale could hardly have raised a ripple.

After dark we put Ron's big lights over the side and went down to explore the reef. It's a different world at night. Many of the busy predators of the sunlit hours go to sleep, some changing their bright day colors for dull nightwear. Stingrays surveyed us with green unblinking eyes. The silvery shoals of larval fish, which have no homes to hide in, hovered in the open.

Though fish were fewer, the far more varied lower forms of life were not. Mollusks came out of the sand in search of prey. Crabs were about. Starfish and urchins edged out of their crevices. But it was the coral polyps that transformed the scene, expanded in their millions like galaxies of fleshy flowers. Night feeders in the main, they reach out their stinging tentacles to seize the plankton that rises into shallow water after dark. They will retract at a touch. But until they do, they clothe the solid structure of the reef with textures and colors never to be seen under the sun (pages 758-9).

To the diver's own senses, too, there is something strange and special about a night dive in a reef. Not fear: The pool of transportable light gives false security. There is a sense of silence, but it is only in the mind. The undersea world is never still. But there is a dreamlike quality to a dive

after dark, a sense of moving in slow motion. Perhaps this feeling is enhanced by the perfect blackness that surrounds the swimmer, by the fact that, limited as he is to the lighted area, his motions are indeed diminished.

I suspect, though, that the almost trance-like state in which the diver hovers weightless and moves without effort derives from the illusion that there is *no water*. In his limited sphere of action, he sees everything near at hand and perfectly clearly. There are no far vistas dimmed by distance. The surface is out of sight. He cannot perceive water, and so, to his now highly suggestible mind, there is none. Yet still he soars through this impalpable atmosphere at the slightest flip of his fins, or balances head down on a fingertip.

Near Gannet Cay is an equally small and unimpressive sandspit that we'd heard was a nesting place not only for gannets but also for those graceful sky pirates, the frigate birds. These nest in the windy southeast corner, since they can take off only into the wind. Airborne, they make their living by literally scaring the



©CHRISTOPHER, SIAA GROUP

Toiling venus tuskfish lifts a broken coral. Then it will fan away the sand beneath with its fins to expose worms and crustaceans.

lunch out of the hardworking gannets, diving on them until they regurgitate their swallowed fish, and catching the falling morsels in midair.

We found the frigate birds long dead in a heap, as nature could never have killed them. Men must have murdered them, presumably for the pleasure of seeing them fall. But gannets survived in great numbers. The brown variety watched over hatchlings. The masked gannets, earlier to nest, had young the size and shape of duck-pins covered with the softest of snowy down and equipped with long sharp beaks and fearsome croaks. Their mothers would come in from the sea, transfer a fish with a small visceral spasm, and go out again to plunge like javelins into the ocean. These birds can fly underwater; they may wing their way down to 40 feet or more in pursuit of their prey.

WE KEPT MOVING NORTH through the Swains, testing new reefs. At The Six, a reef shaped like the number and so providing good shelter, we stopped for a thorough look around.

A good bommie rose 50 feet from the bottom of the lagoon and served as the focal point for life all around. A fair-sized Queensland groper (about 350 pounds; and you don't worry about them until they reach 600 and can eat you) circled the pinnacle, attended by remoras. A hump-headed Maori wrasse—a harmless hundred-pounder capable of crushing the thickest shells in his viselike mouth—poked about in search of mollusks. An ocean barracuda, a silver torpedo six feet long, hung motionless in the middle depths. The full range of predators and herbivores lurked, glided, darted, and scuttled wherever we looked.

But here was something new for *Dolphin's* divers. Sea snakes appeared, one, then another, then a mating pair, most of them of the genus *Aipysurus* (right). I'd dived with sea snakes before, and found them fascinating.* Despite their potent venom, they are rarely dangerous. They may come to investigate a diver, they may follow him so closely and so far that the word "chase" comes readily to mind. One "chased" Ron for fifty yards, to his considerable amusement. But they seldom

*NATIONAL GEOGRAPHIC, April 1971.

attack—probably never without provocation—and most of them, *Aipysurus* included, can't bite through a wet suit.

I watched Ron getting closeup pictures of a snake, holding him lightly by the neck with one bare hand and photographing him with the other. You can do that if you're gentle—it takes the snake more than a minute to get peevish. You can, but few do. The same snake followed along, expressing no hostility at all, so Ron turned to look at it closely. The snake swam right up to his face plate, looked in, and tested it with a darting tongue.

During those rare periods when the winds ease and a calm holds for a few days, most fishermen and divers who visit the outer reef head for the banks on the ocean's edge. These surf-ridden areas, where few humans have ever set line or fin, contain big fish and a lot of them.

Since our weather continued wonderful, Mike took us to the easterly outpost of the Swains, a reef that lay alone, out beyond the rest.

"It's got no name," he said. "I reckon I was there last, and that was 14 years ago. There were tiger sharks in the lagoon then."

We anchored in that lagoon, and sharks came close the minute we cut engine. Not tiger sharks, but gray reef sharks (right).



AIPYSURUS LACINIS, BATES LITTLESLAKE

Death in each hand, author MacLeish grasps two sea snakes. No antivenin exists for this species.

They have a bad reputation because they've attacked a few humans. But unlike the white sharks and tigers, they're very numerous, and their attack incidence is far smaller.

Bates and I went in and found the best visibility we'd ever seen; close to 150 feet horizontally. Clear, bright ocean water. Fish of every kind abounded, and showed no fear. The trouble was, the sharks were tame too. Or curious. There were four, ranging around five or six feet. They circled, slick and supple.

in that lovely water, crowded with fish and corals. The sharks left. With the first lengthening of shadows, so did we.

Our route now took us through the northwest corner of the Swains and across the wide channel between shore and reef to the inshore islands known as the Cumberlands. Before leaving the outer banks, we put ashore on one and went fossicking across its barely covered surface. Here were stunted hard corals, leathery soft corals, clams with mantles as bright and various as batiks. The underside of every



JACKS, GRAYS, WITH GARDABRINUS; WALTER STARCK

Flotilla of jacks keeps formation with a five-foot gray reef shark.

I watched them watching me with twitching eyes set in immobile faces. I had learned something about gray reef shark behavior from Dr. Walter Starck,⁸ an American marine biologist now working in Australia.

"They're not fast enough to catch a fish before it takes cover," Walt said. "They've got to get one that's weak or out of position. So they're apt to be hungry. They see you not as something to eat, but as something that might swipe their food. Come close, and they'll put on a display to drive you off, a head-shaking nervous movement. Come closer, and they'll attack."

"Other reef sharks—whitetip, blacktip—they'll take off if you rush them. But don't rush a gray reef shark. He'll hit you. Just stay away, and he'll leave you alone."

I did, and they did. We dived for an hour

⁸Dr. Starck wrote of the "Marvels of a Coral Realm" in the November 1966 *GEOGRAPHIC*.

slab of dead coral glowed with living colors: sponges, egg sacs, cowries, supple stars, small crustaceans. Where life is so rife that every step must kill, we trod softly. Soon the rising, rushing tide washed us away. We traveled on toward the realm of land where vegetation rules, as it does not in the coral pastures of the sea.

The clustered islands just off Queensland's central coast are among the most beautiful and most popular in the vicinity of the Great Barrier Reef. I say "vicinity" because they are neither on the reef nor part of it.

Dolphin docked at Lindeman Island, whose cottages cluster among big trees behind a palm-fringed beach. We went ashore to collect Valerie Taylor, then sailed on to explore the central region of the reef. Here the banks appear to grow less vigorously, and the barrier seems more diffuse than in the south and north. This central

region, still blessed with magnificent coral growth, is also cruelly cursed with hordes of large poison-spined starfish, appropriately named "crown-of-thorns," that eat live coral, leaving dead limestone (right).

The crown-of-thorns problem is about ten years old. Population explosions of these once rare animals have occurred in the waters of half a dozen nations, all of which have tried with varying success to do something to combat them.*

Many scientists believe the plague is cyclical, and will pass. They may be right. But other experts doubt it. One of the best-informed and most outspoken of these is Dr. Robert Endean of the University of Queensland, who is also president of the Great Barrier Reef Committee.

"We reckon that large areas along hundreds of miles of the reef are pretty well ruined. The government says the coral will regenerate. Of course it will! But when? I'd guess thirty or forty years. As for the theory that the crown-of-thorns infestation is a cyclic phenomenon, I don't think there is any evidence to support it.

"In my opinion, the massive population explosions of the crown-of-thorns are unique phenomena. Man may have triggered the plagues, but the causes of the outbreaks are unknown. Maybe the invasion has run its course, but there is no evidence of this yet. If the infestations continue to spread at the same rate as in the past decade, starfish could be at the southern end of the Great Barrier Reef in another ten years.

"The infestation was first observed near Cairns in the early '60's. The starfish have moved on, and there's been some recolonization by hard corals, though it's disappointingly slow. Now you'll find enormous numbers of starfish near latitude 19 degrees south."

OUR NEXT ANCHORAGE was Hook Reef, a sheltered semicircle of coral 50 miles south of the 19th parallel. A night dive revealed no crown-of-thorns, but a great deal of drifting algae. As I watched these slimy harbingers of sights to come, I reached out to brace myself against the current. My fingers found a good hard ridge. Then the ridge stirred. I

*This menace was reported by James A. Sugar in the March 1970 NATIONAL GEOGRAPHIC.



STARFISH, ACANTHASTER PLANCI; CORAL, ACROPODA TERNATA; BEN CROSS



BOB TAYLOR

Spiked scourge, a crown-of-thorns starfish strips polyps from staghorn coral (top). Proliferating starfish have ravaged vast areas of living reef (bottom).

pulled free as the giant clam closed. Such clams may run four feet across and weigh more than five hundred pounds.

"It's the quiet creatures down there that are the real danger," said Valerie later. "The sharks, snakes, barracudas, morays, they're no great menace. But a box-jellyfish, a hidden stonefish or scorpionfish, a poisonous cone shell—yes, or a big clam—they're the ones to watch out for."

We watched out for them as we worked our way north, making quick survey dives on reef after reef. As predicted, we found starfish near 19 degrees south. A few white patches of freshly killed coral gleamed in the blue depths to show that the polyp eaters were at work. The stars seemed few and widely scattered, until one remembered that their normal density was about five or six per mile.

A few miles farther along we came upon reefs that appeared utterly devastated. Tumbled coral branches lay like dead bones at the foot of every cliff and slope. No colors brightened the dirty gray of what was now lifeless stone. A few dull and flaccid soft corals grew on the barren reef flat; a few small herbivorous fish browsed in the rank algae that stirred obscenely like the hair of a corpse.

It was a sickening sight, the more so when one thought of the beauty that had been there. At Bramble Reef, which Mike had found unharmed just two years before, counting only six crown-of-thorns, we found massive destruction.

"The next couple of hundred miles will be pretty sad country," I said. "Let's go in to Dunk Island and look at something beautiful."

Like the Cumberland Islands, Dunk is a piece of the continent cut off by a strip of sea. Unlike them, it lies in Queensland's high rainfall belt. Therefore Dunk is truly tropical and richly clad in the elaborate vegetation of rain forest. Vines climb, ferns spread, strangler figs strangle lesser trees, and everywhere a canopy of richest green shades the fecund humus of the forest floor.

Dunk was for many years the home of an admirable English gentleman named E. J. Banfield, who referred to himself—more romantically than accurately—as the Beachcomber. He observed with the professional Victorian's enthusiasm and

immunity to boredom each smallest detail of his enchanting home. Now visitors come to spend a week or two at the resort that has replaced his simple dwelling. We walked into their recreation room well after dark, fresh from the sea and the sad spectacle of ruined reefs, to find the assembled guests seated in silence, staring fixedly at the tables before them. Not a sound was to be heard except for the hypnotic chant of a young man mumbling numbers. Occasionally a guest would voice a short hysterical scream.

I wonder what old Banfield would have thought of bingo.

THE TAYLORS left us at Dunk. At dawn *Dolphin* headed out again, bound for Cairns, the northernmost city of Queensland. Like most of the coastal communities, its attention focuses westward toward the farms, mines, and cattle behind it, rather than to the beautiful but not overly productive sea at its doorstep. Still, Cairns has two special areas of ocean interest: a coral cay called Green Island, for decades a busy tourist resort; and big-game fishing, a sport that brings millionaire sportsmen from around the world.

The fishermen were happy. I talked to skippers as they docked that evening, and learned that big black marlin were being taken. One had weighed in at 1,273 pounds.

We sampled the reefs around Green Island. Hard corals had grown back in places, though this previously star-infested area was thick with the dull-hued rubber-tough colonies of the alcyonarians, or soft corals. Off nearby Michaelmas Cay, a dreary sand strip made marvelous by thousands of nesting terns, regeneration was even farther along, suggesting that the reefs of these latitudes might return to the condition of the magnificent creations in the Swains.

Our course now lay inshore under high green mountains drenched by the richest rains of Queensland. Rivers stained the sea. At night we found shelter in the Low Isles, coral structures in which ramparts of reef debris were high enough to enclose a swamp now crowded with mangroves and stinging gnats.

Toward evening beautiful black-and-white Torres Strait pigeons came from shore to shelter in the mangroves. All night

their deep soft voices filled the soft sea breeze with gentle sound.

As we moved into its northern region, the reef assumed for the first time the form of a true barrier—a long slender rampart of coral with occasional narrow breaks. Ribbon Reef, its longest segment, stretched 16 miles north and south, though its shallow reef flat was only half a mile wide. Ashore, the mountains fell away, and we saw glittering in the distance dunes of silica sands washed to the shore by rivers and redistributed by the winds.

Such sands are valuable. So are the almost pure calcium carbonate sediments of the reef floor, which could sweeten the acid soil of Queensland's sugarcane fields. So is oil, whose suspected presence under the reef has aroused considerable interest.

But suppose man does exploit the reef? I recalled a conversation with Dr. Patricia Mather of the Great Barrier Reef Committee and a scientist of high repute.

"The Barrier Reef is a delicately balanced dynamic system, a self-fueled machine in which the sun's energy is converted into sea substances that become land-building materials. The reef environment is stable, but interference could disturb that stability. The reef machinery is fragile. If you damage it by dredging or quarrying or drilling or spilling oil, it may break down. Our technicians can only fix machines they build themselves. And this, the greatest creation of life on earth, is no work of man."

A royal commission has considered the effects of oil drilling, and will report its findings to the government. In the meantime, eager industry awaits ashore.

Now Lizard Island rose before us, a granite mass nearer to the reef edge than to the continent. Lizard would be our northernmost base, for beyond it the reef continues with little change to its end at Anchor Cay. The island has flawless beaches and a permanent supply of fresh water. Yet it's been uninhabited since the departure of poor Mrs. Watson, wife of a skipper who lived there 90 years ago. Mrs.

Colony of coiled springs, delicate ascidians only half an inch long cluster in a thicket of stinging hydroids. Often called sea squirts, sedentary ascidians begin life as free-swimming larvae.

PEROPHORA, GALERIE TAYLOR





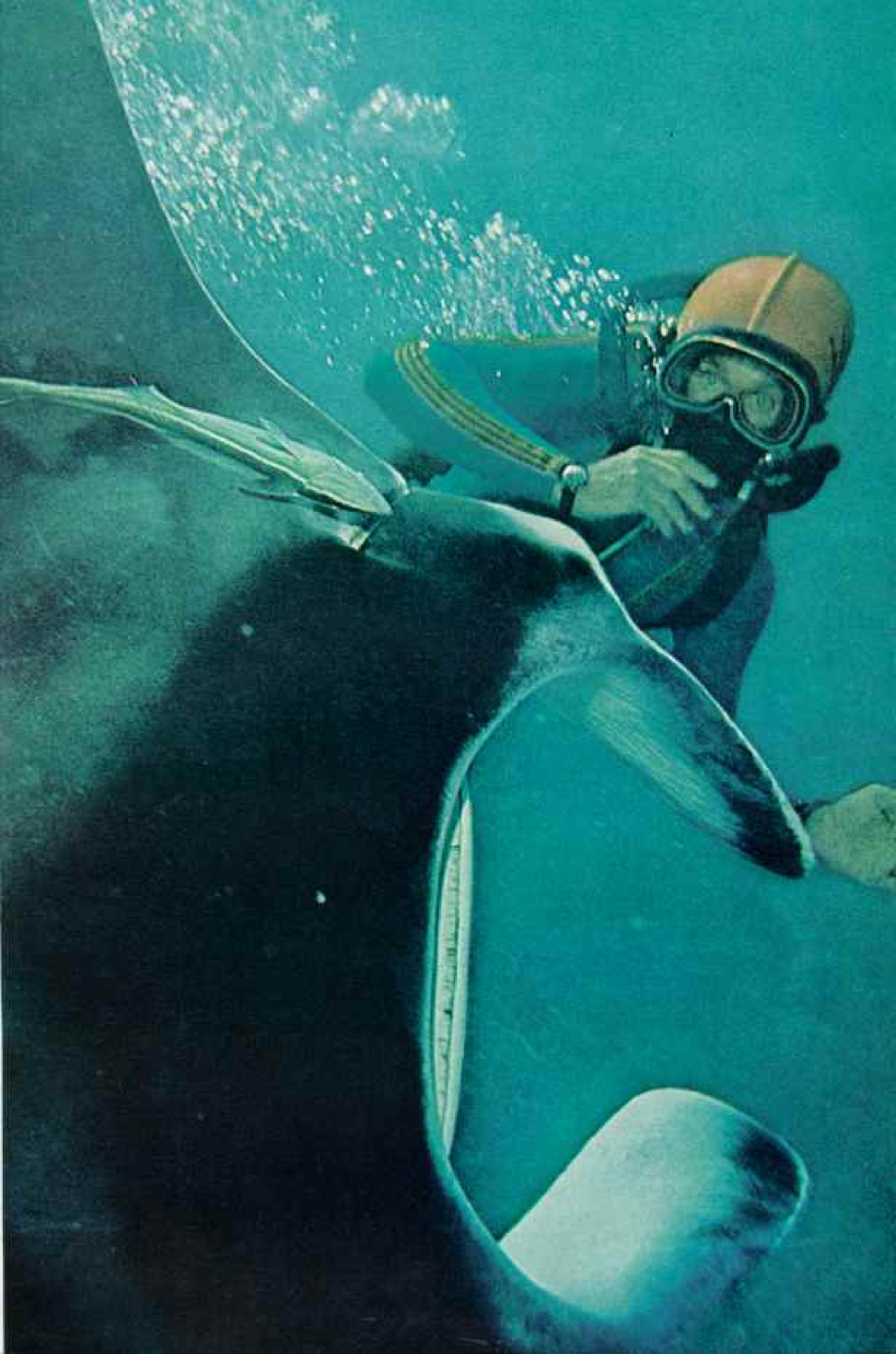
Mildred the mild-mannered manta lolls beside a diver off Heron Island. Each day, as if on schedule, the gentle half-ton ray winged onto the reef from the dark sea. "She was always quiet and curious—an absolute darling," photographer Valerie Taylor recalls. "She particularly liked me to scratch her tummy. She would slowly sink to the bottom in rapture, sometimes settling directly on top of me like a wet blanket and lying there as long as I scratched."

With earlike fins, harmless mantas sweep plankton and small fish into a yard-wide mouth. They can weigh more than a ton, yet frequently vault above the surface like flying fish. Here a remora clings to Mildred with suction-cup dorsal fin, waiting for scraps from her feeding.

Like a bird on the wing (**below**), a flapping eagle ray strikes a bold silhouette against flaring sunrays.



MYLIORATUS, ABOVE; BEN CROFF; MANTA BIRDIE'S AND SCHERER, VALERIE TAYLOR



Watson, then aged 21, put to sea in an iron tank with her baby and a wounded Chinese servant after a marauding party of spear-throwing Aborigines attacked. All three died of thirst on a waterless island.

But now we saw a little camp of poles and tarpaulins in a corner of the beach and went ashore to meet its occupants. These were Peter Faulkes, a lithe young Canadian, his wife, Tim, and a spectacularly healthy year-old baby named Simon.

"We came to spend six weeks," Peter said. "Then we found that Bush Pilots Airways had a strip here and wanted someone to tend it. I do leatherwork to get hold of a little cash, and Bushies [Bush Pilots] bring us what supplies we need. We've been here ten months now. We'll stay forever if we can.

"We don't eat meat: we eat mostly vegetables. I get a fish when I want one, but I only take what we can eat."

He stared out to sea. Then: "This place offers every single thing I've ever wanted."

FROM LIZARD we planned that special dive that every underwater man who comes to the reef yearns for and that most never manage: a dive off the outside edge, where the ocean meets the Great Barrier. For such a dive you need not only an unnaturally calm sea, but also a light wind from the northwest (its most unaccustomed quarter) to flatten the southeasterly surge. Those conditions existed the day after we reached Lizard, and we went north to Hicks Reef.

On the way we passed Cook's Passage, the narrow cut in the Barrier Reef through which that discoverer of the reef found a way out to sea, having gloomily observed from the thousand-foot-high top of Lizard Island that he was still surrounded by reef. Once outside, he made his way northward before finding himself in desperate need of a similar break in the barrier for, becalmed and driven by the swells, his ship *Endeavour* was on the point of being smashed on the coral wall.* An opening appeared so providentially that he called it Providential Channel. He was saved again.

No swells threatened as we entered the open Pacific, then turned to approach the outer edge of Hicks Reef. The living rim of

*See "The Man Who Mapped the Pacific," by Alan Villiers, *GEOGRAPHIC*, September 1971.

the coral rampart lay only a yard beneath the surface. Where it ended, the dark blue of the deep sea began. No transitional green shallows here, but an absolute frontier drawn in strong colors.

Normally a boat kills its engine before divers enter the water; a turning propeller is as dangerous as a buzz saw. Here we would have to keep it running.

"I can't anchor here. No bottom," Mike told us. "Besides, this is tiger-shark country. They patrol this cliff. If one shows up, you won't want to swim a couple of hundred yards to catch me up, I'll just keep maneuvering to stay off the coral. Just watch that wheel when you come up. You'll be 'right."

Thus encouraged, we stepped into the most overwhelming undersea scene I've ever observed. Visibility was unbelievable. Two hundred feet horizontally, I'd say. The whole cliff face, a good hundred feet high, loomed in sight.

I swam directly toward it, suddenly aware that behind me the open sea stretched thousands of miles. I crossed the reef front, skimming along just above the cemented limestone and small sturdy corals at its summit. In this place of violence, where the waves of normal weather develop hundreds of thousands of horsepower each, polyps thrive in oxygen-rich water, replacing what the surf destroys.

I found a smooth spot, stood, and looked seaward. It was like standing on the edge of a precipice: solid rock underfoot, a sharply defined edge, then the abyss. How often have men stood on the brink of cliffs, wishing they could take wing and soar out into the emptiness before them? This time I could. And did.

A couple of kicks took me over the cliff (right). I turned straight down and followed the vertical surface to its base, a hundred feet below. Then the rubble slope began, in dimness deepening to darkness. A few soft corals swayed, a few fish wandered among them. Farther down, the slope went barren. It would continue its steep descent to about six thousand feet.

Here, far from the continent whose shores it protects, the coral world ended. The ocean began. And the indestructible rampart of the reef confronted it, countering the fury of wild water with the unquenchable force of life. □



BRUCE LITTLEHALL

Filmy gorgonians flourish where the reef rampart drops off into the open abyss.

FIRST COLOR RECORD
OF THE

Life Cycle of a Coral

ARTICLE AND PHOTOGRAPHS BY
ROBERT F. SISSON

NATIONAL GEOGRAPHIC STAFF

TUMBLING through watery darkness, the white kernel-like larva—here magnified 13 times—looks like a miniature space capsule as it moves past looming knobs of mature coral. Brown tentacled rings mark the adult polyps, one of which produced this free-swimming youngster from a fertilized egg. As I watch, its hundreds of tiny, nearly invisible hairs generate currents that propel the larva, or planula, on a three-to-ten-day quest for a place where it can settle, grow, and proliferate.

One of the hard varieties, this coral, *Pocillopora damicornis*, spawns intermittently the year round, an activity apparently triggered by phases of the moon. In the Australian summer, December to April, a new moon signals new birth; in winter, a full moon is the catalyst.

Long considered by naturalists to be marine plants, corals actually are predacious, primarily carnivorous animals akin to sea anemones. Some even capture living fish, as documented by the only known photographs of this phenomenon (pages 790-91).

A coral larva
begins its
search for
a home . . .





... while another
is ravaged
by microsharks

THE ATTACK rages quietly within a tiny drop of water, a minibattle on a microscope slide. At first, fifteen or twenty minute protozoans gather, apparently feeding on the damaged coral larva I had isolated from its parent colony (left, upper). Some even eat their way into the larva and out again. Soon hundreds more join the early assailants, surrounding and devastating the helpless victim (bottom) as sharks might destroy a wounded



whale. Fascinated, I watch the swarm balloon still larger, wrapping its prey in a frenzied shroud of death (**below**). After two hours, only seawater remains.

For some unknown reason, the microscopic attackers spare healthy larvae. But even normal young corals lack adequate defenses against the ocean's gamut of perils, and millions succumb before they can mature. Reef-building varieties thrive in water that

is both warm—68° to 86° F.—and shallow—less than 180 feet. But such favorable conditions also support hordes of their enemies—not only protozoans but also crustaceans, fish, worms, clams, and starfish that feed on plankton and mature corals.

Nature's spendthrift way compensates for such calamity. By spawning billions of young, the corals ensure that enough survive to perpetuate the species—and the reef.

783

CORAL LARVAE AND HIGHER-LEVEL PROTOZOA MAGNIFIED 40 TIMES (UPPER LEFT), 20 TIMES (LOWER LEFT), AND 100 TIMES (BOTTOM)





LARVAE (AROUND AND BELOW) MAGNIFIED 34 TIMES



POLYP (AROUND) MAGNIFIED 88 TIMES, (LEADING PAGE) MAGNIFIED 88 TIMES

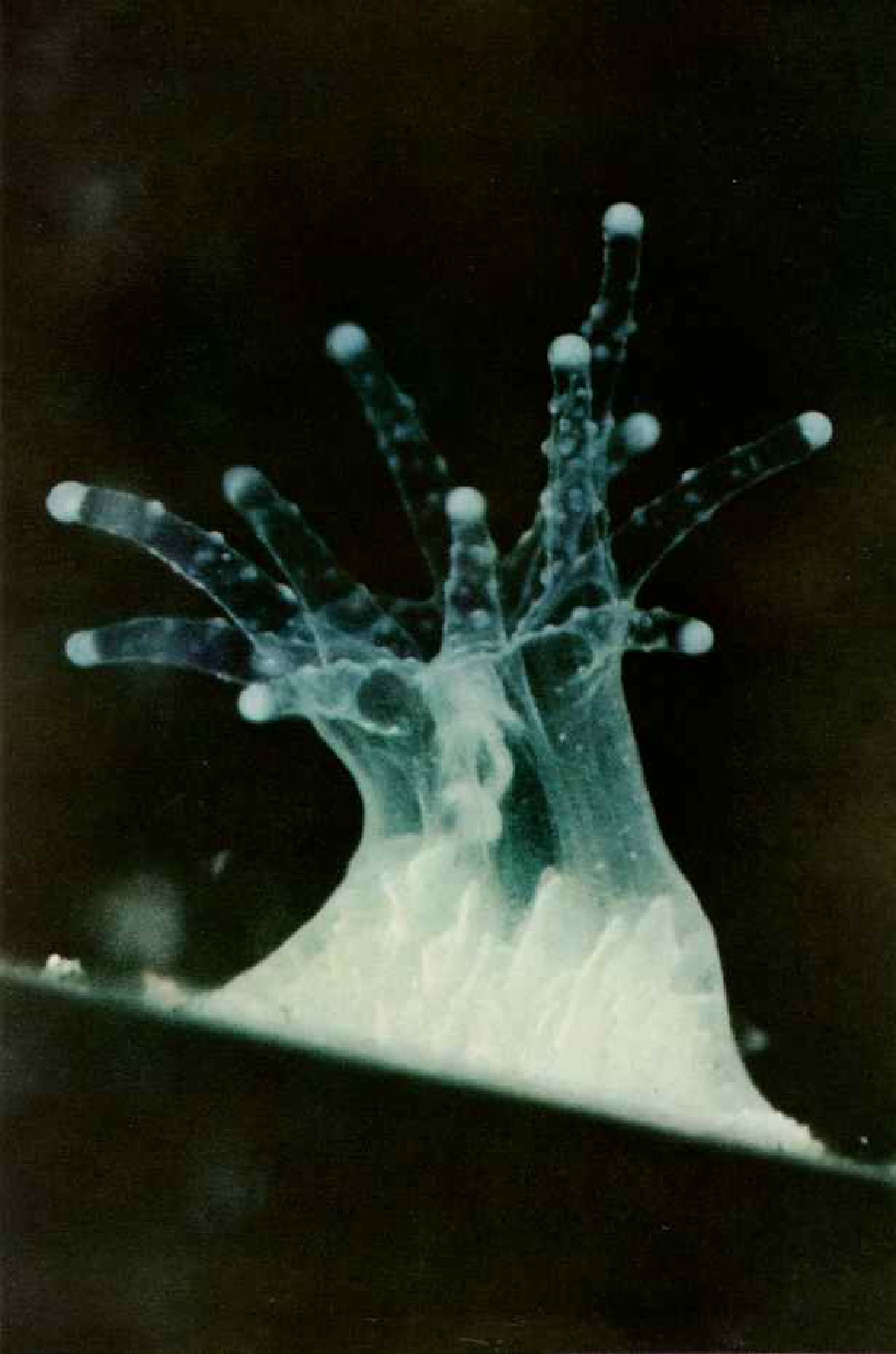
Healthy larvae anchor themselves for life . . .

HALF DRIFTING, half swimming, coral larvae change shape as easily and constantly as clouds. One is a pear this minute, a globe or sausage the next. Part of another—only a week old—extends and droops (**top left**). From a different angle, the developing tissues take on the look of a tomato slice (**middle left**).

Flexible as rubber, young corals need support to grow and mature. I watch a ten-day-old animal thicken, then settle on a smooth surface, spreading out into a disk (**bottom left**). Almost at once it begins to secrete a white starlike outer skeleton, permanently cementing itself to its homesite. Soon the larva becomes a polyp, a word derived from *polypous*, Greek for many-footed. Its center sprouts into a hollow pedestal crowned by 12 tentacles, still stubby after three weeks of growth (**right**).

Air bubbles hang above the polyp. Speckling its transparent flesh with color and contributing to a remarkable partnership, minute symbiotic yellow-brown algae called zooxanthellae live and reproduce within the animal's cells. The presence of the algae promotes—in ways not yet fully understood—the coral's growth; the algae, in turn, utilize the polyp's carbon dioxide, nitrates, and phosphates.





...and burgeon like
tiny volcanoes

STARBURST of tentacles erupts from a four-week-old polyp lying in wait for food (left). Along each appendage, lumpy white batteries of nematocysts—spring-loaded stinging mechanisms—lash out to paralyze prey. Mucus secreted by the tentacles helps snare tiny passersby and pass them along to the centrally located mouth.

Because I raised this coral in darkness, which prevents growth of algae, it lacks the brown tone and shows its true color—bluish green. Yet the coral grew, extending its skeletal fortress as fast as the normal polyps I raised, proving that sunlight is not essential to development.

Reef-making corals grow like a family business, the younger polyps expanding the reef as they bud off from the older generation. At death, *Pocillopora damicornis* leaves honeycombed monuments of fluted limestone cups, each scarcely 1/25 of an inch in diameter (upper right). A few brown remains of dead polyps color this colony of white and otherwise empty skeletons.

The complexity of an individual skeleton amazes me. On a glass slide, dwarfed by my fingertip, one seems a miniature volcanic cone (right). Its ragged edges rise above struts that radiate from the center, giving it the symmetrical beauty of a snowflake.

POLYP (LEFT) MAGNIFIED 30 TIMES



NATIONAL GEOGRAPHIC PHOTOGRAPHER VICTOR R. BUSHWELL, JR.



Knobby fingers or lacy ferns, tentacles reach out for food

HOARDING GOLDEN ALGAE, tentacles of an adult *Pocillopora* coral (right) stretch forth like an open hand to gather prey. Tiny stinging cells bulge from each tentacle's outer surface and may also hide within the tips.

Graceful as a fern, *Tubipora musica* (below, at left) extends eight fringed tentacles from around a conical mouth. Unlike most corals, it opens up in daytime, flourishing atop its unusual rust-colored skeleton. These limestone remains take the form of hard cross-braced tubes, hence the popular name, organ-pipe coral.

When I cast the shadow of my hand over the polyp or touch it, the organ-pipe's leafy appendages immediately curl up and withdraw in self-protection, leaving only the dark cap seen at right. But a few minutes later they slowly emerge again (bottom).

Just outside my door on Heron Island the reef harbors hundreds of other corals, each species building in its own distinct shape—brains, fans, staghorns. Pink, yellow, orange, blue, and green polyps spatter the surface, forming a giant undersea garden of rainbow hues.



CORALS (ABOVE AND BELOW) REPRODUCED BY C. J. TIMES





Photographic proof—
some corals snare fish



“NEVER HEARD OF IT,” my scientist friend said when I told him I had seen corals capture fish. Acting on a hunch, I had put damselfish in a tank with a mushroom coral, which grows as large as a foot in diameter; this largest of stony-coral polyps has a mouth several inches long.

Each time I dropped a fish into the coral's tank, some of the polyp's tentacles pointed toward the swimmer, following its every move—perhaps by sensing light, motion, or chemical change. When a fish ventured too near (**above**), a tentacle or two grabbed and stung the victim. The fish frequently broke this initial grasp, sometimes tearing off chunks of its own flesh in the process.

One fish, stunned, swam crazily on its side and shuddered as if in shock. Soon the

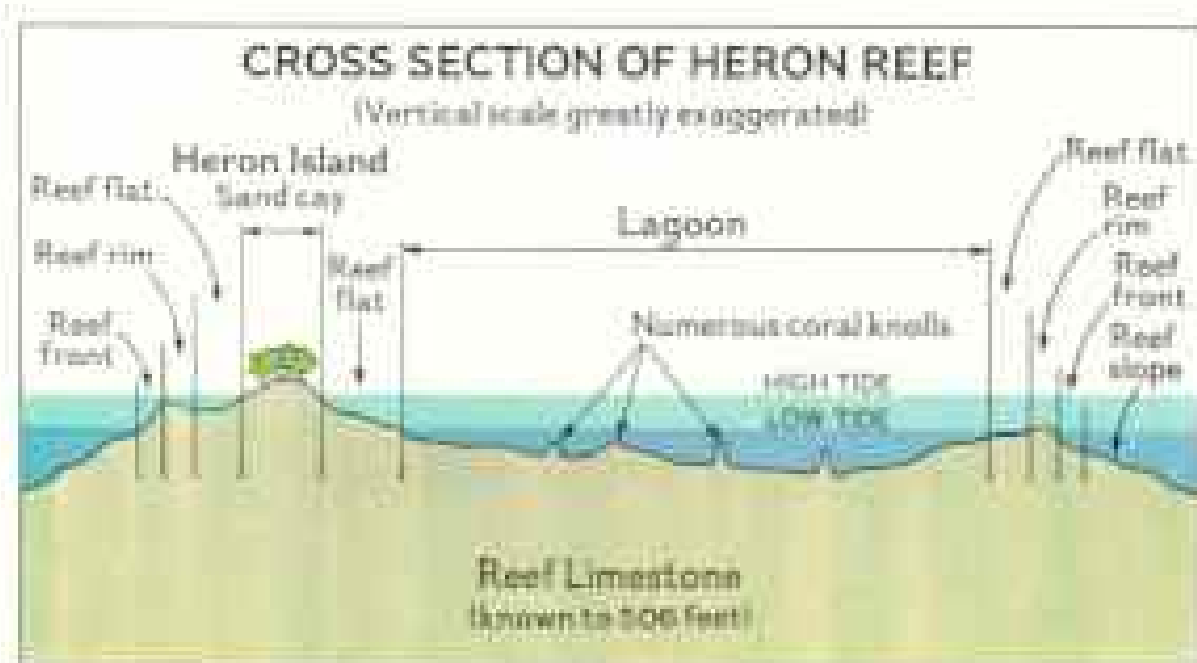
coral struck again, this time for keeps. Like a bucket brigade, its tentacles passed the paralyzed fish from one arm to the next, ever closer to the mouth (**above**). The coral's accordion lips slowly bulged up, drawing its meal inexorably inward. As the fish entered tailfirst, its gaping mouth mimed a mute “Help!” (**right**) just before disappearing completely, only twelve minutes after the first contact.



FUNGIA ACTINOFERRIS PILIPP, 3 INCHES IN DIAMETER; DAMOSELLA FISH, ABOUT 5/8 INCH LONG



Together the tiny
master builders
create vast
undersea villages



RESEARCH BY ANN KUHNER; DRAWING BY ELIZ SMOER

REEF-BUILDING corals labor in silent concert with cementing pink algae (above left). With limy secretions, the plants mortar together dead coral, sediment, shell, and other marine rubble, buttressing the reef against the ocean's ceaseless pounding. Paradoxically, although the reef withstands crashing breakers, it easily succumbs to careless beachcombers, divers, and



boaters. If broken off from the rest of the colony, a chunk of living coral and whatever denizens it supports may perish.

As the sea ebbs, I trek to the reef crest and stand, my back to the ocean, looking at an azure lagoon between it and Heron Island (above). The structure here (left), typical of most coral reefs, at first seems as deserted as the moon. But in a few

minutes a crab rushes from its tiny cave to snip off a tuft of algae. A green-mantled clam spits water high into the air, then clamps shut. Gradually the reef's niches and crannies come alive with tiny worms, sponges, and other marine animals. A wholly interrelated world reveals itself to me, the massive but strangely fragile realm of corals and their companions. □



Hiking the Backbone of the Rockies

By MIKE W. EDWARDS

NATIONAL GEOGRAPHIC STAFF

Photographs by LOWELL GEORGIA

WE HAD TOILED through a long day, Lowell and Steve and Mick and I, up from the Valley of the Rocks and Golden Valley, up tortuous switchbacks on well-named Fatigue Mountain, up finally to the meadow where the waters divide—one trickle for the Pacific, another for Hudson Bay.

Our lungs heaved, our blisters screamed.

When, at last, evening's cool stillness came, we needed refreshment for mind and body.

On the Great Divide Trail in the Canadian Rockies, at the end of an August day, the best place to rekindle spirits and forget aching pain is atop a crest with a view. So, shedding packs, we clambered up Citadel Peak to watch night's calm descend on tossing summits.

Across the ranges the western sky exploded in oranges and purples. The lowering sun hoisted shadows, stealing away the landscape. First the valleys went, then the walls of matted conifers, next the glaciers.

Only the tips of the peaks held day's last light as another hiker joined us—a Swiss woman in her twenties, sun bronzed and pigtailed. The spectacle of mountains putting on nightclothes inspired her to hum a song she had sung around campfires in the Alps. As the peaks darkened, no world existed for any of us save the pure, grand, remote, abiding, enchanted world of mountains.

Jousting with a willow, a bull elk wins a garland for his trouble. He and his harem of a dozen cows live near Floe Lake in Kootenay National Park, one of the wilderness rewards for those who hike the Rockies along Canada's new long-distance trail.



Fast-fading light hugs the peaks above Haiduk Lake in Banff National Park. Mike Edwards tends the campfire, flanked by his son, Mick, left, and Steve Georgia. Author Edwards, who told of his trek along the United States' Pacific Crest Trail in the June 1971 NATIONAL GEOGRAPHIC, went on to sample Canada's 340-mile Great Divide Trail, a composite of old wilderness paths.

I knew many evenings as magical of mood as I backpacked for 275 miles through the country crossed by the Great Divide Trail. Canada's first long-distance hiking and horseback route keeps mainly to the famous foursome of national parks along the Rockies' spine: Originating in the southern tip of Banff, it wriggles generally northward through Kootenay, Yoho, and Jasper. It's a new trail welded from old parts—paths once trod by Indians, trappers, explorers, surveyors. Eighty percent complete now, it will total about 340 miles when gaps have been spanned between some of the segments. Until then, a sturdy hiker trying to go all the way will



sometimes have to bushwhack or detour on highway asphalt.

Twice the trail wanders into provincial parks that hold particularly awesome peaks. One of these is the glaciated obelisk of Mount Assiniboine, rising to 11,870 feet on Banff's western flank. Near its northern end the trail skirts 12,972-foot Mount Robson, highest Rocky in Canada.

Eight times the trail crosses the Continental Divide, the chain of saddles and summits that parcels out the snowmelt. Some of this icy runoff joins the Canadian part of the Columbia River and eventually spins turbines and nourishes apples in Washington

State. Some flows east to sustain Canadian plains, some north to the Arctic Ocean.

But the scenery along the route is more than a monotony of high places—if such is ever monotonous. In fact, the path itself goes no higher than 8,747 feet. Threading valleys where rivers thunder and boil, dawdling beside glinting lakes, transiting shaggy forests of spruce and fir, cooling its heels on glaciers, the Great Divide Trail works hard to sample the whole Rockies landscape.*

Parts of the high trail are as crowded as a

*The majestic range was described by Alan Phillips in "Canadian Rockies, Lords of a Beckoning Land," NATIONAL GEOGRAPHIC, September 1966.



Canada's Great Divide Trail

- Planned trail
- - - Proposed alternate
- · · · · Continental Divide

SCALING THE ROCKIES, the trail meanders through four national and two provincial parks, veined by hundreds of miles of additional footpaths.



- Kinney Lake*
- Snake Indian Pass*
- Robson Pass*
- Berg Lake*
- Mount Robson*

- Athabasca Pass*
- Maligne Lake*

- Mount Columbia*
- Howse Pass*
- Two Falls Chalet*
- Duchesnay Pass*
- Lake O'Hara*
- Mount Goodwin*
- Floe Lake*
- Ball Pass*
- Scarab Lake*
- Mummy Lake*
- Citadel Peak*
- Mount Assiniboine*
- Leman Lake*
- Paliser Pass*
- Mount Queen Elizabeth*

- Mount Whyte*
- Pharoah Peaks*
- Haiduk Lake*
- Egypt Lake*
- Fatigue Mountain*
- Golden Valley*
- Valley of the Rocks*
- Lake Maligne*
- Bryant Creek Warden Station*



HIGHWAY SIGN SIGNALS TRAIL CROSSING



DRAWN BY JODI S. DEARNS
 COURTESY OF LEAR R. MCCOYVILLE

watermelon stand on the third of July. Others envelop a traveler in absolute loneliness. My son, Michael, Jr., who is 19 and known as Mick, and I saw not another soul for five days as we slogged through snow and rain in the northern reaches of Jasper National Park.

Yet we had, part of the way, a companion. We learned about him afterward from two hikers who had been traveling behind us.

"Did you see that grizzly tailing you?" asked Dexter Cummings. "We were following your boot prints, when all of a sudden we found his tracks right on top of yours."

"He must have been a monster," said Paul Devereaux. "Those tracks were this long!" He held his hands nearly a foot apart.

Dexter estimated that the bear had followed us about five miles. It left the path not far from where we stopped for the night.

Was it merely curious about two intruders? Probably it was just using our trail—or, properly, we were using its trail. Still, the thought of this beastly shadow was chilling.

Son Shows Flair as Camp Cook

Most travelers of the Great Divide Trail probably will use it as I did, for a week here or a weekend there, taking feeder trails and fire roads to the main stem.⁴ Photographer Lowell Georgia went with me much of the way and brought along a relay of his children—14-year-old Steve for two weeks, then Steve's sister Terry, 15. Mick went with me every step, sidewinding up ridges with an ease I envied and proving himself a resourceful cook—as witness the raisins he cast into our macaroni one night, transforming a so-so meal into a lively wilderness pilaf.

Time is a precious commodity in country that counts only eight weeks or so of good hiking weather. And so, early in August, Lowell, Steve, Mick, and I boarded a helicopter, bound for the remote southern terminus of the trail—6,836-foot Palliser Pass in Banff National Park. In obedience to park rules, we landed outside the boundary.

After the chopper left, we just stood awhile, awed by the jagged limestone of Mount Queen Elizabeth, soaring beside us. Ragged slabs of snow clung to the crevices, like bad patchwork by a do-it-yourself plasterer. Silt

⁴Official maps of the trail have not been published. Maps of the four national parks, showing most of the existing trails, are available from the offices of Banff National Park, Banff, Alberta, or Jasper National Park, Jasper, Alberta, for 50 cents each in Canadian currency (about 55 cents U.S.).

produced by weathering of the rock turned streams the color of thin milk. Warm weather had come tardily; the grass was splotted with golden avalanche lilies, among the first flowers of spring.

Mosquitoes soon found us. "I think we must be the first humans they've seen this summer," Steve moaned. He smashed three on his arm with a single slap.

My favorite memory of Steve is from the next morning. Shivering as I emerged from the tent at 6:30, I beheld him in the gray light, attaching a fly to his fishing line. He crunched across the frosted grass toward the gentle Spray River, a man with a mission—and soon returned with a small trout.

It was the first of a dozen cutthroats we caught that day, a lazy, get-acquainted-with-the-wilderness day. We soaked up sun, watched a mule deer as it watched us, and dined regally: trout for lunch, trout for dinner, trout for breakfast the next day.

The Spray swelled into an icy torrent, thigh deep and 20 yards wide where we forded it as we journeyed north. My too-new boots raised blisters on my too-tender feet—grumbling companions that I'd have to endure all the way to Mount Robson.

No roads reach Banff's western neighbor, Mount Assiniboine Provincial Park. Does that mean solitude? Not, we discovered, on the first weekend in August, an unofficial three-day civic holiday. White-maned Mount Assiniboine, gazing at its own reflection in the green glass of Lake Magog, had attracted 200 backpackers and horsemen.

Bather Braves the Morning Chill

We made camp on a hillock above the lake. Ice rimmed the water in our canteens the next dawn as we built a breakfast fire.

Lowell shivered as he pointed toward Magog. "I wasn't cold until I saw that," he said. At water's edge a camper was vigorously splashing, stripped to the skin.

Despite its holiday popularity, Assiniboine remains a primitive park. Warden Ken Jones scowled as he told me a road to its boundary was proposed a few years ago. "If it were built, I'd never use it," he said. "I wouldn't insult the country by riding on it."

Weathered face and legs like knotted rawhide testify to Ken's 40 years in the Assiniboine country, as warden, guide, climber, and skier. We sat in front of his one-room cabin—his home from June to October—as he



talked about his preference for the primitive.

"People say, 'Why do you want to be so far from town? There's no life out here.' No life? Why, there's life all around! You just can't get to the bottom of nature."

The elk are Ken's special friends. "They know me. Sometimes when I'm alone and see some cows in the grass, I talk to 'em. I ask 'em what they're up to and whether they're enjoying life." He smiled, the faint smile of a man almost—but not quite—making fun of himself. "They don't answer. At least, not so I can tell what they're saying."

Ken's reputation as a walker is legendary. "I wouldn't want to try to keep up with him on a slow horse," said Eugene Seely, an outfitter who had escorted 18 riders to Assiniboine that weekend. "He'll do five miles an hour downhill, easy."

"I only go that fast when I'm mad," Ken said modestly. Truth to tell, he makes four miles an hour on level ground. Most backpackers do well to average three. One night he walked 60 miles nonstop to summon a doctor for a hunter with appendicitis—and after an hour's rest mounted a horse to guide the physician to the patient.

Hiking Know-how Eases Strain

Ken strolled with us to the park boundary, considerately setting an easy pace as he talked about the techniques of walking. Here, distilled, is advice from a veteran:

Don't kill yourself at the start; begin slow, then speed up. Plan to get over the tough climbs before the day grows hot. To increase speed, maintain your pace but lengthen your stride. Breathe in and out every four steps on level ground, every two steps going uphill. Soak your feet in cold salty water before a hike to toughen the skin.

Following his guidelines, we found the hiking easier. Sometimes the way was grassy and level; sometimes we scrambled over avalanche rubble; sometimes we got lost.

Being lost can have its rewards. Mick taught me that after we took the wrong turn at a trail junction between Howse Pass and the highway in Banff Park. The trail soon petered out. We tried to bushwhack out of the dead end, fighting for balance in snarls

of fallen timber. As the sun grew hotter, I lost my cool as well as the way.

I was spouting oaths and putting my boots on after wading a creek when Mick suggested, "We might as well have some fun out of this." He motioned toward a pool where a huge trout was visible beneath a log. He jointed up our rod and went to work. Neither salmon eggs nor artificial flies drew a nibble. Then Mick trapped a horsefly and cast it almost on top of the fish's snout. The explosion that followed nearly dried up the pool.

I would have been screaming with joy. Mick, endowed with the calm confidence of the inexperienced, said only, "I've got him."

And he did, of course. His prize was a



Beagle with a broken toe, injured during a romp in the brush, snoozes in a backpack as his master pauses at Leman Lake to cast for cutthroat trout. En route to Mount Assiniboine Provincial Park, a hiker (above) buckles on a formidable pack after a stop for water at Bryant Creek Warden Station.



Quagmire drowns the trail in the wake of packhorses carrying people and provisions to a lodge on Berg Lake. A backpacker negotiates the muddy morass, the result of horses' hooves and hikers' boots slashing the turf. Concerned officials plan to build up such sections or reroute the trail around them to protect the fragile environment. Moss campion (below) and other alpine flowers resist wind, cold, and snow, but their small size and the thin soil make them easy prey to a hiker's heel.



25-inch Dolly Varden, which, for want of better insulation against the day's heat, we wrapped in my long johns after cooling them in the creek. Without complaint, Mick backpacked this sodden package the 15 miles or so to our car—once we regained our way. In the town of Jasper the fish fed six men.

Howse Pass. Other memories of our trip to that mountain-hemmed slab of earth keep flooding back: two black bears ambling near us; a bull moose foraging in a pond, its rack festooned with aquatic plants; and the company of David Thompson, Canada's great explorer and map maker.

Explorer Unlocked the Northwest

I could only imagine his presence, for it was 166 years ago that Thompson traveled our way. A Welshman apprenticed to the Hudson's Bay Company at 14, he died in poverty and obscurity. Yet some geographers now rank him as the equal on land of Capt. James Cook upon the sea. In his busy life, Thompson explored more than a million square miles of western North America.

In 1807, seeking a route across the Rockies to the Pacific, he canoed up the Howse River. From the river his party went on horseback up a northbound creek to Howse Pass. Beyond, Thompson beheld a trickle of water running south: the origin of the Blaeberry River, a tributary of the famed Columbia.

He stood beside that mighty river of the West five days later, but failed to recognize it as a vital link in the route to the ocean.

In 1810 he tried again, driving dog teams in the dead of winter over Athabasca Pass in what is now Jasper Park. This time he not only opened a trail that thousands of trappers and traders would use, but also mapped the Columbia from source to sea—1,232 miles.

At the end of our first day on Thompson's Howse River route, Mick and I camped on a sponge cake of silt at the river's edge, the only level ground. Across the valley a glacier poured itself into a cataract. Conifers hugged the narrow walls beneath spires of gray rock—canine teeth snatching at the first star of evening. The summits burned gold, then merged into one dark shape, faintly etched by the northern lights. The river wove silver braids between bars of gravel, humming a timeless lullaby. We slept well.

Next day we walked to Howse Pass the way Thompson went, along Conway Creek. On the south side of the pass we found a faint

depression holding a finger of crystal, intercepted a cupful of Pacific-bound water, and drank a toast to Thompson.

The decision to establish the Great Divide Trail recognized a shifting visitor pattern in Canada's mountain parks. For many years gorgeous scenes advertising the Canadian Pacific Railway attracted mature, usually well-to-do vacationists. They scaled peaks with imported Swiss guides and traveled trails on horseback, led by dude outfitters who tented and fed them and saddled their mounts.

While mountain climbing has become more popular than ever, fewer horse parties venture out. The challenge of exploring peaks and valleys on foot and the joy of solitary wandering have lured throngs of young people to the parks, many of them from the United States. They shoulder their own gear and guide themselves. The Great Divide Trail fulfills their quest for footloose wilderness pleasure. It is possible that someday the trail will be extended 200 miles southward to join the proposed Continental Divide Trail in the United States, creating a 3,700-mile pathway to New Mexico.

Should Hikers Lead a Sheltered Life?

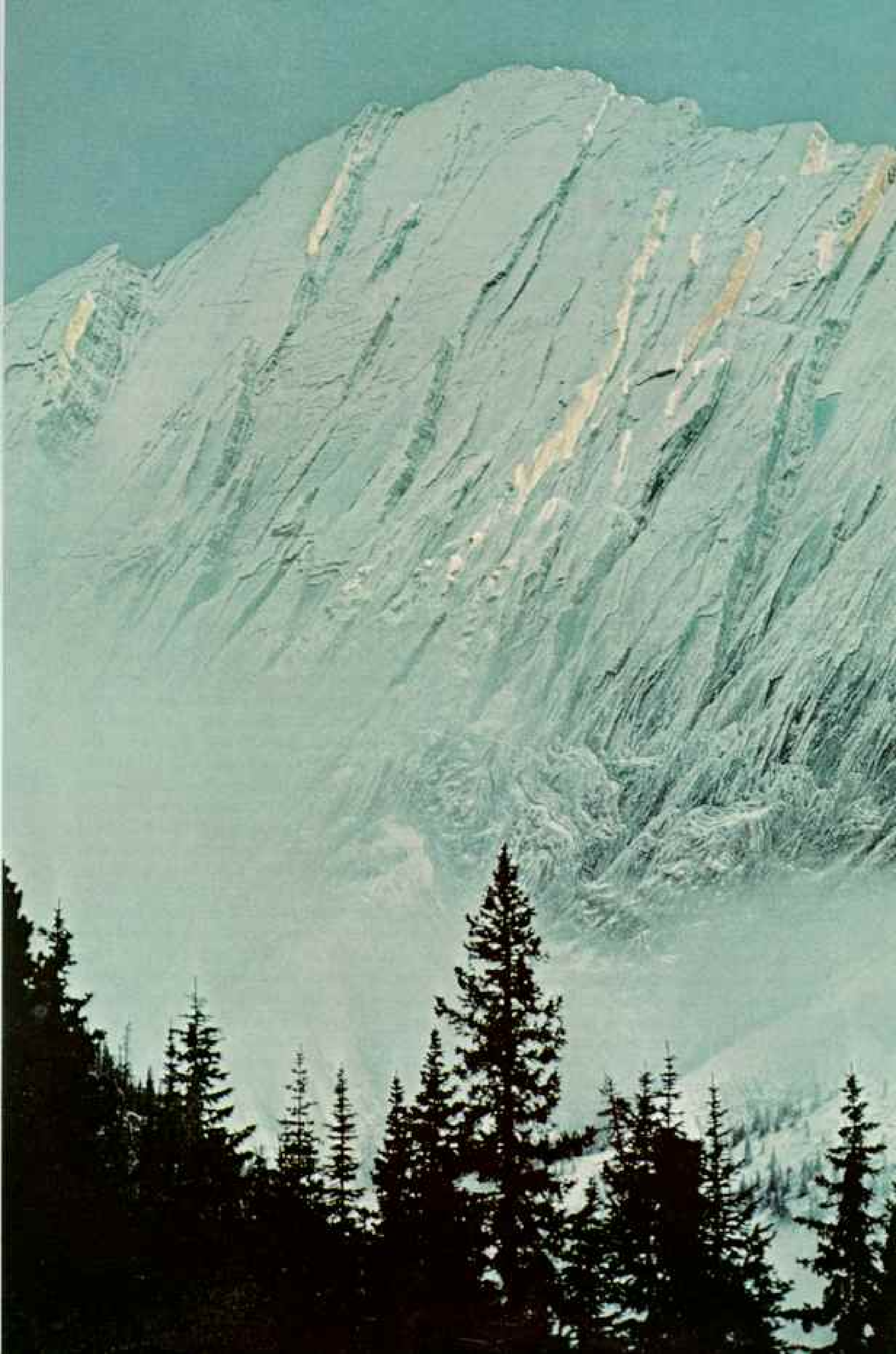
The officials are still undecided about building a chain of shelters for hikers. One theory is that shelters would concentrate camping in a few areas, thus protecting the rest of the landscape. But at two test shelters, park wardens are having problems with litter, vandalism, and visitors who use the cabins not as way-stops but as destinations for extended vacations. Some wardens feel that buildings also intrude on a hiker's wilderness experience.

An intrusion? Not so, according to the visitors' log at a shelter near Egypt Lake, west of the town of Banff. A Rhode Islander had exulted: "Great to be close to God and the original plan. . . Will be back."

Another hiker, refreshingly honest, wrote: "This is beautiful country and I really do intend to return. But right now I want a cheeseburger (forgive me)."

Toward evening the grassy flat around the cabin bloomed gaudily with tents: green ones, orange, yellow, and blue ones. At dark we sat beside our dying fire, watching other fires die across the meadow. Under the mantle of night Egypt Lake, one of the Great Divide Trail's busiest campsites, offered its own time of solitude and contentment.

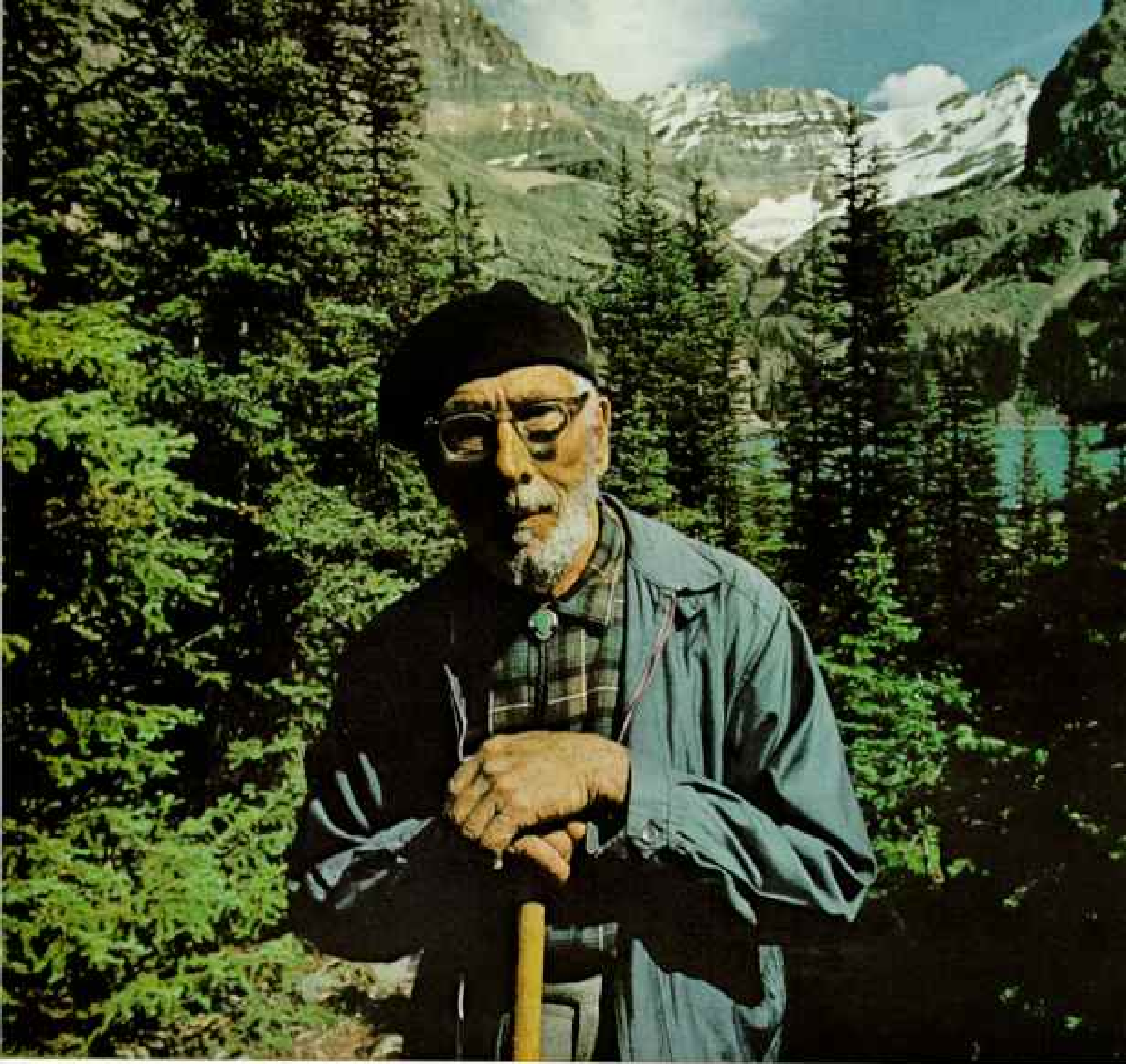
Almost 9,000 feet high, the twin Pharaoh





In silvered majesty, a nameless peak in the Queen Elizabeth Range offers its weathered face to the kiss of morning. Like the rest of the Rockies, the mountain once was part of a shallow seabed that extended from the Arctic Ocean to the Gulf of Mexico. With infinite slowness, inexorable forces tilted the many-layered sea floor almost vertical. Rain and ice eroded the ridge, and great slabs cracked and split away. Avalanches and erosion sent rocks plummeting to the valley floor to join material deposited there by glaciers. Over thousands of years the rubble broke down into soil, where white spruce trees now spire and alpine bearberries (below) don their fall scarlet.





Peaks stand watch over Egypt; not far away Mummy Lake and Scarab Lake gleam amid wispy larches. A. O. Wheeler, a surveyor who passed through in 1913, recorded that the summits already were called the Pharaohs; apparently their pyramid shapes had inspired an earlier traveler. Wheeler gave kindred names to the nearby waters.

The Kicking Horse River in Yoho Park got its name the day Dr. James Hector, who penetrated the wilderness in the 1850's, was walloped by his mount. Coal beds that sometimes smoldered gave an Arctic-bound river rising in Jasper the name Smoky.

Many of the explorers who bestowed such names knew desperate hardship. Mastering Athabasca Pass, David Thompson endured

temperatures of -32° F. Hector and his companions lived for days on a little dried meat and blueberries. When they finally shot a grouse, they cooked a meager stew fortified with tallow candle stubs.

As we pitched our tent beside Haiduk Lake in Banff Park (pages 796-7), I reflected on the struggles of my predecessors—and grew ashamed of complaining about my blisters. Infinitely better victualed and equipped, Mick and I could tote, in packs weighing less than 45 pounds each, all our modern gadgetry: gasoline stove, insect repellent, plastic rain fly, safety pins, and about 100 other kinds of items. We dined on featherlight freeze-dried hamburgers; they needed only boiling water to spring back to instant goodness.



Discussing their waning business as outfitters who bring visitors to Mount Assiniboine Park on horseback, Merle Seely, right, and Ray McBride consume cookies and coffee in their tent along the trail. "Fifteen years ago hardly anybody walked these trails," says McBride. Now backpackers, who bring in their own supplies, outnumber mounted travelers.

Pathfinder in his younger years, Dr. George K. K. Link, 85, blazed 32 trails "through the forest and among rocks" near Lake O'Hara. The former University of Chicago botanist still walks the footpaths he carved, now also trod by hundreds of other vacationists.

Topping the Continental Divide at Ball Pass, we left Banff and descended into lesser-known Kootenay National Park, a 543-square-mile preserve strung with long ridges and hanging valleys. We followed a creek hurrying to get to the Pacific, crossed a wide, treeless, boot-burning fan of tumbled rock, and eased through a forest of lodgepole pine, cool and eerily dark, to the highway where we had parked our car.

We rested a couple of days and then drove north to Yoho National Park to sample and savor. Near two-spired Mount Goodsir, a bubbling creek gave us a meal of trout. We struggled up a steep rock wall to the 8,747-foot crest of Duchesnay Pass, the Great Divide's highest point. No man-made path exists there

yet, so we followed faint goat trails and the sure lead of Park Warden Gordon Rutherford.

Square jawed, well muscled, an expert climber, he seemed as much a part of the landscape as the rock itself. When Terry Georgia lost her footing and almost went sliding down the long steep slope, Gordon warned us, "Don't lean in toward the mountain. The only way to keep your feet under you is to stand straight."

We were bone weary as we surmounted the shale of the summit, loose layers of old ocean sediment, stacked like oversize pancakes. Handfuls of snow cooled our parched mouths.

At log-walled Twin Falls Chalet in the Yoho Valley, we met Kirsty Leighton. A fetching blonde, she qualified for her summer job

because she has a strong back and can cook on a wood stove. The lodge is six miles from the nearest road and lacks electricity.

The Canadian Pacific Railway built the two-story lodge in the early 1900's. Owner Fran Drummond of Calgary, Alberta, arrives on weekends to help care for the guests—as many as ten—and scores of hikers who stop for tea or lunch.

Every bite of food comes in on someone's back. Kirsty and Joey Neidermayer, the entire weekday staff of the lodge when I visited, walked to the roadhead with packs, she returning laden with 50 pounds, he with 40.

"I've logged 200 miles hauling groceries this summer," 15-year-old Joey said. "Sometimes we make two round trips in a weekend."

Kirsty had baked six pies the day we arrived—apple, cherry, blueberry. "My family lived in a rural part of British Columbia for several years," she told me. "That's where I learned to handle a wood stove."

That night she served roast beef, creamed onions, potatoes, salad, tea, pie, and gelatin chilled to perfection in a creek. I've never eaten a better meal on any trail.

Artist Bedeviled by Nature's Tricks

Lake O'Hara, southeast of Duchesnay Pass, attracted John Singer Sargent in 1916. The artist wrote a friend that he endured rain and snow, "my tent flooded, mushrooms sprouting in my boots, porcupines taking shelter in my clothes, canned food always fried in a black frying pan getting on my nerves, and a fine waterfall . . . pounding and thundering all night." He came away, he added, with a "repulsive picture," presumably a reference to his painting of the lake, now hanging in Harvard's Fogg Art Museum.

But Sargent harbored no bad memories of O'Hara's emerald surface, its seven-branched falls, or the peaks dripping snow beyond; in fact, he called the lake the most beautiful he had ever seen.

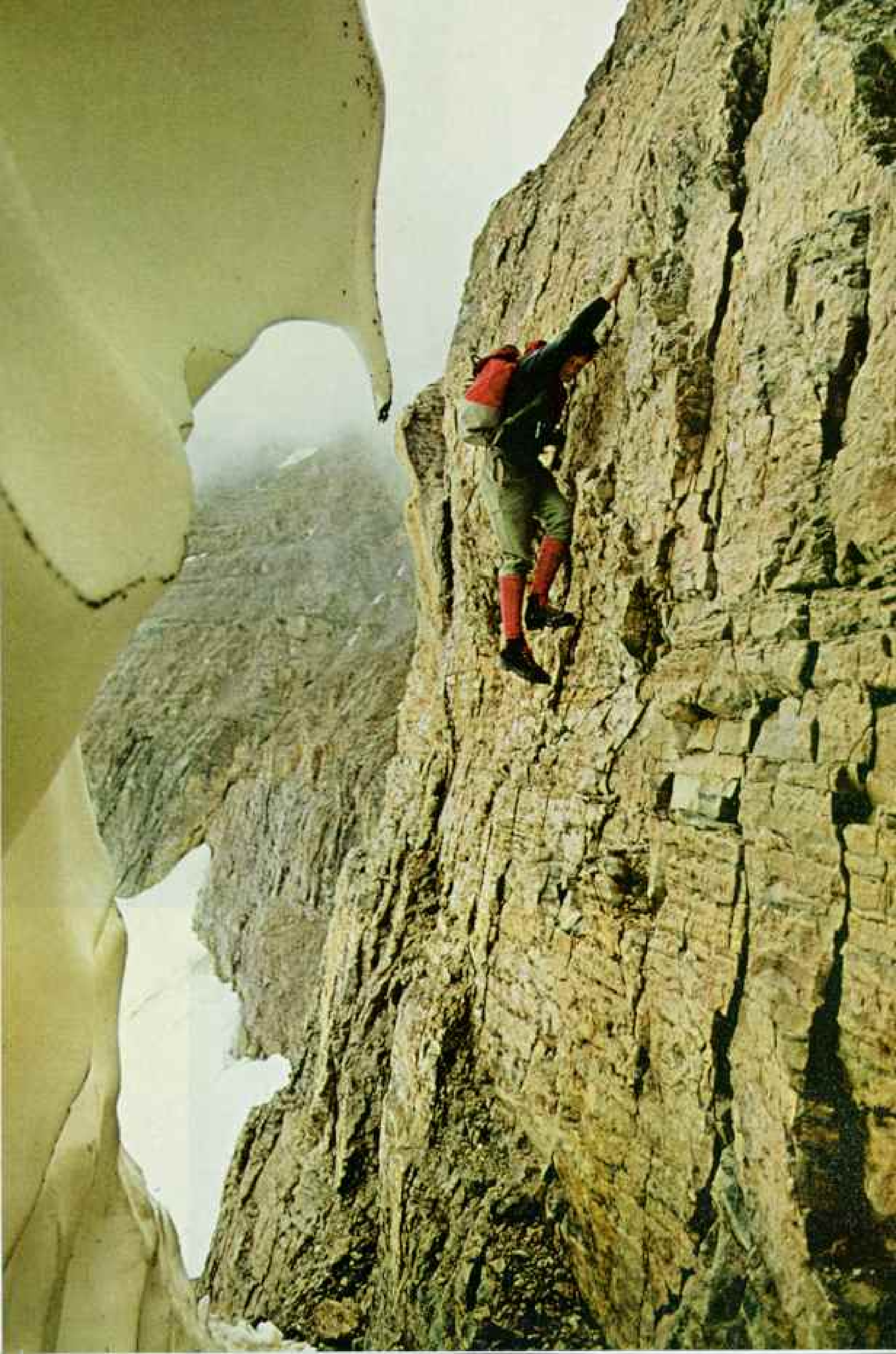
For many years visitors were so rare that they could do much as they pleased—even, like Dr. George K. K. Link (page 806), build their own trails. Now retired from a professorship at the University of Chicago, Dr. Link was on his 44th visit to the Lake O'Hara Lodge when I met him. He told me he began to build trails in the 1940's. "My wife and I wanted to get away to places, and that notion grew into making ways for others to get around. Finally it became a compulsion."



Like pillars of a ruined temple, ravaged cedars near Kinney Lake attest the awesome power of a partly airborne snow avalanche. Racing down mountainsides at speeds approaching 100 miles an hour, such frigid juggernauts generate wind blasts of devastating force. Saws sectioned the fallen trees to clear the trail.

"There'd be pop bottles everywhere if they put roads through this country," says Ken Jones, park warden at Assiniboine. A prodigious walker, he carries his trademark, an ax. "I use it to chop the stingers off mosquitoes," he jokes.





With ax, bar, and grub hoe, he cleared 27 miles of pathways linking the lodge with beauty spots. Mrs. Link helped on some. After her death, he deposited her ashes on a plateau where they had shared many good times.

It may be that, in 1973, the O'Hara area is too beautiful for its own good. While the lodge accommodates only 50 guests, the campground half a mile away has held 200 tent dwellers on a weekend. Wardens closed the camping area last fall to allow the badly scarred meadow to recover.

The Great Divide Trail will bring more campers—and more such problems. With this in mind, park officials, assisted by environmental specialists from the Canadian Wildlife Service, set out to pinpoint fragile areas along the trail corridor.

Experts Probe the Tender Trail

Late in August Mick and I joined two of the investigators, Archie Landals and Leonard Knapik, who had already spent six weeks on the 180-mile-long stretch of trail in Jasper Park. We went with them on the most heavily traveled leg, the 28-mile Skyline Trail, which chases 8,000-foot ridgetops north from Maligne Lake.

The end of summer suddenly seemed at hand. Wet flakes of an overnight snow were piled around lavender fleabanes and yellow arnicas. Cold winds whipped us when we stopped for lunch.

"This'll help," Archie said. He rose from his sputtering stove to hand me a cup of liquid fire—coffee laced with rum and sugar.

Scudding clouds sent down new snow, obscuring our view of the peaks hung on every compass point. But the weather was just teasing; by late afternoon the skies had cleared, and we snoozed on warm rocks.

Archie and Len were especially concerned about damage to three bowls of grassland, typical alpine meadows—rill-veined communities of grasses, sedges, heather, moss, and herbs. Daisies and Indian paintbrush brightened the swales.

"This topsoil is only an inch or two deep," Len told me. "It's easy to churn up. Then it washes away. If this meadow is heavily trampled, it could take a thousand years to return to its present state."

Decades of use by horses had carved segments of the trail into ruts, many deep enough to conceal my boot tops.

Archie scanned a ridge several hundred



By fingernail and boot tips, Don Vockeroth tests his skill on a short but nearly vertical rock face at Mount Whyte. The author and his son (above, center) pause at the summit with Vockeroth and Rudi Gertsch. Each summer some 5,000 climbers challenge the Canadian Rockies' peaks. Weathered layers of tough siltstone and softer limestone created the curious shapes (below) found at Duchesnay Pass in Yoho National Park.



feet above. "That's where the trail belongs," he said. "Up there on the rock, where there's no vegetation to worry about."

Several legs of the trail will be rerouted to protect vegetation; horses have been banned in fragile areas. Some segments will be relocated to avoid disturbing game habitat.

Caribou and wolves—extremely man shy—are particularly vulnerable, but wildlife specialists think the animal most threatened in the Canadian parks is that premier wilderness denizen, the grizzly bear.

Laszlo Retfalvi, a wildlife biologist who coordinated the trail study and is enumerating grizzlies in the national parks, told me he believes that fewer than a hundred grizzlies remain in Jasper's 4,200 square miles. Their numbers have been reduced in part by human activity: bears killed by poachers or hunted legally outside the boundaries; bears struck by cars and trains; bears killed in the name of safety.

Occasionally grizzlies, and more frequently

smaller black bears, roam near drive-in campgrounds and towns, lured by garbage, picnic lunches, and tourists who try to feed them—a risky business and a violation of park rules. A few days before our visit to Lake O'Hara, a huge grizzly was seen ripping apart the steel plates of a garbage bin.

Some of these bears become troublesome to people—though it should be noted that most of the 15 or so injury-causing grizzly attacks in the parks since 1960 occurred in the wilds. Wardens usually get rid of a campground habitué by shooting it with a drugged dart and hauling it by truck or helicopter to the back country. Occasionally a bear, overdosed, never awakens. Some return repeatedly to campgrounds, unable to break old habits, and are then killed.

"Bears are unwittingly baited with garbage," Laszlo said. "When they take the bait they have to be moved or shot. It's a serious, sad corollary to recreation in the parks."

Wardens advise hikers that encounters



Anyone have coffee for a cup? Reluctant to face the morning chill, a snug hiker at Howse Pass tries to lure someone with a steaming pot.

Would-be benefactress isn't. A motorist on the Icefield Parkway feeds bread to bighorn sheep. Park visitors may legally give food to any creatures except bears, but wardens discourage the practice; they say it makes the animals reluctant to forage for food. Officials last year prosecuted 44 people for feeding bears in Canada's national parks.



with bears can be avoided by hanging food in a tree at night, not leaving garbage around, and not cooking in tents. But what if you suddenly meet a grizzly on the trail—perhaps the most dangerous, a sow with cubs?

How to Confront a Bear

Wilderness veterans offer numerous suggestions, some conflicting. The ones I heard went like this: Freeze. Make noise. Walk well off the path to pass. Climb a tree. (But remember that black bears, unlike grizzlies, can climb too.) If charged, fall to the ground in a posture of harmlessness, like a puppy before a large dog. Curl into a ball, with arms protecting the neck. Stand your ground and bluff the critter down.

Some hikers tie small bells on their packs so grizzlies will hear them coming.

"Most bears will avoid you," Laszlo said. "But as to what to do if you meet one, I wouldn't want to give advice." I asked Laszlo what he did. "I got scared," he answered.

"I've been close to grizzlies twice on trails. I froze, then backed off, and hoped they would go away. They did."

As September arrived, Mick and I were anxious to finish. We pored over maps of the last and longest stretch of trail we would travel—101 miles.

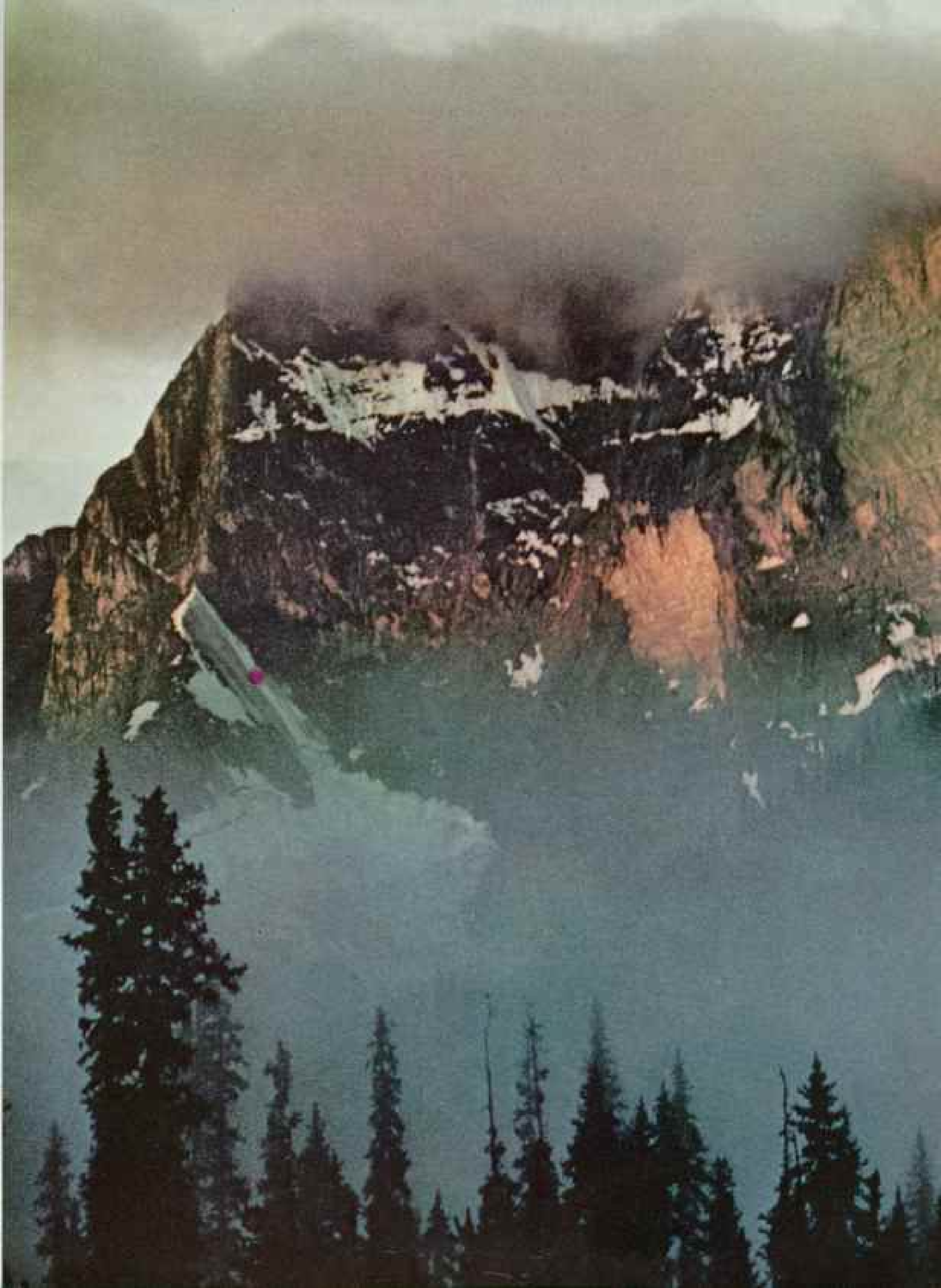
It looked easy: A walk mainly along the Snake Indian and Smoky Rivers, draining the northern parts of Jasper, with only two modest climbs; then across Mount Robson Provincial Park and down to trail's end at the Yellowhead Highway.

This promised to be as pure a wilderness as we would see; its middle reaches, far from roads and feeder trails, are known to only a comparative handful of hikers.

Under a clear sky we started off on this last leg of our long trek. Wolves had walked this path a day or so before; their tracks showed in the mud around stream beds. We wound across fields of low yellowing willows and through clumps of gleaming aspens.



JAGGED TOWERS of Mount Goodsir pierce a cap of clouds. Glaciers still carve the flanks of the 11,686-foot mountain, highest in Yoho National Park.





"I can't get enough of these mountains," said Dexter Cummings as we shared a campfire on our second night. He and Paul Devereaux were planning to roam and fish for a couple of weeks. A footloose, bristly-bearded youth from Massachusetts, Dexter had supported himself for two years with odd jobs in Jasper town. "I thought about going to New Zealand," he told me, "but I can't leave—there are so many trails here that I haven't walked."

About 2 a.m. the patter of rain awakened us. Gray clouds drifted low after daybreak, bringing more showers. We debated whether to travel on or wait for sunshine. Paul and Dexter decided to wait, curling up with books in their tent. "Let's go on and see what happens," Mick said. We put on ponchos and set out. Cold drizzle followed us.

Next morning, more rain; in the afternoon, snow. Our boots and pants legs were soaked. Mick developed a nasty cough. We found a dry spot beneath two big spruce trees, built a fire of dead limbs, and dried our sodden garments.

Overnight the snow buried willows and grass. I was coaxing warmth from a few twigs at dawn as two bucks strode by. They stopped, staring disdainfully. *You don't belong here*, they seemed to be saying. All day the temperature hovered near freezing. Now and then the gloomy clouds parted, tantalizing us with a view of long snow-clad ridges. Then the clouds closed over. *You've seen enough*.

Rain Hides the Smoky's Beauty

Halfway through this journey, Mick said glumly: "This isn't a hike anymore; it's an endurance contest." How true.

We couldn't short-cut misery, we were locked into a routine: Arise, build a fire, eat, slosh on until noon, warm up with tea, slosh on more, build a fire, dry our wet clothes, eat, sleep. Just the thought of a fire at the next campsite made us hurry.

As we parched socks and boots beside the rushing Smoky, Mick gazed up and exclaimed, "Look! Stars!" In a fragment of cloudless sky Cassiopeia shone reassuringly. We got our best sleep of the trip that night—but awoke the next morning to our seventh day of rain.

Dripping willows whipped us as we trailed the Smoky. The river shrank to a trickle in Robson Pass. Beyond, glacier-fed Berg Lake was the color of pea soup beneath cloud-draped Mount Robson. We never saw the summit.

It was downhill all the way then, down a valley thundering with falls, through an avalanche-battered forest, out to the highway, on to a hot shower in Jasper.

We'd seen a lot of country in six weeks, known the grandeur of mountains and valleys: the sunset view from Citadel Peak, the Howse River's shining braids, the Skyline's meadows. But the Snake Indian and Smoky watersheds remain, so far as I'm concerned, a wilderness reluctant to reveal itself—perhaps, as those bucks had seemed to say, a place where we didn't belong.

A man in Jasper asked us where we'd been. "That must have been a marvelous trip," he said when we told him. "I'd sure like to see that Snake Indian and Smoky country."

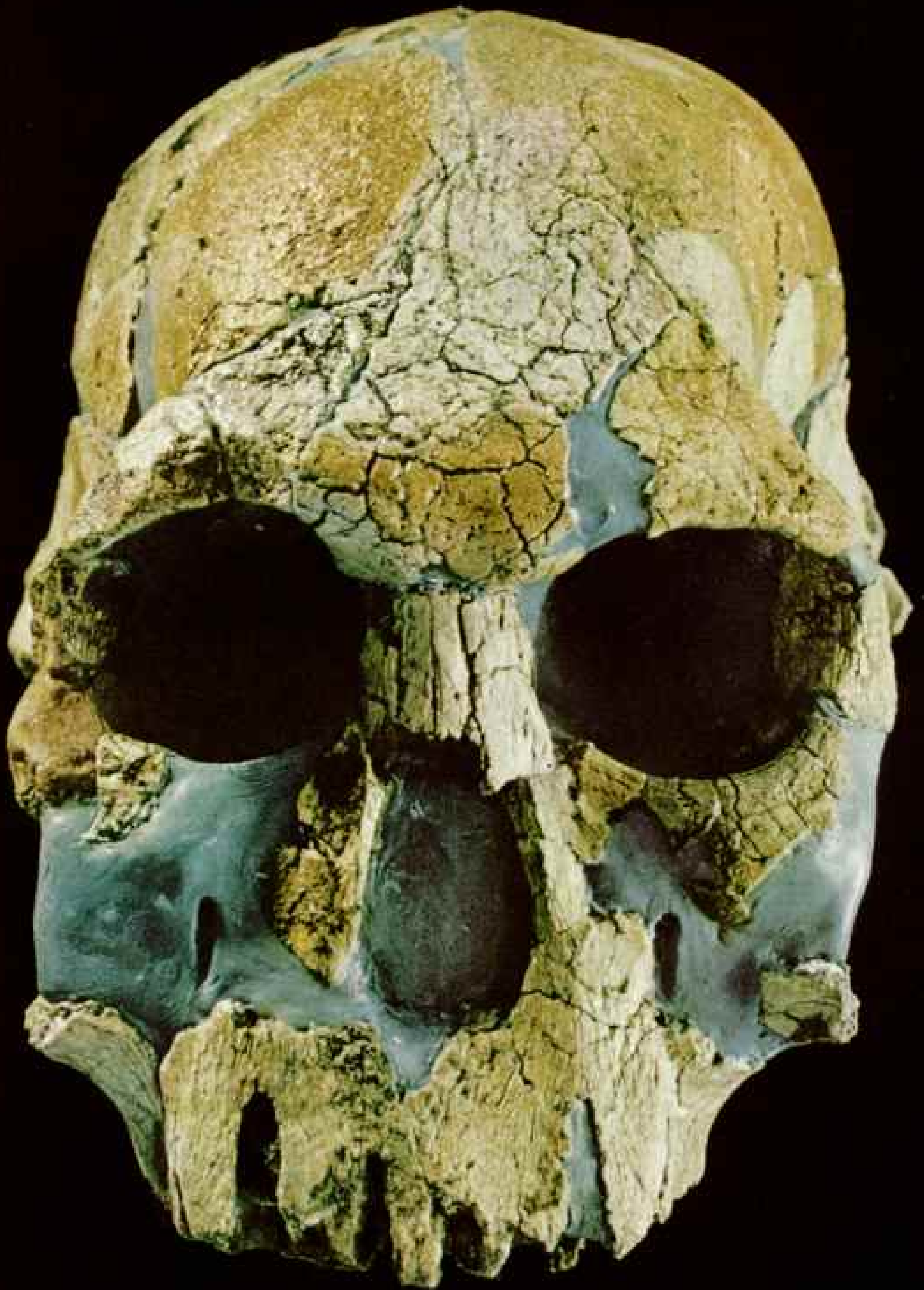
"So," I said, "would I."



Eyes front and ears rear, a



mule deer doe remains alert as she munches a sprig of fireweed.



SKULL 1470

Discovery in Kenya of the earliest suggestion of the genus *Homo*—nearly three million years old—compels a rethinking of mankind's pedigree

By RICHARD E. LEAKEY

ADMINISTRATIVE DIRECTOR, NATIONAL MUSEUM OF KENYA

Photographs by BOB CAMPBELL

EACH TIME I FLY over the parched and broken gray-brown wastelands east of Kenya's vast Lake Rudolf, the same thought constantly nags me: *Somewhere down there lies the key.*

This brief flight, on a blazing day in August 1972, was no exception. On a routine visit to an inland field camp from our lakeside headquarters at Koobi Fora, I flew low over tortured terrain, scanning the rich, awesomely old fossil beds we had been probing for the past four years. And as always I wondered when and where we might find it—the key to understanding man's beginnings.

At the makeshift landing strip my chief deputy, Kamoya Kimeu, who headed our field team of five Kenyans, approached the

six-seater Cessna with the broad smile of unconcealed excitement. A few hours later I took off again with a bagful of fossil skull fragments, already convinced that they were extraordinarily important.

Only after weeks of further digging, sifting, and painstaking reconstruction did it become clear how important. We may now stand a *million years* closer to comprehending our own dim origins, for I believe these fossil fragments represent the oldest skull of early man yet discovered.

Young Bernard Ngeno had found the shattered cranium in a steep, wild gully: a few scraps of bone weathering out of sandy sediment. We dug out more than 30 pieces that first day, most of them small, many no larger

"Either we toss out this skull or we toss out our theories of early man," asserts anthropologist Richard Leakey of this 2.8-million-year-old fossil, which he has tentatively identified as belonging to our own genus. "It simply fits no previous models of human beginnings." The author, son of famed anthropologist Louis S. B. Leakey, believes that the skull's surprisingly large braincase "leaves in ruins the notion that all early fossils can be arranged in an orderly sequence of evolutionary change. It appears that there were several different kinds of early man, some of whom developed larger brains earlier than had been supposed."

PRELIMINARY RECONSTRUCTION, IN BLUE PLASTICINE MATRIX, OF FOSSIL KNM-ER 1470, NATIONAL MUSEUM OF KENYA

than a thumbnail. Two of the larger ones, from the frontal section of the skull, told me instantly these were the remains of a hominid different from any other known form of early man.

The earliest previous suggestion of our genus had been a 1.8-million-year-old creature, called *Homo habilis* by my father, the late Dr. Louis S. B. Leakey; its various remains were found in the 1960's at Olduvai Gorge in Tanzania.* Many scientists prefer to recognize another species, *Homo erectus*, as the earliest representative of true man, dating only as far back as a million years.

These precious skull fragments found at the East Lake Rudolf site (map, page 826) were eroding from a deposit since dated in the laboratory at some 2.8 million years old. Thus our past has now been pushed back at least 10,000 centuries—and baffling new questions have arisen concerning the human pedigree.

Piecing Together a Prehistoric Jigsaw Puzzle

At our headquarters beside the green shallows of Lake Rudolf my wife, Meave, viewed the fragments with joy—and a frown.

"We have a jigsaw puzzle with no edge pieces," she said. The task of fitting the shattered skull together fell principally to her, assisted by a London anatomist, Dr. Bernard Wood, and others.

Progress was slow, and each day Bernard and Meave eagerly awaited the arrival of new fragments recovered from screening operations at the site. Sometimes days passed without the successful coupling of any two pieces. But gradually a remarkable mixture of both primitive and advanced features emerged.

After six weeks the reconstruction was complete enough to establish the enormous importance of the find, which still remained nameless. (Simply as a matter of convenience, we currently refer to it as "1470 man," after the registration number assigned to the specimen by the National Museums of Kenya.) It became apparent that the skull lacked the protruding eyebrow ridges—beetle brow—of *Homo erectus*. And the braincase, though nearly three times as old as *Homo erectus*, was nearly as large.

Using a syringe from our medical kit and some fine sand, we tentatively measured the capacity of the "1470" cranium. In the laboratory Dr. Alan Walker, an anatomist at the University of Nairobi, later confirmed our estimate of 800 cubic centimeters. By comparison, skull specimens of the much later *Homo erectus* range between only 750 and 1,100 cc. (The average modern human cranium holds about 1,400 cc.)

Yet this surprisingly advanced early man, "1470," was a contemporary of the primitive East African creature now known as *Australopithecus*. The desiccated fossil beds of East Rudolf have so far yielded more than 40 specimens of *Australopithecus*, ranging widely in age, from one million to 2.9 million years.

From several well-dated sites at Rudolf the expedition co-leader and archeologist, Dr. Glynn Isaac, has unearthed 300 simple stone cutting and chopping implements: mute evidence that something—or someone—possessed a relatively high order of intelligence and dexterity here at least 2.6 million years ago.

I doubt strongly that *Australopithecus* could, or would, have

*The author's father described his discoveries in September 1960, October 1961, and January 1963 *GEOGRAPHIC*. In February 1965, Melvin M. Payne summarized the work of the Leakeys of Africa in "Family in Search of Prehistoric Man." The author reported his own dramatic finds in the Lake Rudolf area in May 1970. A tribute to the late Louis S. B. Leakey appeared in the January 1973 issue.





Sleuthing after fossil man, the author and his Kenyan assistant Bernard Ngeneo pack fragments of a second hominid skull found at the same level as "1470 man." Keen-eyed Mr. Ngeneo, a field aide on the 1972 National Geographic-supported expedition, sighted both major finds amid the rubble of eons on Lake Rudolf's eastern shore.

The second skull—only cranial fragments and teeth remain (right)—may be that of a child of the same species, Mr. Leakey believes. Leg bones from the same stratigraphic level (left) are almost indistinguishable from those of *Homo sapiens*. They, too, may have belonged to a "1470" kind of hominid.

From such fragmentary evidence the author pieces together a "very tentative" picture of a large-brained, upright-walking, meat-eating species of our own genus that hunted along the shores of Lake Rudolf.

Still other finds strongly suggest the intriguing probability that "1470 man" coexisted in the same environment with another hominid, or manlike creature—the beetle-browed, smaller-brained *Australopithecus* of East Africa.



Fleshing out a face from the past

COMBINING known anatomical facts with well-informed speculation, artist Jay H. Matternes here reconstructs a likeness of "1470 man." He begins with the reconstructed skull (far left), whose cranial capacity measured some 800 cubic

centimeters. This is little more than half modern man's, but significantly larger than that of *Australopithecus*—that apelike hominid which roamed East Africa at the same time as "1470 man."

To the bare bone, artist Matternes adds teeth, lower jaw, and other missing skeletal fragments—shaded dark brown (left center). Teeth found with fragments of the second skull (page 821) provided a basis for the lower jaw's reconstruction. Jaw and molars of *Australopithecus* were more massive,



made these tools. Although this near-man could have walked more or less erect, he had a cranial capacity averaging only 500 cc. His massive molars suggest that he was a vegetarian, with little need for tool-making skill.

It would be tempting, but I fear premature, to attribute these tools to the hands of a "1470" hominid. We must consider other possibilities as well.

There is *Homo erectus*, for example. As the familiar Peking man and Java man, originally dated at perhaps 500,000 years ago, he was long thought to have been our oldest ancestor. His age was pushed back to a million years by recent dating of discoveries made at Olduvai in 1960, and quite possibly even older prototypes will be found.

And there is *Homo habilis*. Some scientists prefer to place him in the *Australopithecus* group, arguing that his relatively small—

650 cc—braincase disqualifies him from the genus *Homo*. Unfortunately, we cannot be sure of his body size: A 650 cc brain might actually be large for an individual of extremely short, light stature.

Among remains of some 90 hominids we have unearthed in the past five years, fragmentary evidence—scattered jaws and teeth found in two-million-year-old strata—suggest to me that a *habilis*-type man once lived at East Rudolf, but I cannot be certain.

Several million years ago, when *Australopithecus* and the "1470 man" coexisted, Rudolf was probably a much larger freshwater lake fed by tropical streams. The wealth of fossils we have found evokes a picture of a vast green expanse teeming with game.

In the region's multilayered geological record we can read periods of frequent flooding and widespread volcanic activity. The

suggesting a diet of coarse vegetation. Those of the second specimen—still somewhat larger than ours—imply a mixed diet of raw foods, including meat.

The artist adds eyes, fatty tissue, cartilage, and underlying musculature (right center). Note the absence of the apelike “beetle brow” of *Australopithecus* and such later creatures as *Homo erectus*. For a comparison of skull shapes, see drawings on page 829.

Adding ears, more cartilage, eyebrows, and lips,

plus salivary glands, superficial muscles, and fatty tissue, the artist approaches the finished portrait (far right). Narrow nasal aperture of the original skull and a lack of bony support beneath the nostrils might indicate a rather gorillalike nose. This characteristic is perhaps the most strikingly un-human feature in a physiognomy that displays an intriguing mix of the primitive and the advanced.

For a glimpse of the fully fleshed form, go forward one page and back nearly three million years.



PAINTING BY JOE W. BATTERED

sediments left by the rise and fall of the ancient lake, and blankets of volcanic ash, have left us a unique stratified fossil record.

The scientific treasure spreads over an area of some 900 square miles. A find in any one section is usually followed by others. For example, several weeks after the discovery of the “1470” skull in a 12-square-mile sector we call Area 131, Meave picked up a tooth and several bits of the skull of a cercopithecoid monkey—often a clue, we have found, to the presence of early man.

Leg Bones of the Same Creature?

Across a valley we sighted Dr. John Harris, a paleontologist attached to the National Museums and a longtime colleague at Rudolf. He signaled, and we approached.

“What is it, John?” I called.

“I can’t believe it,” he replied. “Look!”

I examined his find, and my pulse quickened. Amid a mass of shattered fossil elephant bone lay both ends of the femur of a remarkably advanced hominid. Further search turned up the missing pieces, parts of the tibia, and a fragment of the fibula.

Complete leg bones are extremely rare in hominid fossil collections. Presumably scavengers made short work of the limbs of most fallen creatures in the dim eon before burial became a human custom. But if ever there is a chance to find a skeleton of early man, it is here. We plan to dig further this year.

John also discovered another femur in Area 131. All these leg bones lay in deposits older than 2.6 million years. Do they belong to our new-found “1470 man”? Frustratingly, we cannot be sure.

It is quite clear, however, that these femurs
(Continued on page 828)

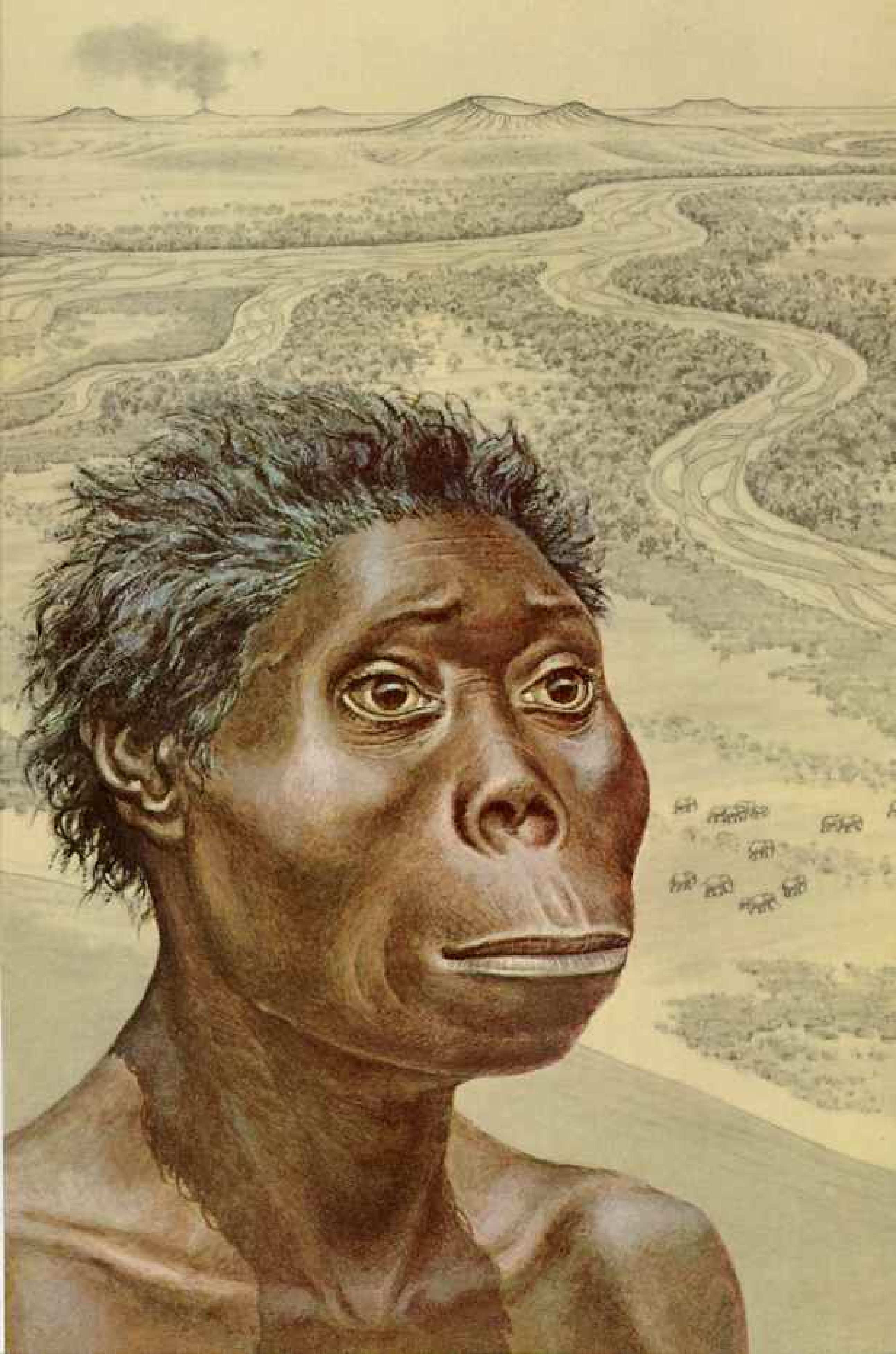


WAS "1470 MAN" A WOMAN? The completed visage by artist Matternes reflects anthropologist Leakey's suggestion that the seemingly frail prototypal skull may have belonged to a female of the species. Nose, ears, skin color, and details of hair are purely conjectural.

In the backdrop scene, a broad sun-drenched landscape of grasslands, swampy delta, and

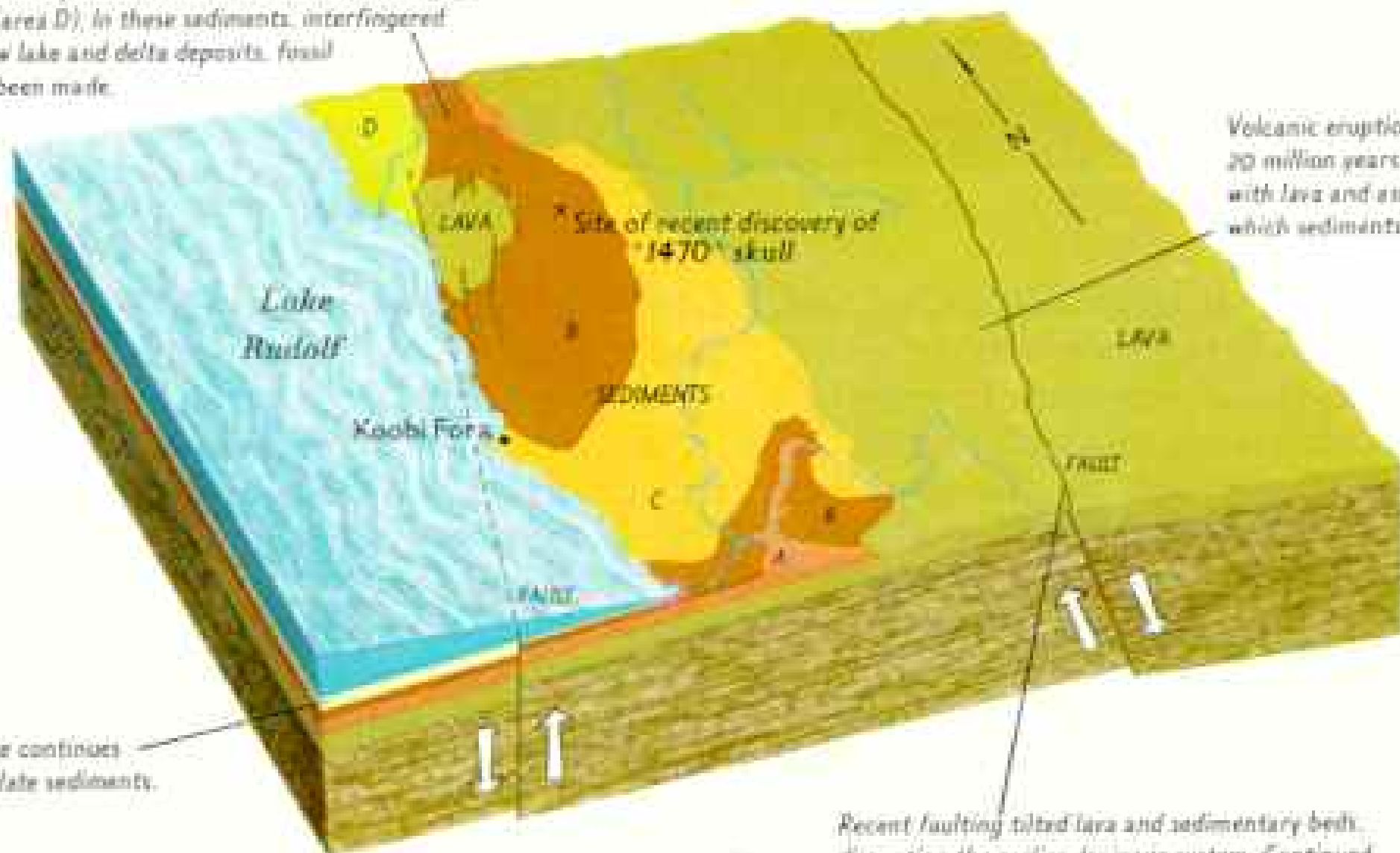
river-fringing forests—all teeming with wildlife—unrolls from the shore of ancient Lake Rudolf.

Ash from volcanic vents fuming on the horizon settled in layers between the lake sediments. These layers of volcanic tuff, datable by the potassium-argon method, have led scientists to fix the age of the level that yielded the "1470" skull at 2.8 million years.





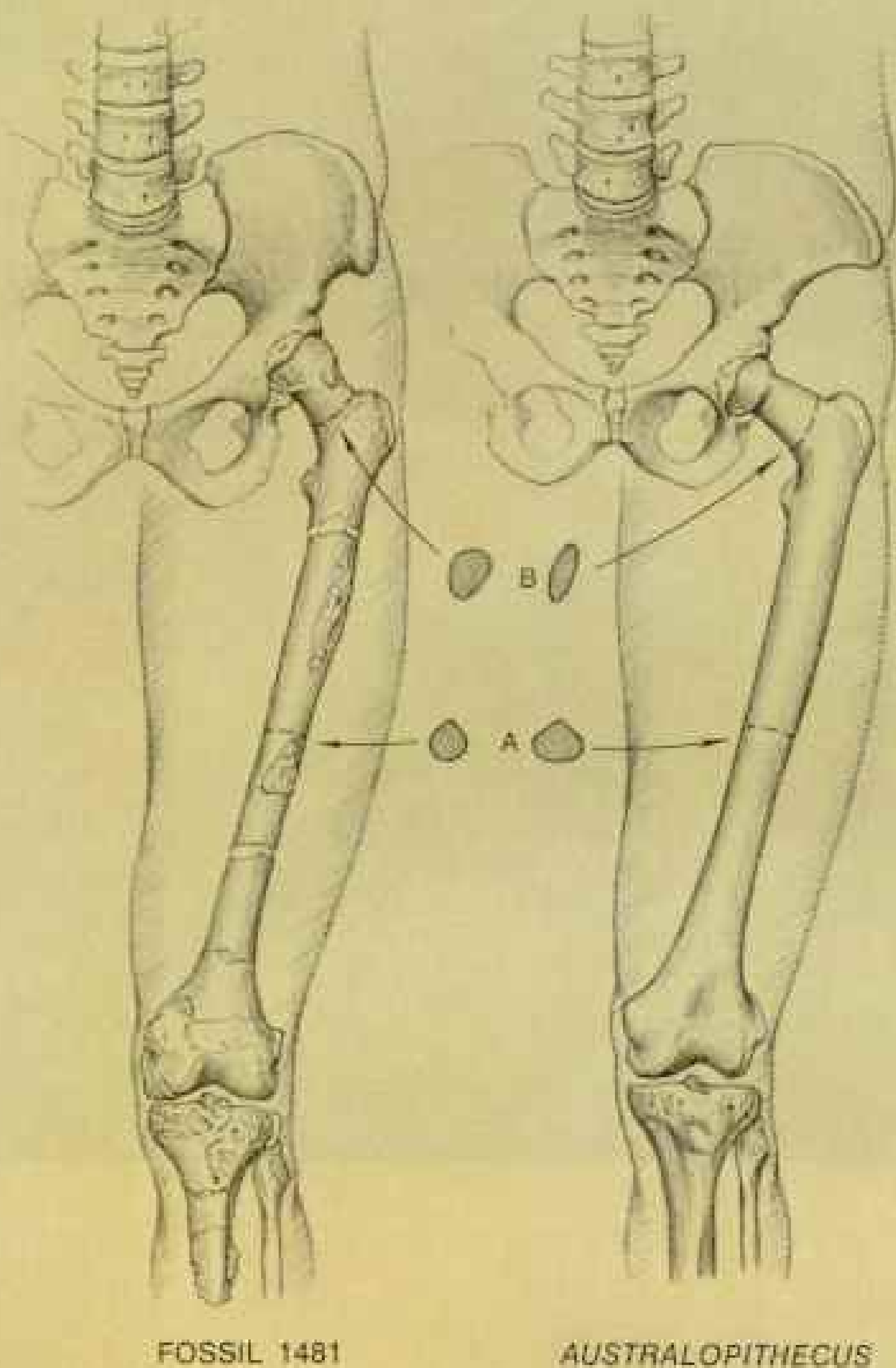
Sediments, layered with ash from periodic volcanic eruptions, were laid down by streams from the east (areas A, B, C) and north (area D). In these sediments, interfingered with shallow lake and delta deposits, fossil finds have been made.



Volcanic eruptions over the past 20 million years covered ancient rock with lava and ash, forming a base upon which sediments were deposited.

Today's lake continues to accumulate sediments.

Recent faulting tilted lava and sedimentary beds, disrupting the earlier drainage system. Continued uplifting forms new drainage patterns that accelerate erosion of sediments to expose fossil remains.



DRAWINGS BY JAY W. MATTHEWS

Leg bones tell a tale of two contemporaries who walked in different fashions through the lush land of East Africa three million years ago.

Reconstructed femur on the left, tagged "1481" after its fossil registration number, belonged to the same species as the "1470" skull, Mr. Leakey believes. That on the right belonged to the more apelike *Australopithecus*.

Cross sections through the centers (A) of the femurs show a similarity of circumference and, hence, of weight-bearing ability at midshaft. But a marked dissimilarity appears at the necks of the shafts (B), just below the ball-and-socket joints with the pelvis. The more ovoid, less robust shaft neck of *Australopithecus* implies that the latter, though capable of walking upright, did so only for short periods. Stronger neck shaft of the femur on the left suggests its owner probably walked upright as his normal mode of locomotion. Some parts of the skeletons are conjectural.

Mosaic of skulls from East Africa reflects the author's views of hominid development: One group led to *Homo sapiens*; the other, including *Australopithecus*, died out. *Kenyapithecus wickeri* may have been ancestral to both. South African australopithecines are omitted because their age is unknown.

are unlike those of *Australopithecus*, and astonishingly similar to those of modern man.

John's discoveries contribute to what has been by far our most successful season in the field at East Rudolf. In less than four months we collected remains of some 35 hominids, ranging in age from roughly one million to 2.8 million years. Most striking, of course, was the shattered "1470" skull. But another surprise awaited us. And again, it was Bernard Ngeneo who was responsible.

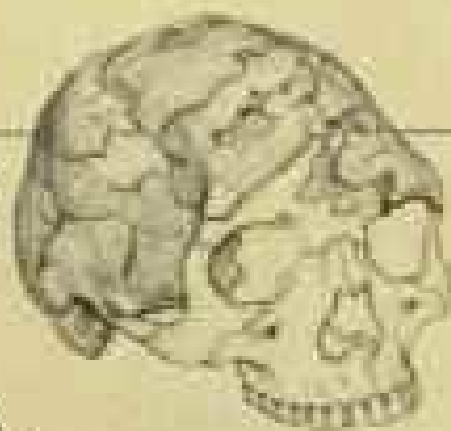
It was in October 1972, as our season of

fieldwork was drawing to a close, that Bernard discovered the teeth and badly fragmented partial skull of a child.

Again, the age of the stratum from which erosion had exposed these fragments approximated that of the "1470" find, although the two sites were 8 miles apart. Once we began to reconstruct the new skull, we found it to be of similar configuration. The teeth, as well, indicated to me that this was no australopithecine. From their wear and stage of growth we deduced that the child was probably no

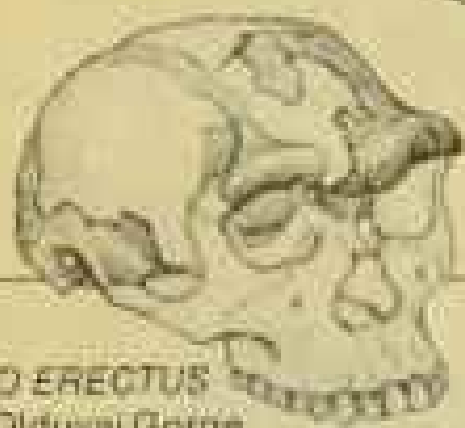
PRESENT

HOMO SAPIENS
from Qmoo River



1,000,000 YEARS

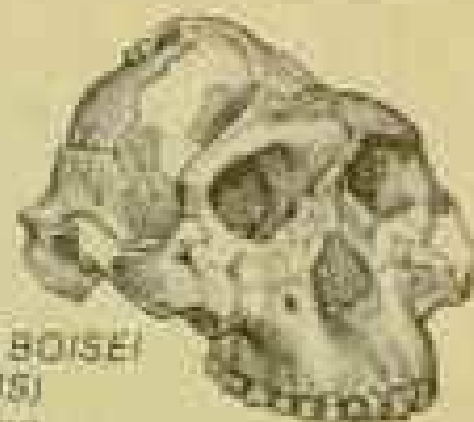
HOMO ERECTUS
from Olduvai Gorge



HOMO HABILIS
from Olduvai Gorge

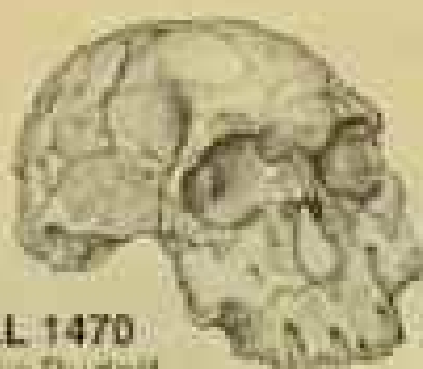


AUSTRALOPITHECUS BOISEI
(*ZINJANTHROPUS*)
from Olduvai Gorge

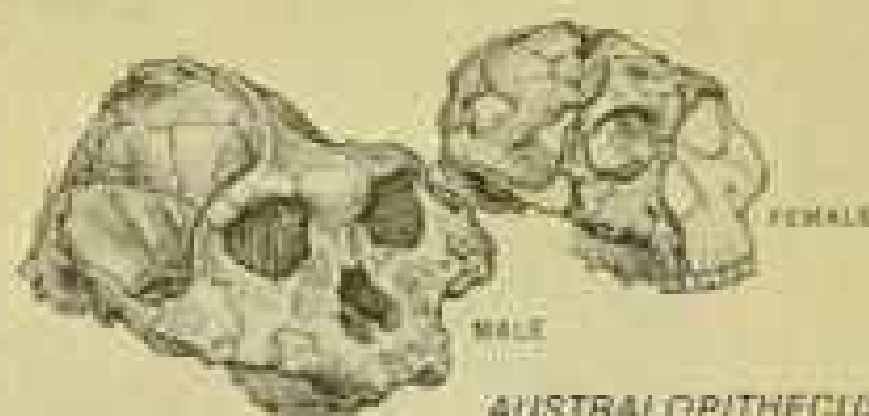


2,000,000 YEARS

SKULL 1470
from Lake Rudolf



3,000,000 YEARS



AUSTRALOPITHECUS
from Lake Rudolf

HOMO

Sole survivor among the small group of species in this elite genus. *Homo sapiens* evolved more than 100,000 years ago.

AUSTRALOPITHECUS

Probably a relative rather than a forebear of mankind, apelike *Australopithecus* existed for at least two million years before it reached an evolutionary dead end.



KENYAPITHECUS WICKERI
from Fort Ternan

14,000,000 YEARS

KENYAPITHECUS

Oldest hominid form yet discovered in East Africa, *Kenyapithecus wickeri* roamed the area as long ago as 14 million years.

more than 6 years old at the time of death.

Discovery of all this material provides us with another block in an emerging mosaic concept of human development. This concept leans toward the view that there may have been a number of models of early man—geographical or regional variants of the same species. Undoubtedly, more pieces will emerge as our research—sponsored largely by the National Geographic Society and the U.S. National Science Foundation—continues.

I feel confident that one day we will be able

to follow man's fossil trail at East Rudolf back as far as four million years. There, perhaps, we will find evidence of a common ancestor for *Australopithecus*—near-man—and the genus *Homo*, true man.

Meanwhile our study of this wealth of new material continues—and continues to surprise us. Only recently, after months of analysis and comparison, we reached a conclusion tinged with gentle irony:

Our remarkable "1470 man," it now seems, may very well have been a woman. □

By GORDON YOUNG

Photographs by EMORY KRISTOF

BOTH NATIONAL GEOGRAPHIC STAFF

Whatever Happened to TVA?



Focus of raging controversy in the '30's, the unique Tennessee Valley Authority harnessed a river and made a region prosper

"STOP HERE FOR FERRY," the sign said. And the ferry, of course, was on the opposite side of the river. With a sigh I climbed out of the car to wait.

But then the sounds and sights and fragrances of a Tennessee spring morning enveloped me, reminded me of how isolated I had really been in that automobile. A pine-scented breeze ruffled my hair and rippled the Tennessee River's blue surface. The river whispered back with a liquid burble as it flowed. By the time the tiny ferryboat nudged into the bank to receive me, I was at peace.

Peace. That's the word that always comes to mind when I think of the valley of the Tennessee. But of course I hadn't known it in less peaceful days.

In the 1860's, for instance, when civil war swept through the valley like a torrent. Or in the depression of the 1930's, when food money was even harder to come by here than in much of the rest of the nation.

Those days are gone, praise be. Today tow-boats and pleasure craft cruise past silent cannon at Shiloh and Chattanooga, and lock through dams whose humming turbines brought a new hired hand called electricity to the valley's hard-pressed farmers almost 40 years ago. The entire 650-mile length of the main river—which curves south from Knoxville in a great wavering arc and north again to meet the Ohio River in Kentucky—is navigable now (map, pages 834-5).

TVA Plan Stirs Cries of "Socialism"

When did the valley's fortunes begin to change? Surely in 1933, when the Federal Government launched a bold experiment, the Tennessee Valley Authority. Simply TVA, the government people called it. Some shocked valley residents called it socialism.

TVA was never meant to be just a power company. When President Franklin D. Roosevelt signed the Tennessee Valley Authority Act on May 18, 1933, TVA was given a range of missions to upgrade life in the valley: Improve navigation on the river, provide flood control, work in reforestation, strive for more effective use of marginal land, and generate low-cost electricity, to spur agricultural and industrial development in the valley of the Tennessee.

In its early years TVA came under fire from diverse groups. Some Congressmen questioned its constitutionality, and state leaders warned that it invaded states' rights.

Private power companies complained loudly that it offered unfair competition.

But, in spite of the barrage of criticism, TVA went about its business of building dams. Born in the midst of the depression, it had its pick of engineers, and it chose the best. It began construction at a rapid rate, completing 16 of its 23 major dams in the first dozen years.

Ecologically speaking, the hydroelectric plants in the dams ranked high as sources of electricity. They needed no expensive air-polluting fuel, for cascading river water spun the turbines. But when the nation began to gird for war in 1940, power needs zoomed. TVA sped the construction of dams and built a coal-fired steam generating plant.

Into the Age of the Peaceful Atom

One of the reasons for that increased power consumption was a plant erected in 1943 west of Knoxville. Signs at the gate said "Clinton Engineer Works," but the world knows it now as a key part of the Manhattan Project, which produced the atomic bomb.

A government-built city to house workers went up at incredible speed. Two and a half years after the first house was started, Oak Ridge had become Tennessee's fifth largest city, with a population of 75,000 people.

Most Oak Ridgers didn't have the foggiest notion what they were doing at the plant. "Whatever they're making in here," one puzzled worker is said to have remarked, "they'd be better off buying it someplace."

The roadblocks and fences that ringed the city are gone now, but Oak Ridge is far from being a ghost town. Even today, many of its 28,000 residents clip on their government badges and head for the site of the old "Clinton Engineer Works." It is now the headquarters for the U.S. Atomic Energy Commission's Oak Ridge operations.

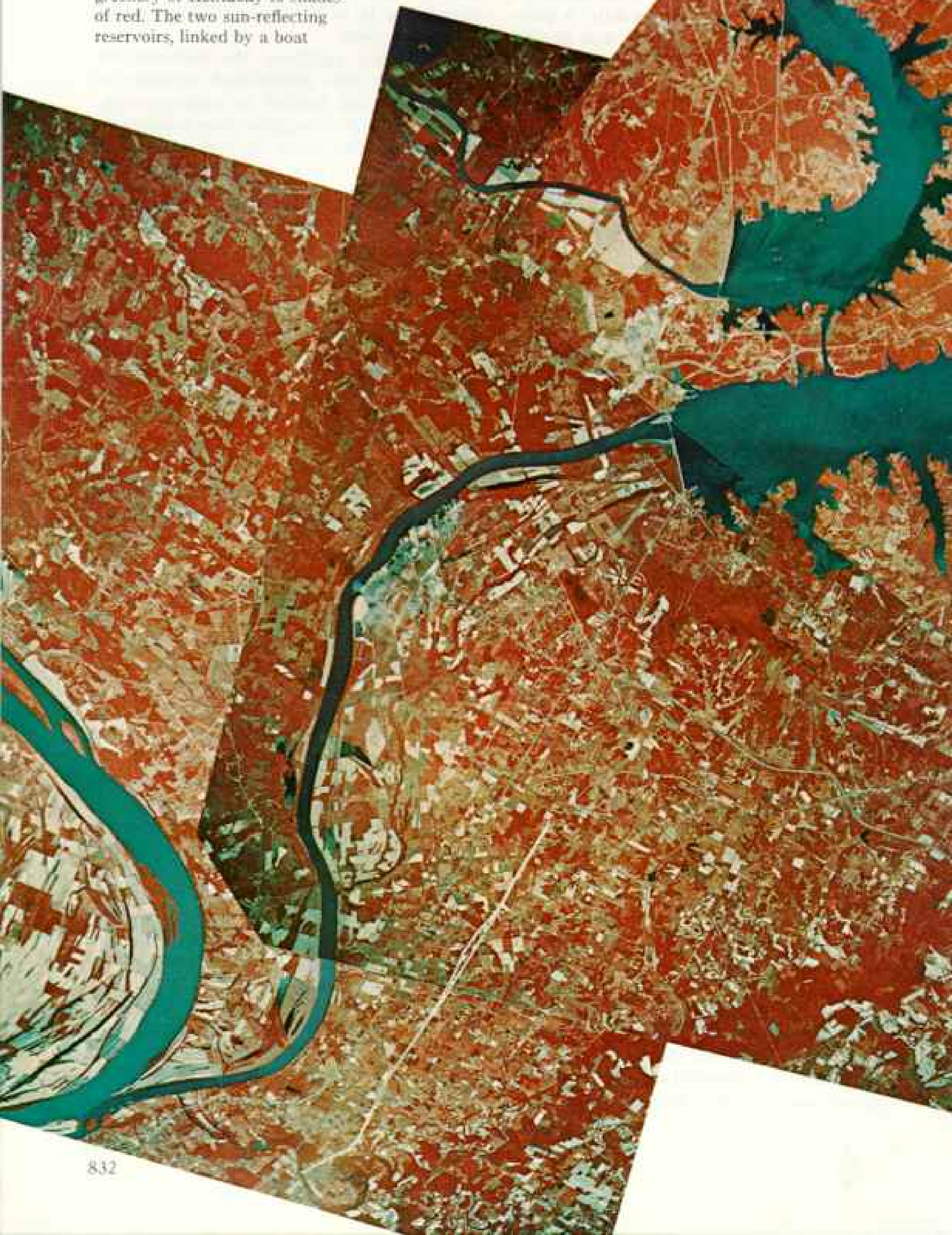
How long should it take to tour an atomic-energy research and production complex? With the whole valley to cover, I allocated half a day. But two days later I was still following my host, Jim Alexander of the AEC information office, at a fast gallop. There are 90 square miles, 15,000 people, and an awesome number of projects there.

A few still deal with nuclear weaponry, but most of the projects focus on peaceful uses of the atom. How can nuclear power plants generate electricity more effectively?

(Continued on page 836)

Bridles on once-wild rivers, Kentucky and Barkley Dams restrain the Tennessee, center, and the Cumberland, top, on their run to the Ohio, lower left. This composite infrared photograph, made from 11 miles up, turns the greenery of Kentucky to shades of red. The two sun-reflecting reservoirs, linked by a boat

channel, flank the Land Between the Lakes (pages 836-7), where woods show a darker hue. White marks freshly tilled fields, while pink discloses pasture or sprouting crops. MADE FOR THE








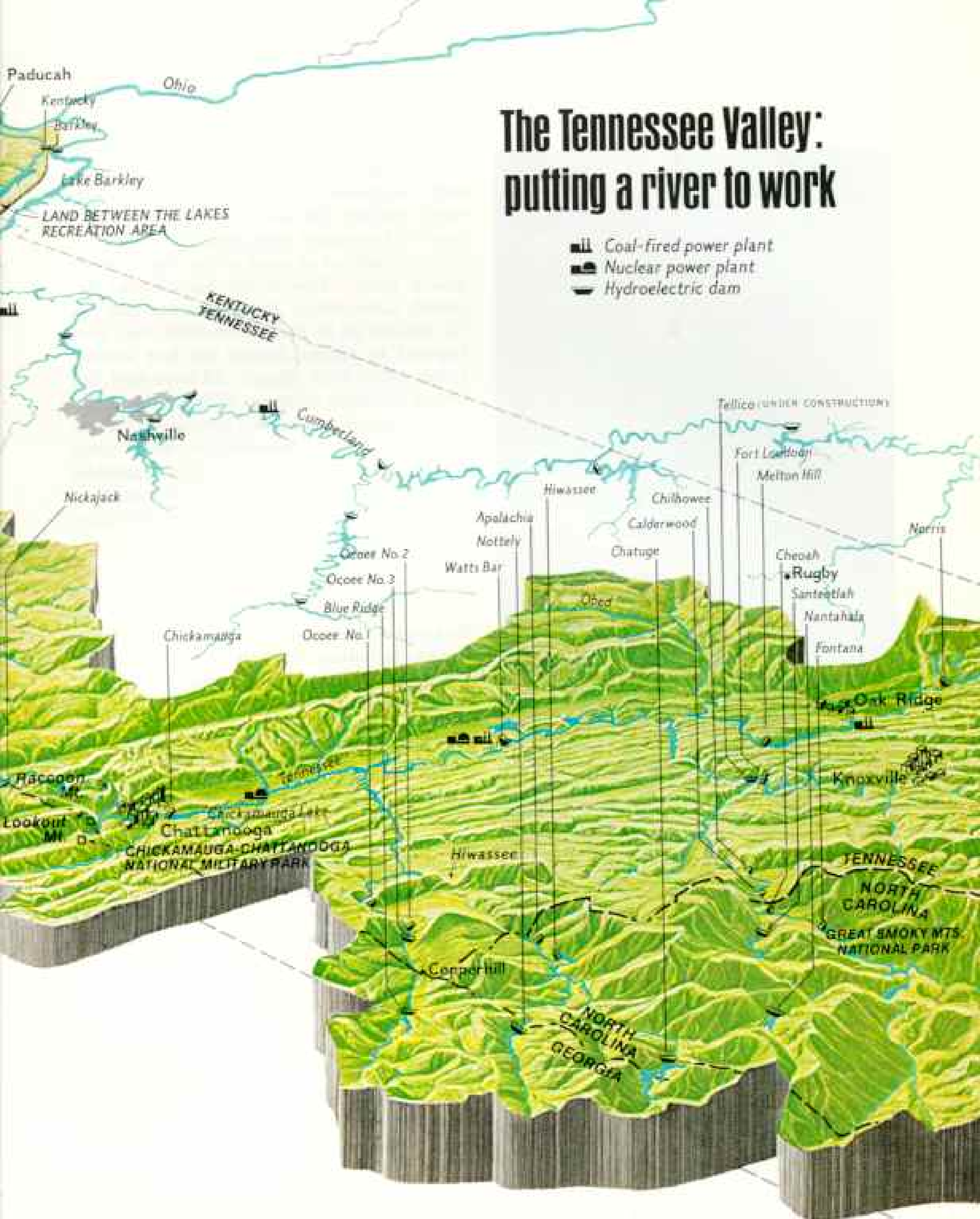
Infrared erases haze but not the blue puff of factory smoke hanging over the river between Kentucky Dam and the Ohio. Cheap power and river transportation spur industrial growth. The area now attracts more job seekers than it loses.



ROARING UNCHECKED out of the Appalachian Mountains, the Tennessee often overflowed, devastating farms and cities. Man compounded the problem by stripping away timber and misusing cropland. In 1933 Congress set up TVA to rejuvenate the region. The agency created a network of dams to control floods, improve navigation, and generate power, stirring protests as it supplanted private utilities. World War II spawned Oak Ridge's atomic plant, and demand for electricity outran capacity. TVA then built giant coal-burning plants that also generated controversy by discharging heated water into streams, fouling the air, and causing strip mines to proliferate—problems it is now trying to solve. TVA has inspired similar developments in India, Iran, and Colombia.

The Tennessee Valley: putting a river to work

-  Coal-fired power plant
-  Nuclear power plant
-  Hydroelectric dam



MAP BY THOMAS E. SMITH
COMPILED BY GUNNAR J. RUTINS



Relishing nature's world, teen-ager Lorraine Lassiter launches herself on a swinging vine in the Land Between the Lakes. During a week of backpacking, she and her friends waded a creek (opposite) to reach a remote bird-watching overlook. The challenge of outdoor living—met and mastered—brings a new sense of self-assurance to these members of Upward Bound, a federal program for high school students.

TVA has transformed this 40-mile-long thumb of land between two reservoirs into an innovative recreation area. The agency not only carved out campsites and boat ramps, but also provided wildlife clearings, a buffalo range, watering holes, and an environmental education center. One area is reserved for cross-country motorcyclists.

Can man duplicate the sun's energy process—nuclear fusion—in a beneficial way? Can nuclear power plants desalt seawater? Those are some of the areas under study here. Soon my head and notebook were crammed with information on cancer research, diagnostic studies, the use of radiation in bone-marrow transplant operations.

Seemingly out of place in the vast complex was a farm. "This is the Agricultural Research Laboratory," Jim Alexander told me. "It was set up to study beef cattle that were exposed to fallout during the first atomic-bomb test in New Mexico. All have died, but not of radiation sickness. We're doing radiation studies on other cows, plus sheep, burros, and pigs. In the greenhouses we're using radiation to produce mutations in vegetables and ornamental plants. Selected mutations can increase yields and strengthen resistance to disease."

Clearly, there's a great deal of elbowroom for researchers in the nuclear field. Some scientists, for example, are investigating a wasp that seems to have an uncanny ability to sense nuclear radiation—it studiously avoids radioactive mud in building its nest, while other wasp species do not.

Strange Cooks in "Katie's Kitchen"

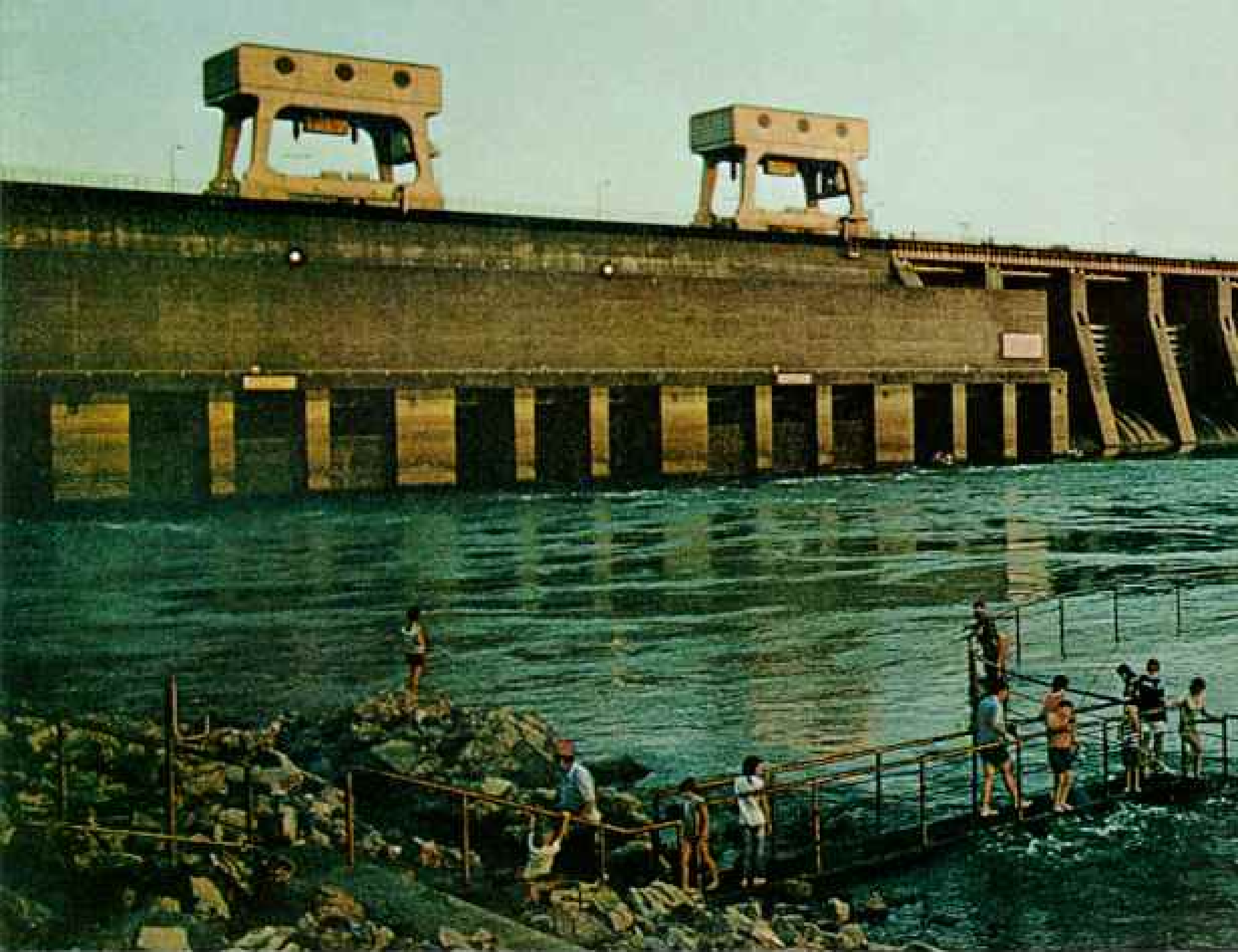
But the Oak Ridge complex still produces a product: fuel for nuclear power plants. The giant Gaseous Diffusion Plant consists of five monstrously large main buildings, plus 70 smaller ones, spread over 600 acres.

"Uranium for the early bombs was processed here," Jim said. "Now it's being used by nuclear power plants. But it takes electricity to produce atomic fuel, which of course is one reason the Manhattan Project ended up here. This plant used about four billion kilowatt-hours of electricity last year, plus more than 100 million gallons of cooling water a day. There are three plants like this; the others are in Paducah, Kentucky, and Portsmouth, Ohio. In 1957, a peak year, those three plants were gobbling up 10 percent of all the power sold in the United States!"

In the Manhattan Project days a nondescript little "farm" on the property carried a top-secret rating. Tucked away in a remote area of the sprawling works, it consisted of a silo and a barn perched on a hillside. Hardly worth a second glance from any visiting spy.

*Kenneth F. Weaver reported on "The Search for Tomorrow's Power" in the November 1972 *GEOGRAPHIC*.





Come on in, the fishin's fine! Even during high water, anglers wet lines—and feet—on an old bridge pier below Kentucky Dam.

Brain behind the muscle of the nation's largest power complex, this TVA control center in Chattanooga (below) monitors the output of 48 dams and 11 steam plants.



But the barn was merely a facade to hide the entrance to a secret room in the hillside. Surrounding woods hid barbed-wire barricades. Here the output of Oak Ridge—enriched uranium—was crated for shipment. Later the room came to be called “Katie’s Kitchen.”

Ironically, the room serves ecology today. I visited it with Dan Nelson, who helps run the Oak Ridge National Laboratory’s environmental science projects. “We use it as a field headquarters for our land-management and water-quality studies,” he told me.

A strange headquarters indeed! “Notice, this really is a room within a room—for added security,” said Dan. “It has double walls all around. On the silo, guards with submachine guns scanned the area, which was heavily planted with alarm devices.”

And there was another reminder of the room’s former tight security. At its entrance a foot-thick bank-vault door still hung on its hinges, but was carefully propped open. “Someday we’ll get around to removing this thing,” Dan muttered as we passed it.



That afternoon I unclipped the radiation badge from my shirt and drove out of the AEC's world to find another farm. This one was what it seemed—and to me it was a welcome change from somber memories of war.

With me rode Dr. Herbert Walch, an agricultural economist who heads the University of Tennessee's Rapid Adjustment Farming Program. "The program, partially funded by TVA, helps farmers specialize in the crops and livestock that fit their land best," he told me. "When a farmer is interested, we check over his resources and have our computer work out four or five alternate farming programs. He chooses one, and then we give him all the guidance and advice he needs."

Young Teacher Returns to the Land

We bumped our way over back roads to the dairy farm of Wayne Hubbs, near Heiskell, Tennessee, 15 miles north of Knoxville. City dweller, think not that all Tennessee farmers are weather-beaten men with angular wives: Wayne Hubbs, in spite of his overalls, looks

like the young schoolteacher he had been, and his wife is a tall, gorgeous brunette.

A press agent could have dreamed up these two and their three appealing children (page 846). But when we tramped Wayne's 165 acres, it was clear that he was a working farmer. He had 96 head of well-tended Holstein cattle, a shining automatic milking room, and quiet confidence in his future.

Wayne's grandfather had been one of the many farmers displaced by the expanding reservoirs. "I don't think he was too resentful," Wayne said. "When TVA's Norris Dam flooded him out, they helped him get 65 acres here. It was better land than he had before. TVA seemed to be trying to do the right thing in the cases I've heard about. Of course, it was quite a wrench for a man to leave land his family had worked for generations."

Not many farmers have enrolled in the Rapid Adjustment Farming Program, fewer than three score in the valley. To join, they must agree to follow a selected plan faithfully
(Continued on page 845)



Fly ash by the ton spews from a 20-year-old coal-fueled power plant at New Johnsonville, adding to air pollution that afflicts much of the U. S. Highlines leap the hills to power-hungry



Memphis and Nashville. To cut the smoke, TVA is gradually installing electrostatic precipitators in all its coal-burning plants, but the problem of sulphur emissions remains to be solved.



High jinks know no age when Paducah, Kentucky, celebrates its Summer Festival. Auxiliary policemen (above) compete in a children's wheelbarrow race. Parading as a moonshiner, his jug at the ready, Pete Broadbent (right) jogs along with the Wildhaired Hilltoppers, a men's club from nearby Cadiz. Scrambling for free watermelons, youngsters find their prizes hard to hold (below) when the fire department douses everyone with soapy water; child in whiteface, lower center, entered a clown contest.

Paducah, named for a Chickasaw chief, grew up as an important port where the Tennessee meets the Ohio. Today payrolls from an atomic plant, chemical complex, and railroad repair shops bring prosperous times.







—and farmers, of course, are men with strong faith in their own opinions. Besides, Dr. Walch and his associates are careful about choosing candidates. In Wayne Hubbs's living room, though, the subtle long-range impact of the program came through.

For three years he had followed the program's rules, worked hard, and increased his income. Other small dairymen and neighboring farmers had begun to drop by, looking speculatively at his operation. This wasn't some computer telling them how to run their farms; this was a neighbor who was making good. Many would leave with the resolve to adopt some of Wayne Hubbs's techniques.

Cannery Becomes a Pack of Trouble

In 1880 an Englishman's utopian dream took shape in the Tennessee hills 50 miles northwest of Knoxville. It was the colony of Rugby, designed primarily for "young men of good education and small capital." These younger sons of British gentry and merchant classes could work at manual trades without disgrace in the Tennessee wilderness.

Tennessee hill people looked on quizzically while the newcomers made bridle paths, tennis courts, and croquet grounds. A tomato cannery had been planned—in fact labels had been preprinted, giving a price in shillings.

But the plan failed to include growing enough tomatoes to can. The enterprise failed.

And there were other problems, such as getting products to market on muddy roads. Rugby's lanes, complained a villager in the local paper, were "not passable, not even jackassable, and those who would travel them must turn out and gravel them."

For a decade the colony struggled to attain the dream of founder Thomas Hughes: "Are our swans—our visions, already so bright, of splendid crops, and simple life, to be raised and lived in this fairyland—to prove geese? I hope not. It would be the downfall of the last castle in Spain I am ever likely to build."

But the dream faded. Some of the aristocratic pioneers returned to England; others drifted to cities, where a gentleman's social graces could stand him in better stead.

Perhaps Rugby will live again. I roamed its quiet streets with James N. Keen, vice-president of the Rugby Restoration Association. Seventeen buildings still stand, and many of them already have been restored. Rugby's tiny Christ Church, Episcopal, built in 1887, still echoes to the sound of hymns. The library still has its original 7,000 volumes—including *Tom Brown's School Days*, written by Thomas Hughes himself. That classic's



Calm or crashing, river waters respond to the hand of man. A flotilla of pleasure craft (left) enters the locks of Kentucky Dam, first upward step in the Tennessee's 650-mile navigation channel. White-water enthusiasts (above) battle the Hiwassee when a posted schedule indicates high flow from an upstream dam; low water draws trout fishermen.

setting is the British boys' school of Rugby, Hughes's alma mater, hence the colony name.

Trees are a big asset to the valley of the Tennessee; more than half the area is wooded. TVA's Division of Forestry, Fisheries and Wildlife Development, quartered in Norris, northwest of Knoxville, works to upgrade the region's wild resources, including trees. I chatted with the division's Dr. Robert Farmer, whose specialties include tree genetics.

"The forests are important for the value of their wood products," he said, "but they're also increasingly vital for a host of other uses. They improve water quality and flow, serve recreation, add wildlife habitat, and form a major scenic resource. Part of our job is to make sure all these benefits enhance the quality of life for valley people."

Tracking Down a Haunting Sound

Some trees don't have to justify their existence. They just stand there looking beautiful. The dogwoods, for instance, which dot the green valley with white and pink splashes

each spring. It's no wonder that Knoxville's spring celebration is called the Dogwood Arts Festival.

During last year's fete, I strolled Knoxville's streets. There were wood carvings that needed buying and band music to listen to. I bought and I listened. Then, as the red-coated young bandsmen packed up their instruments, I heard another tune. The haunting sound of a dulcimer playing "Barbara Allen."

I tracked it to its source, for five years earlier, while writing a story on the Great Smokies,* I had become a dulcimer buff. The source turned out to be Dorsey Williams, a burly man whose big hands could coax the gentlest of sounds from his homemade instruments. For an hour we talked together and played together. Dorsey's introduction to dulcimers had come ten years before.

"I borrowed the first dulcimer I ever saw," he said, "steamed it apart, made tracings of all the pieces, and glued it back together before returning it. Then I made my own."

*See the October 1968 issue of the *GEOGRAPHIC*.



They chose the land: Wayne Hubbs gave up teaching and returned with his family to his grandfather's acres near Heiskell. He joined the Rapid Adjustment Farming Program, a scientific farm management plan sponsored by TVA and the University of Tennessee.

This, too, I learned from the ingenious Dorsey Williams: A nylon rattail comb, suitably whittled and scraped, makes an exceedingly fine dulcimer pick.

Scars Blight a Lovely Landscape

Those early cries of socialism are seldom heard in the valley now, but TVA faces criticism on another front. Environmentalists feel that the nation's largest coal consumer is doing far too little to prevent strip miners from leaving ugly gashes on the land.

With environmentalist Grimes Slaughter, a physicist from the Oak Ridge National Laboratory, I flew over the strip-mined area northwest of Knoxville (pages 852-3). It was a disheartening sight from the air. Grimes pointed out despoiled ridge after despoiled ridge. "As long as those miners can rape the land and get away with it," he said, "this is the way it's going to be."

He pointed out that TVA's contracts with strip miners have clauses requiring that the pits be reclaimed. "But there's not much

reclaiming going on down there," he noted.

The day after our dismal flight, I looked up a fellow journalist in Knoxville, Lee Sheppard, TVA reports editor.

"We're catching a lot of flak for buying strip-mine coal," Lee told me. "But we're really doing our best to correct the situation, tightening enforcement of our contracts and working on new reclamation techniques."

He leaned back with a thoughtful frown. "Part of the problem is that, in 1965, when we began putting mandatory reclamation clauses in our contracts, people expected instant results. Well, results come slowly at first in a massive operation like this."

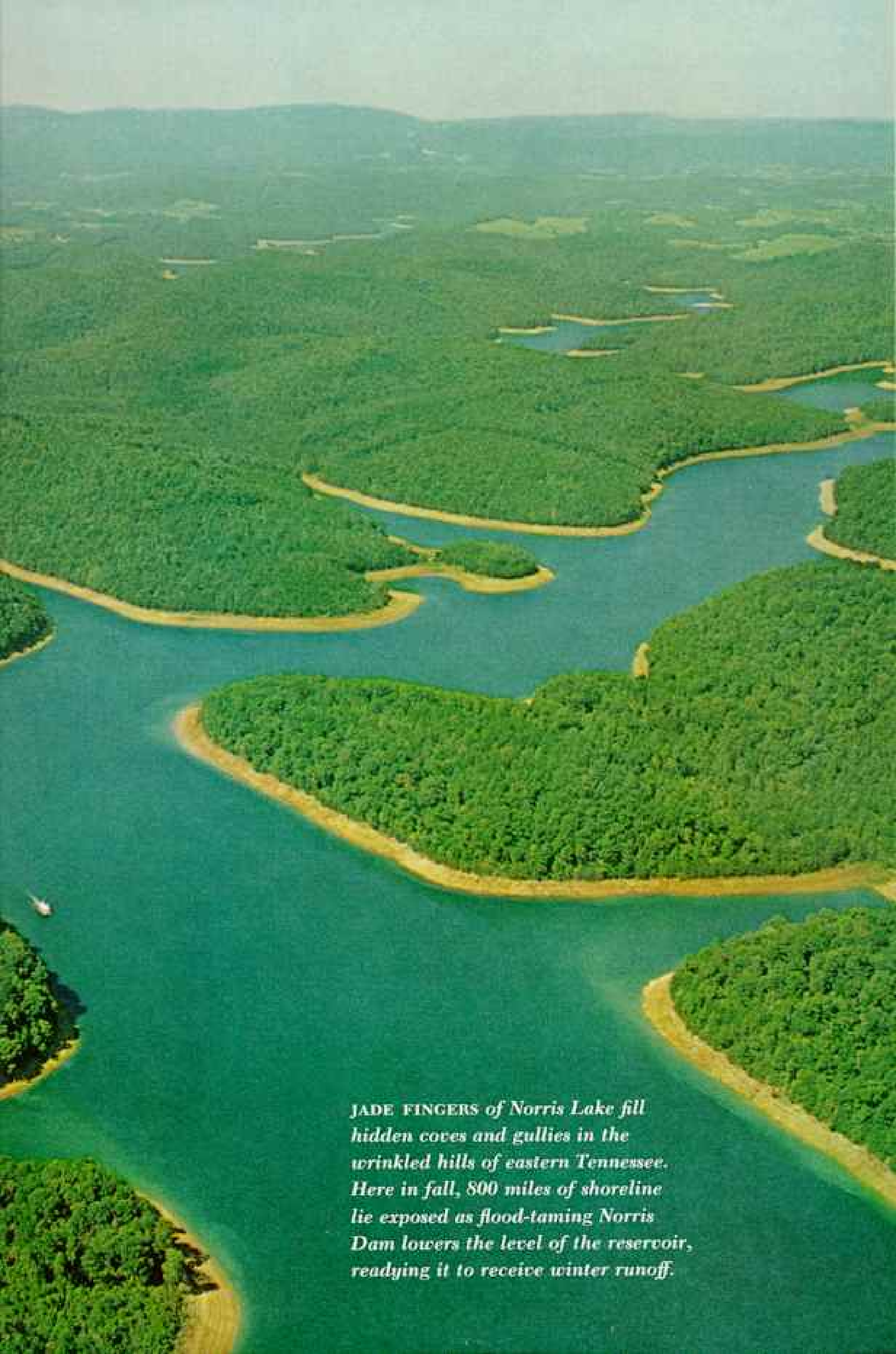
He gave me a wry grin. "In forty years we've made a lot of friends in this valley, so this new role of villain really hurts. Our job is to upgrade the valley—not destroy it!"

Next day I drove the valley of the Tennessee toward Chattanooga. If someday you drive that road on a beautiful spring morning, be wiser than I. Turn off the air conditioner. Open the car windows. Drive slowly, for



Chopping corn for winter feed, Mr. Hubbs pulls a harvester over his fields. The young farmer had soils tested and applied recommended fertilizer, dramatically increasing his yields. Now his land, a demonstration farm, serves neighbors as an open-air classroom.





JADE FINGERS of Norris Lake fill hidden coves and gullies in the wrinkled hills of eastern Tennessee. Here in fall, 800 miles of shoreline lie exposed as flood-taming Norris Dam lowers the level of the reservoir, readying it to receive winter runoff.



there is scenery that should be savored like wine. Lush pastures with sleek cattle, fields to please the eye, and gingham-clad, poke-bonneted women working in their gardens.

But of river views, there are none. You must leave the main road, as I did, to find the Tennessee. And thus that ferry wait. After the crossing I drove slowly, with windows open to let in the warm spring breezes.

TVA: Despot or Savior?

Chattanooga, a bustling industrial city, is located at the neck of a funnel. Above, the Tennessee flows between low-lying shores, but for a 20-mile stretch below Chattanooga, the river is penned between steep, winding banks. The city's lower areas often flooded, for here is where the river backed up first.

I lunched with Gilbert Stein, senior partner in the Stein Construction Company, and asked him about those pre-dam floods. Mr. Stein, an incredibly youthful 68 years of age, lived through quite a few of them.

"Yes, I've seen parts of Chattanooga underwater," he said. But then civic pride took hold, and he waved a warning finger. "Understand, though, it wasn't as bad as out-of-state newspapers played it. This city didn't just disappear underwater each spring. Most of us lived and worked on higher ground."

Even with dams and reservoirs, floods can still occur. Last March, torrential rains swelled the "tamed" Tennessee, sending it out of its banks in a two-state area. Lower Chattanooga went under again—but without those dams, the flood crest would have been far higher, the damage much greater.

Is the Tennessee Valley Authority despot or savior? In Mr. Stein's view it falls somewhere in between. "When TVA began, it seemed like socialism to me. But I've come around to seeing it in a kindlier light. It has been good for the valley, I think."

Later we drove down to the waterfront. I asked about the importance of river traffic.

"From a tonnage point of view, barge transportation is not nearly as important as truck or rail," he answered. "But the simple fact that barge transportation is available holds down rail and truck rates." He smiled.

"So a plant owner may not use the towboats, but he's happy to see them out there."

Civil War buffs come to Chattanooga, but they turn their backs on the Tennessee to prowl the Chickamauga-Chattanooga National Military Park, oldest and largest memorial of its kind in the nation. They climb the heights of Lookout Mountain, which straddles the Georgia-Tennessee border just west of Chattanooga. There the "Battle Above the Clouds" took place.

I ascended Lookout Mountain's steep slope on a cable railway. It was well worth the trip, for at Point Park near the summit I could gaze down 1,200 feet at a magnificent view. At the river S-curving southwest from Chickamauga Lake. At downtown Chattanooga nestled in a river bend. I leaned against a cannon to marvel at the courage it must have taken for Union troops to storm this mountain, bristling with Confederate guns. Their mission succeeded, and the way was soon open for Sherman's march to the sea.

A curious new TVA project near Chattanooga has begun to attract attention. Puzzled attention. Engineers have excavated a crater on Raccoon Mountain. Electric-powered pumps will lift river water a thousand feet up there to create a 530-acre lake. Then the water will run back down to the river, generating electricity as it falls.

If the logic of that endeavor escapes you, remember this: Water will be pumped up at night, when power demands are low. It will surge down again to generate added power during times of peak demand.

Journey Into Past Spans 8,000 Years

After threading the gorge downriver from Chattanooga, the Tennessee flows within sight of Georgia and dips into Alabama.

So did I. It would be unseemly—perhaps undiplomatic—for a National Geographic staff member not to stop at Russell Cave National Monument, for that archeological site was donated to the nation by the Society.*

A jolly giant clad in Park Service green

*See in NATIONAL GEOGRAPHIC: "Russell Cave: New Light on Stone Age Life," March 1958, and "Life 8,000 Years Ago," October 1956, both by Carl F. Miller.

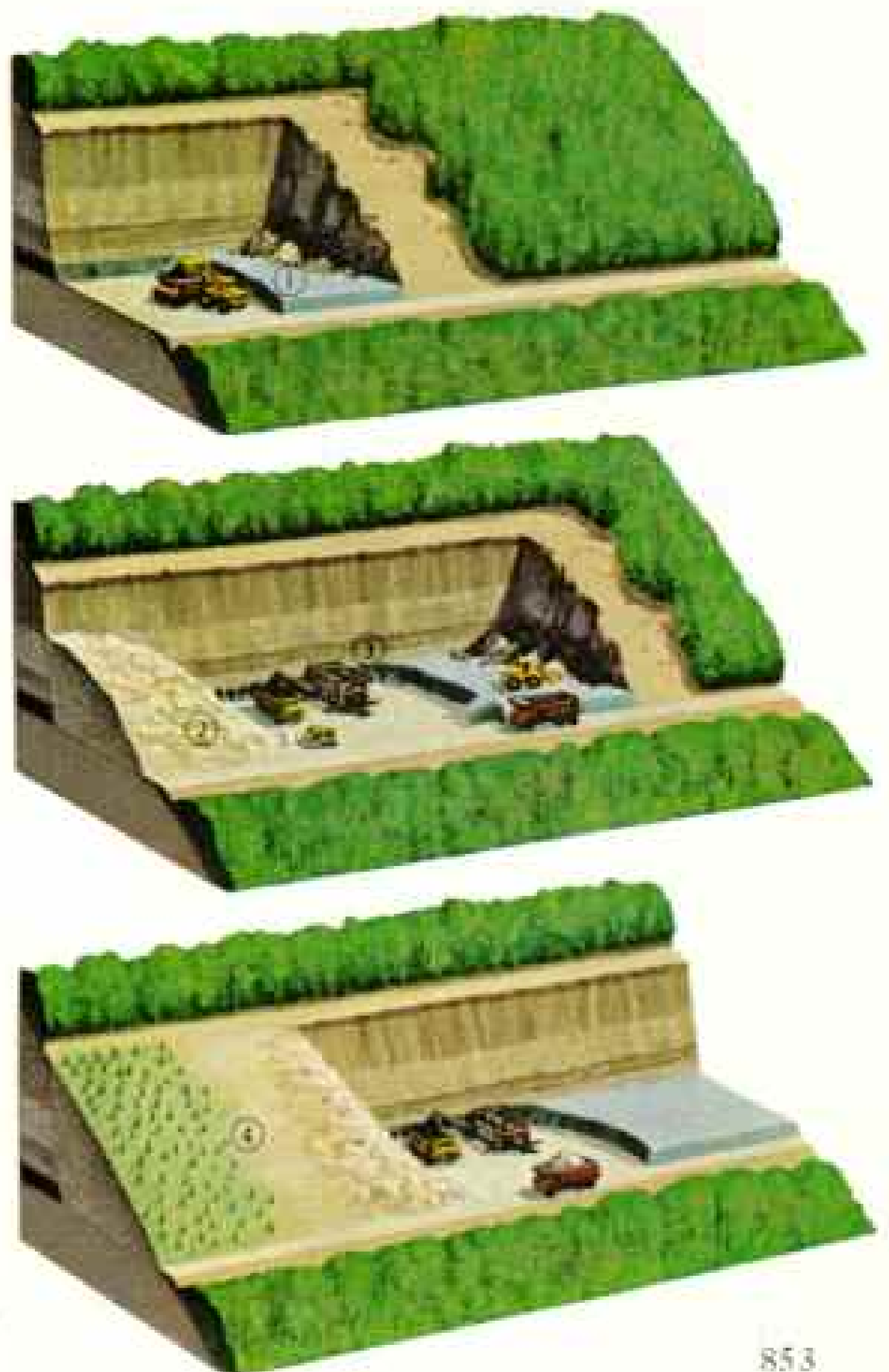
Portraying a four-armed Oriental statue calls for tongue-biting concentration from Terri Seier and anonymity from her partner as they rehearse for the Oak Ridge Civic Ballet. The city, founded in 1942 to harness the atom, boasts 600 Ph.D.'s among its 28,000 residents and takes special pride in its symphony, playhouse, and arts center.





Serpents of destruction, strip mines coil across the Cumberland— a price Americans pay for more and more electricity. Stripping yields almost two-thirds of the coal burned by TVA plants. Abandoned a decade ago, these "orphan" mines in eastern Tennessee continue to erode, slide, and pollute valley streams.

One healing operation called cut-and-fill could end the worst abuses of mountain stripping. Contractors blast and bulldoze a bench, hauling overburden to a storage area rather than dumping it downslope. Front-end loaders work the exposed coal seam (1). Then earthmovers restore overburden in the worked-out pit (2), even as augers drill like corkscrews to extract more coal (3). Grass and seedling trees, planted on recontoured slopes, control erosion and bring back the forest (4). Across the nation coal strippers rip out an estimated 1,200 acres a week. Most have yet to launch effective but costly restoration projects, despite rising public concern for the ravaged land.



Forest in the making, pine seedlings take hold on a reclaimed bench west of Oak Ridge. The nation's largest coal buyer, TVA has since 1965 written increasingly stringent reclamation requirements into its contracts with strip miners. One company covered this worked-out seam with earth and planted 1,000 pines to the acre two years ago; costs ran \$250 to \$500 an acre. In a demonstration project in Campbell County, the cut-and-fill method shown in the diagram is being tested. While encouraging improved mining practices, TVA also tests a variety of fertilizers and vegetation.

was chatting with a departing family of tourists in the visitor center. "Y'all come back Friday, if you can," he called, "and I'll show you how to stew a rabbit with hot stones."

I stepped forward to introduce myself to that genial host, but introductions would have to wait. He had spotted a teen-age tourist pawing through the contents of a display table, and headed back to intervene.

Intervene? He had headed back to help! The table bore a sign, "Please Handle." In a moment he was showing the lad how to chip out an arrowhead from chert, and how to hurl a spear with a throwing stick.

Our introduction came at last, and soon I was drinking coffee with Billie Guedon, park technician, and scratching the ears of Prissy, his Weimaraner.

"We get about 20,000 visitors a year," he told me. "They don't come after gee-whizz stuff, but because they're interested in archeology and the old ways. That's why we have that sign on the table."

He pointed a finger down the trail, where Russell Cave was hidden by trees. "Those folks lived 8,000 years ago. It's hard to tell a tourist what life was like back then, but if the visitor chips out an arrowhead the way they did, he begins to understand."

From Watercress to Rocket Ships

A few decades ago civic boosters in Huntsville, Alabama, dubbed their town the "Watercress Capital of the World." But watercress growing wild in nearby springs is now largely ignored, for Huntsville has become "Rocket City, U.S.A." Its four square miles have grown to 109, and its population exceeds that of Montgomery, capital of the state.

Huntsville, like Oak Ridge, owes its growth to a giant government operation. And Huntsville, too, found itself suddenly with a community of scientists and skilled technicians.

They had come to conquer space. Evidently they have conquered Huntsville as well—for

Underwater rehearsal for Skylab provides the feeling of weightlessness that astronauts find in space. In this huge tank at NASA's George C. Marshall Space Flight Center at Huntsville, Alabama, a team times space-walk maneuvers with a mock-up of the Skylab station scheduled to orbit this year. Huntsville laboratories assembled many of the Saturn rockets that launch such missions.

nowhere else in this nation have I seen city speed-limit signs marked in kilometers as well as miles per hour.

Just outside Huntsville the Army's Redstone Arsenal sprawls over 40,000 acres. Near its center lies a civilian-controlled, 1,800-acre area—the National Aeronautics and Space Administration's George C. Marshall Space Flight Center. The center's management teams led development of the Saturn rocket used in Apollo space shots and the "moon buggy" known as the lunar rover.

History was being made the day I saw the center. Apollo 16 astronauts, their lunar visit over, were still orbiting the moon, preparing to enter an earthward trajectory and come home. As I chatted with Joseph M. Jones, who heads the center's information office, loudspeakers relayed the flow of technical talk between the astronauts and Mission Control in Houston.

There were smiles of accomplishment on



the faces of men at the center, but I sensed sadness and uncertainty too. The Apollo shots were almost over. Would a budget-conscious Congress appropriate enough funds for projects that were to follow?

Michael Inabinet, branch chief of structural planning, showed me some of those projects. One was a 45-foot-long cylindrical laboratory—a possible successor to the earth-orbiting Skylab, scheduled for launch in May 1973. We prowled through the mock-up, past banks of instruments lining the central corridor. More consoles paralleled them above my head. But no ladders led up to those lofty panels. Then I realized that ladders would not be needed in the zero gravity of space (below).

The astronauts were heading back to earth by the time Joe Jones and I left the center. Joe looked around as we drove through the sprawling Redstone Arsenal toward Huntsville. "I'm not certain how important river transportation was to the Army when they

picked this arsenal site," Joe said. "But it certainly has been important to us. The only way we could move the Saturn to Cape Kennedy was by river barge. It's much too large to fit on trains or trucks."

Nuclear Plants Stir Little Alarm

By 1949 the Tennessee River's hydroelectric potential was largely utilized, and TVA began to build more and bigger coal-fired steam generating plants. Now it has gone one step further and is building three nuclear power plants. The largest—in fact, the largest in the United States—is located 40 miles downriver from Huntsville at Browns Ferry.

Bill Kelleghan, project manager, told me that local residents had put up little opposition to the plant. "The people here have confidence that we'll lean over backward to build a safe plant," he said.

After a tour of the plant I gave Bill a firm handshake and my borrowed hard hat and





set off down the river. So much for the atom; it was time to investigate the pigtoe mussel.

Poor pigtoe! This mussel is as ugly as its name, and its meat is tough. Its infancy is perilous, for after leaving its mother mussel, the tiny pigtoe can survive only if it drifts into the mouth of a host fish. There it lodges in the gills for two weeks or more, developing a tiny foot. Then it sinks to the river bottom and digs into the sand. For the rest of its life—which might be fifty years—it stays there, filtering nourishment from the passing water.

But beneath the pigtoe's homely exterior lies an inner shell of white perfection. Generations of button manufacturers have prized it. Now it's sought by the Japanese, for use as nuclei for growing cultured pearls.

At Florence State University, in Florence,

Alabama, I visited Dr. Paul Yokley. His field is malacology—the study of mollusks—and he is on intimate terms with the pigtoe.

"Many mollusks act as natural filters," he told me. "We're currently interested in one in particular, an Asian clam that has become a pest after being introduced into the U. S. by accident more than a quarter-century ago."

Dr. Yokley and his scuba-diving students collected 35,000 Asian clams for an experiment run by Alabama's Auburn Agricultural Research Station. Placed in catfish ponds, the clams consumed uneaten fish food, feces, and plankton, clearing the water and promoting the growth of the fish. Thus a pest in streams may yet prove an asset to fish farming, an expanding industry.

Take the river bridge from Florence, and



you cross over Muscle Shoals. No, not Mussel Shoals—though it has long been a prime place for pigtoes. Perhaps a map maker unschooled in malacology made the spelling error.

I crossed that bridge to pay a duty call at TVA's National Fertilizer Development Center. After my visits to space labs and nuclear plants, how exciting could fertilizer be?

Exciting enough to draw hundreds of domestic and foreign visitors to the center each year. Not tourists, but agricultural technicians, chemical engineers, and agronomists. In their undemonstrative way they could get very worked up about a handful of tiny pellets, for those laboratory-born particles might be the forerunner of a fertilizer that could increase crop yields dramatically.

(Continued on page 862)



Mantled in green, Knoxville (left) lies at a gateway to the Great Smoky Mountains National Park, here seen on the horizon 20 miles away. The University of Tennessee borders the river, foreground. Once acrid smoke from coal furnaces smudged facades, but many residents converted to electric heat, and now the city enjoys clearer skies.

Strumming for science, a Knoxville rock band plays as Dr. David Lipscomb notes the volume preferred by blond fan Jan Keck. Director of Noise Research at the University of Tennessee, he found young people choosing a noise level that injured the ears of guinea pigs, an intensity just short of pain. In tests of college freshmen, he discovered that six out of ten suffered hearing losses, and concluded that rock music was a factor.



Bleak monument to heedless man, this moonscape resulted when miners near Copperhill, Tennessee, cut forests to fuel copper smelters. Sulphur fumes killed underbrush; rains carried



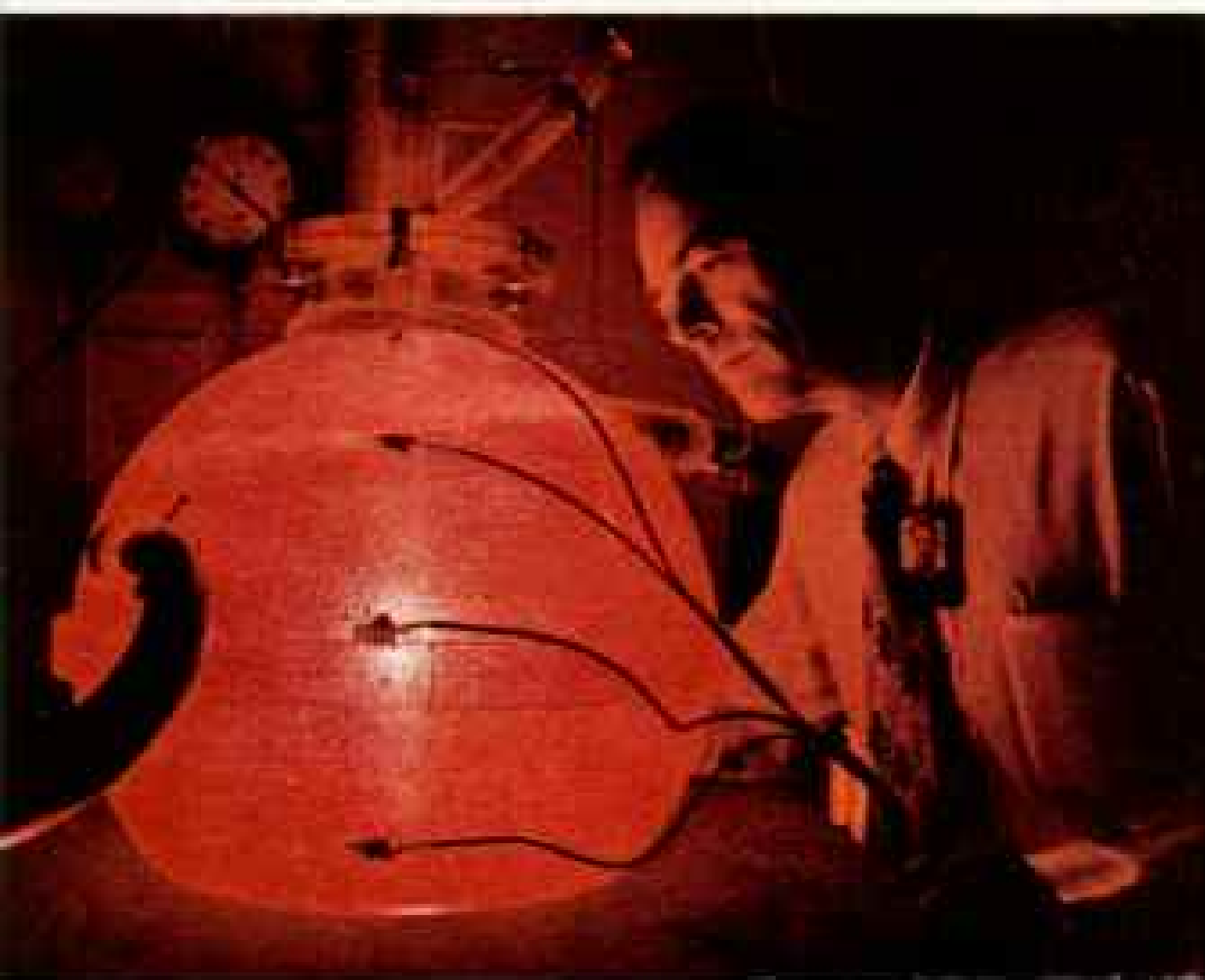
away topsoil. By 1900 fifty square miles lay barren. But operators learned to capture fumes and extract marketable sulphuric acid, and revegetation has reclaimed all but 15 square miles.



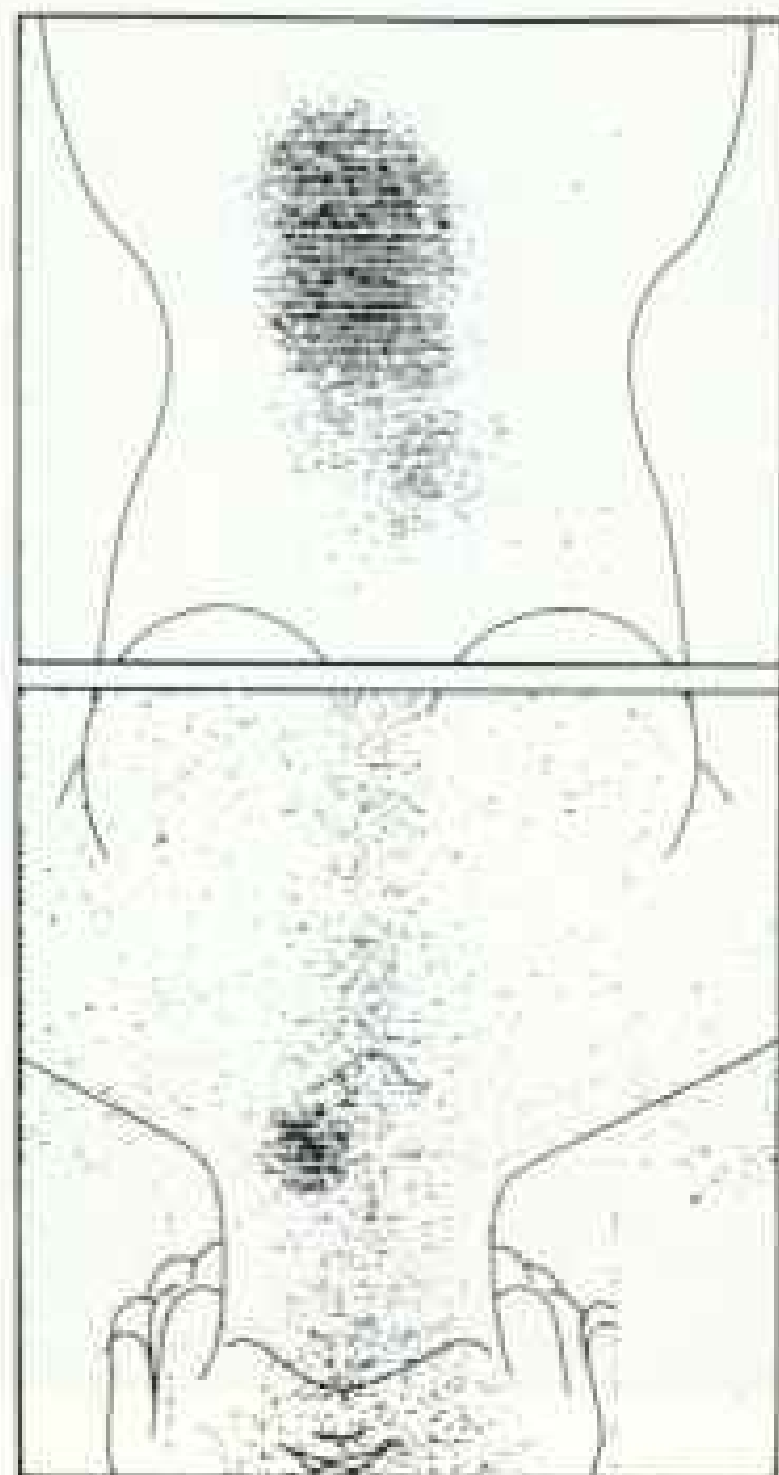
Master recycler, nature gives up secrets to Nelson Edwards, an ecologist at Oak Ridge National Laboratory. He measures the rate at which decaying leaves release carbon dioxide, the compound utilized by green plants in photosynthesis. This and other tests give a quick reading on a forest's growth rate.

Blanket of light covers a volunteer in this time-exposure demonstration of a cancer-detection technique at the Oak Ridge Associated Universities' hospital. To show the path of the scanner rolling above the table, a light was attached that traced this 30-minute survey of the entire body. Similar to a Geiger counter, the machine locates radioactive isotopes, injected intravenously, that gather in malignant tissue.

Electronic portrait of a real patient (below) paints dark areas of cancer in the throat and lower abdomen. The method permits diagnosis without surgery.



Bubble of energy: With a plexiglass scale model of a reactor, engineer Arthur P. Fraas at the National Laboratory simulates laser-fusion blast effects. Such a reactor could produce heat to generate electricity.



OAK RIDGE ASSOCIATED UNIVERSITIES, INC.

OHIO-NUCLEAR, INC.



Freak spring flood turns Lee Highway in Chattanooga into a kayaker's waterway. Abnormally heavy rains last March caused South Chickamauga Creek, an uncontrolled tributary of the Tennessee, to inundate the Brainerd section of the city for three days. Even the big river itself rose seven feet above flood stage. Damage appraisals ran as high as \$5 million dollars, but authorities estimated that losses would have been nearly ten times greater without TVA's dams and reservoirs.



It takes more than Bunsen burners and test tubes to father a fertilizer. The center has electron microscopes that magnify 300,000 times, plasma torches that reach 20,000° F.

I learned that liquid fertilizers are coming on strong these days, and that a sulphur-coated urea pellet being developed at the center is nothing short of a breakthrough.

Fertilizers usually release nitrogen so fast that crops can't use it efficiently. So center scientists took urea—very high in nitrogen—and coated it with sulphur, another needed element. The sulphur dissolves gradually, releasing the nitrogen over an extended period, and the plants have time to soak it up.

Glamorous it isn't, but the center is playing a key role in upgrading agriculture.

Restoring Wildness to Wilderness

The river turns north into Tennessee and soon broadens into man-made Kentucky Lake, formed by Kentucky Dam. Another river-turned-lake runs parallel to it; a dam across the Cumberland forms Lake Barkley. Between the two lies 40 miles of second-growth

hardwood forest called, not surprisingly, Land Between the Lakes (pages 832-3).

Iron smelters operated here in the 19th century, some devouring 10,000 cords of wood a year in charcoal form. For seventy years axes rang and furnaces roared. There wasn't much left of Land Between the Lakes.

In 1960 TVA came in with an intriguing pilot project: to turn the misused land into a national asset. Land Between the Lakes opened its gates as a recreation area in 1964.

Soon fishermen were trailering their boats in for bass and crappie. Woods were thinned to improve wildlife habitats. Many animals live there now—turkey, deer, beaver, bobcat, and buffalo (imported from the West). Bald eagles and an occasional golden eagle soar above, and wild geese glide in and linger.

Something puzzled me as I roamed Land Between the Lakes. TVA had set out to utilize the area's maximum recreational potential, yet I found only three developed family campgrounds in its 170,000 acres. But project director Robert Howes explained:

"Group campgrounds have been getting a



BOBBI HODGE, CHATTANOOGA NEWS-FREE PRESS

lot of our attention lately. Many experienced camping families prefer the primitive lake-side sites, but we get groups of city kids who've never known the outdoors. We put them in our Youth Station, which includes dormitories. They can live comfortably while learning about nature—in the midst of nature.”

Dams Help Meet a Crisis

The valley of the Tennessee ends at Paducah, Kentucky, where the river flows into the Ohio. I turned in my rental car and boarded an airliner for home. Shortly after takeoff, I looked down and saw inundated fields. Obviously, I had just missed a flood.

Back home, I called Lee Sheppard in Knoxville to check. Yes, there had been a flood on the Ohio. For a critical three-day period TVA had “turned off” the Tennessee River by shutting Kentucky Dam to help keep the Ohio’s flood crest down.

“Didn’t you notice how high the lake was?” Lee asked. “That was water being withheld from the Ohio. That’s why you found the fishing so poor at Land Between the Lakes.”

Comforting knowledge. I had attributed my lack of crappie catches to ineptitude.

My Tennessee travels are behind me now, but the memories remain vivid.

From a rattail comb I have whittled out one of Dorsey Williams’s dulcimer picks. Somehow, it seems to fit my hand most comfortably when I play the sweet old airs that have been played for centuries in the valley. Songs that have aged gracefully while the world went on to newer things.

And the valley itself has aged that way, in spite of rocket labs and atomic plants and TVA’s benevolent presence. It is a big valley. The river spends only brief moments in the turbines; most of the time it whispers along through quiet dogwood-dotted countryside.

In years to come it will surely serve new industries, carry more fishermen and water-skiers and houseboats. But even then, I think, it will remain a peaceful river, and in an increasingly crowded country, the land through which it flows will become an even more precious national treasure—the quiet green valley of the Tennessee. □

AMERICAN Mountain People

AMERICAN

Mountain People

PHOTOGRAPHED
BY BRUCE DALE

NATIONAL
GEOGRAPHIC
SOCIETY

Loyal to the land that has nurtured his family for generations, a mountain farmer turns thin Kentucky soil deep in Appalachia.

1973-74 SPECIAL
PUBLICATIONS SERIES

Slab Fork, Small Boats, the Somba, and Spoonbills

IN THE RUGGED CUMBERLANDS of Kentucky, a retired judge lovingly crafts a long rifle—the weapon that won a wilderness two centuries ago.

In a Venezuelan jungle, an Indian shaman sinks into a trance and hurls “magical death” toward enemies in a distant village.

On Martha's Vineyard, New England's last living harpooner recalls the whale hunts of his youth.

A wildlife biologist in Florida counts hawks—snail-eating Everglade kites—and sadly registers only 34.

Such are some of the people you'll meet—in their fascinating environments—in the four books of the 1973-74 series of National Geographic Special Publications. The first, *American Mountain People*, is available now; others will follow at three-month intervals.

This latest quartet of handsomely illustrated low-priced volumes continues a phenomenally successful publishing endeavor. Since its inception in 1965, the Society's Special Publications Division has distributed nearly eight million copies of 28 books to Society members. Most of the subjects, ranging from the Nile River to the Civil War, were suggested by members themselves.

In the 200 color-filled pages of *American Mountain People*, skilled writers introduce you to the country's steadfast highlanders—proud folk as rugged as the stony soil they till. Follow the roads of gumbo clay to weathered Appalachian communities with names like Slab Fork and Marrowbone, where coal means both black gold and black lung. Fly by bush plane into the snowbound village

of Stehekin, high in Washington's Cascades.

In the Ozarks of Missouri and Arkansas you meet craftsmen and musicians, and hunt wild ginseng root (worth some \$30 a pound!) up near Roasting Ear Creek. And you find the common denominator among the West Virginia blacksmith, the Colorado high-country rancher, and the solitary homesteader in California's snowy Sierra: a profound respect—transmuted to abiding love—for their mountain homelands.

The pages of *Primitive Worlds*, second in the new series, bring into focus six widely scattered peoples of this planet—peoples “lost in time.” Their material culture is simple, and they lack government as we know it; by these standards we call them primitive. But the tribesmen of the far Pacific, Africa, and the Americas lead fascinating lives, often more logical than our own.

“When my wife and I first arrived,” writes



BRUCE DALL

Still in fine fiddle, octogenarian Dolle Gilbert plays the foot-tapping music preserved in her native Ozark hills. *American Mountain People* opens a nostalgic window to the past. This first of four new Special Publications is now available.

anthropologist Wilson Wheatcroft, “and they discovered that beneath our heavy boots were soft, pinkish feet like a baby's, they laughed, and everyone wanted to touch them.” With “primitive” hospitality, the Tifalmin of New Guinea promptly built a house for Wilson and Peggy Wheatcroft. And when they prepared to leave two years later, the villagers offered to buy the couple from Wilson's parents so that they might stay.

Over the past eight years, working among

the Yanomamö Indians of southern Venezuela, Dr. Napoleon A. Chagnon gathered the material that appears in his chapter of *Primitive Worlds*. The "Fierce People," as they call themselves, wage war with spirit allies as well as with arrows. On a jungle trail Dr. Chagnon takes part in a nervous peace parley between two villages, ending—temporarily, at least—20 years of treachery and bloodshed.

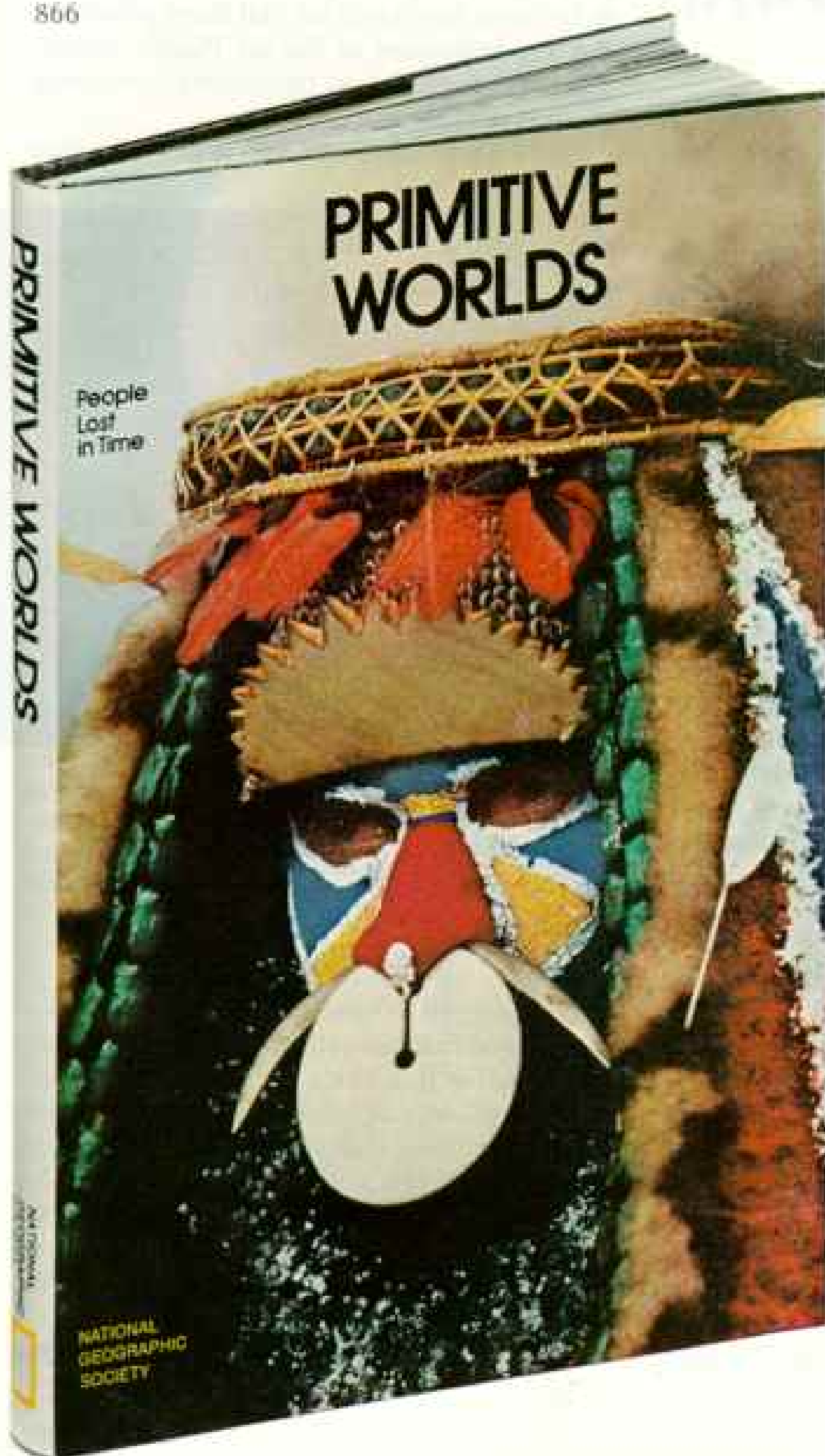
You'll visit, too, such peoples as the Somba of northern Dahomey, West Africa, who build miniature mud-brick castles in defense against belligerent neighbors; Kenya's proud Turkana; and the Tarahumara of Mexico, virtually unchanged since the Spanish conquest.

America's Inland Waterway, third in the

series, takes you coasting with GEOGRAPHIC Senior Assistant Editor Allan C. Fisher, Jr., down the remarkable 2,000-mile water highway from Massachusetts to Key West.

Cruising New England waters in the wake of the whalers, author Fisher puts in to storied ports like New Bedford and Newport, Woods Hole and Vineyard Haven. Living history permeates the route, from Connecticut's Mystic Seaport—one of the world's great maritime museums—to Cape Kennedy, where spacecraft lift off over shoals on which Spanish treasure galleons foundered.

Americans are heading for the water in lemminglike waves, in more than seven million boats by latest estimate. They seek, in



E. RICHARD BODERICH

Seashell moustache adorns a warrior of the New Guinea highlands (left). A New Hebrides villager displays cult objects from a men's ceremonial house. Little touched by civilization, the varied cultures of these and other remote groups unfold before you in *Primitive Worlds: People Lost in Time*.

Mr. Fisher's words, "release... freedom—a closeness to nature." They sometimes find a traffic jam: Near Manasquan, New Jersey, 6,000 craft crept under one railroad bridge in a recent 12-hour holiday period. But, reports the author from the helm of the 43-foot motor-sailer *Andromeda*, you find astonishing stretches of pure wilderness along the Intra-coastal Waterway—the tidal marshes of Georgia, for example, where a sea of grass reaches for the horizon like a tawny African plain.

Just a placid, unadventurous ditch? Try groping around Cape May in a woolly fog. Or brave North Carolina's Neuse River or Albemarle Sound aboard *Andromeda* when a blue norther whistles down! You'll be glad

to dock at Florida's glittering cities by the sea.

A Marine Corps sergeant-major in California, concerned over the growing peril to America's wildlife, wrote the Special Publications Division urging, "Please add your voice to those of our great naturalists!" We reply with *Vanishing Wildlife of North America*, fourth of the current series, by Geographic editor-writer Thomas B. Allen.

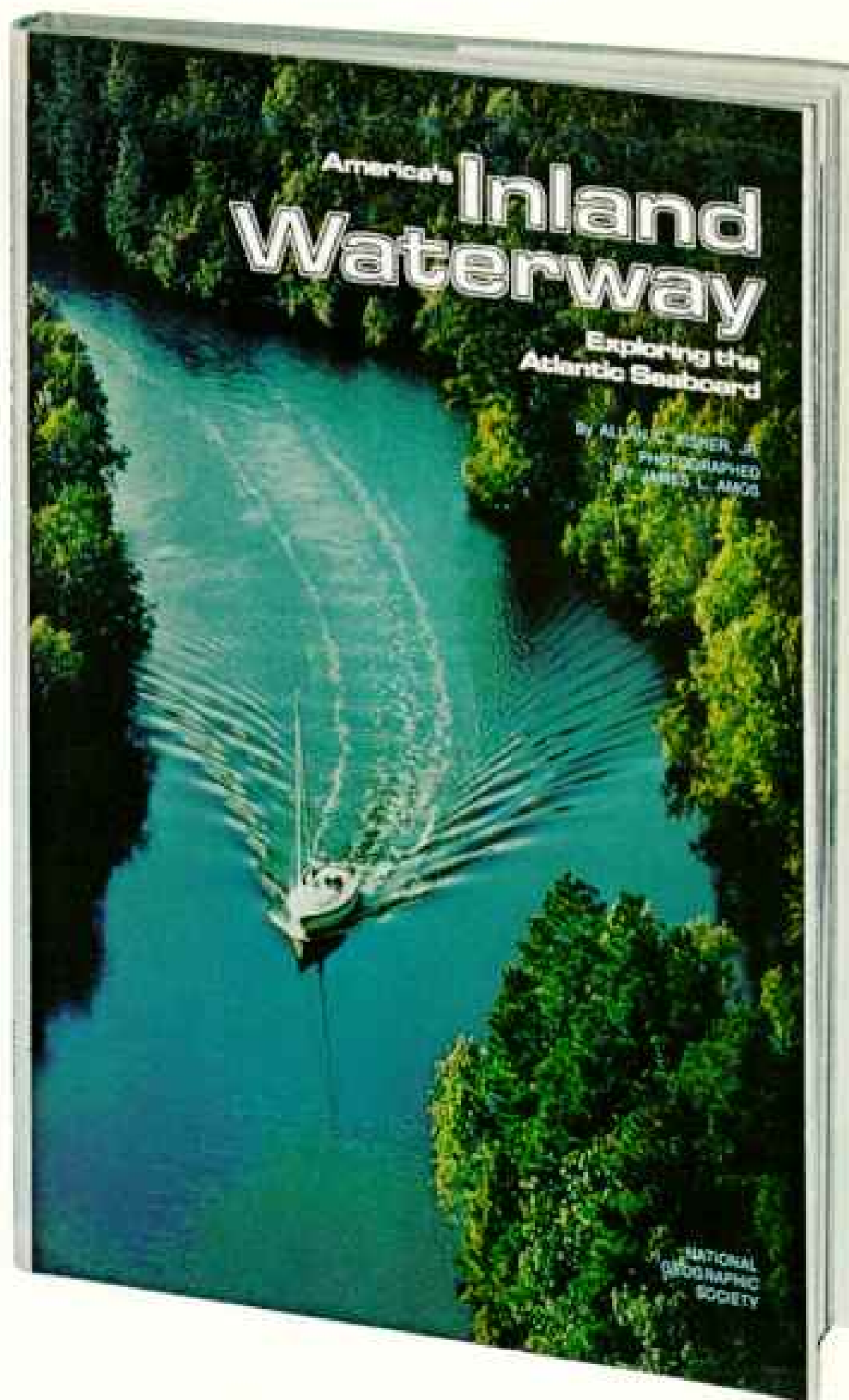
In the 1920's, Tom Allen reports, the graceful Everglade kite skimmed over nearly every freshwater marsh in Florida. After decades of draining and hunting, however, scarcely 15 of these birds survived by the 1960's. Federal Wildlife Biologist Paul W. Sykes, Jr., today can vouch for 34—the number he has banded.

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BOY BY JAMES L. AMOS

In quiet beauty or beneath roaring bridges of Manhattan, the *Inland Waterway* reflects the life of the eastern U. S. On the 2,000-mile voyage—Massachusetts to Florida—we see lobstering at Martha's Vineyard (below) and school days on a Chesapeake Bay island (above).



Fresh realms of experience await the entire family in the Society's four Special Publications for 1973-74.

Savor the folkways cherished by *American Mountain People*. Be among the privileged few who have penetrated the mysteries of *Primitive Worlds*. Explore the natural beauty along *America's Inland Waterway*. Join those working to save the *Vanishing Wildlife of North America*.

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He still finds kites senselessly slaughtered.

The alligator is one of more than 100 creatures on the U. S. Government's endangered-species list. Yet author Allen watched a legal "harvest" of these great reptiles in Louisiana: some 1,300 gators killed and skinned for shoes and handbags in 13 days. The new book explains this grim anomaly.

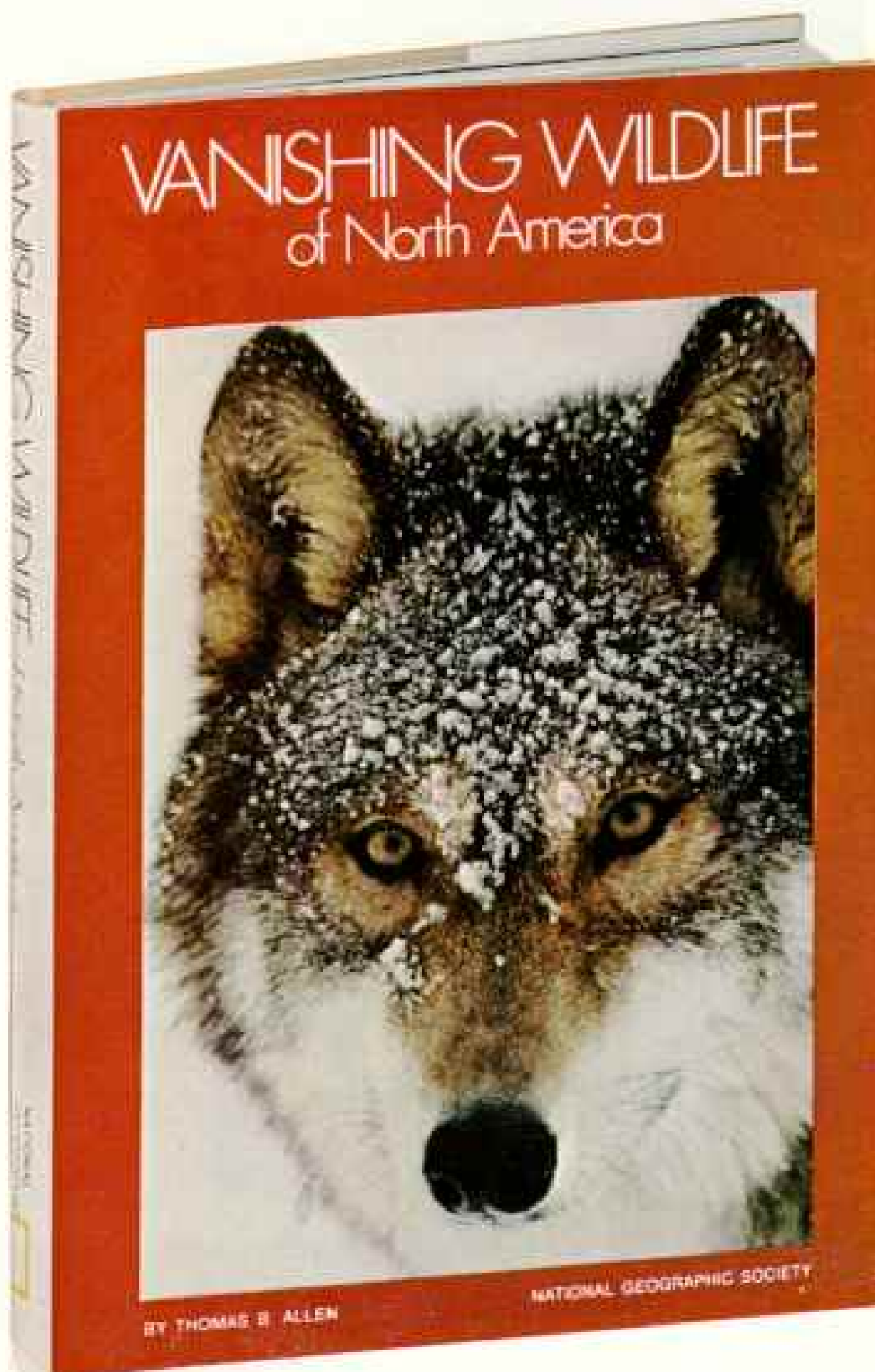
The rare red wolf in Texas may be breeding itself out of existence—by mating with encroaching coyotes. The California condor, largest land bird on the continent, desperately needs quiet. Death Valley's unique pupfish may be running out of water. Though the ground swell of conservation effort is rising, *Vanishing Wildlife* points out that these and scores of others are rapidly becoming

868

the mere remnants of once-thriving species.

With such books in mind, a Connecticut reader recently wrote, "... you have remained the environmental conscience of our country." It is one of thousands of messages of appreciation received by our Special Publications Division each year. "I have a library of about 2,000 volumes," wrote a member from New Hampshire. "Your various volumes on the world and its peoples are by far the very best in my collection." And from Oklahoma: "We were so pleased with the books we received that we want to order some more..."

You may reserve the latest four books in this landmark series for your own library—at no obligation—simply by filling out and mailing the postpaid coupon at left.



LOREN WILDTYRE

Wildlife SOS aims to save endangered species, including the roseate spoonbill (above) and the gray wolf, alert at left and tranquilized below. The book traces America's wildlife from past abundance to today's struggle for survival.



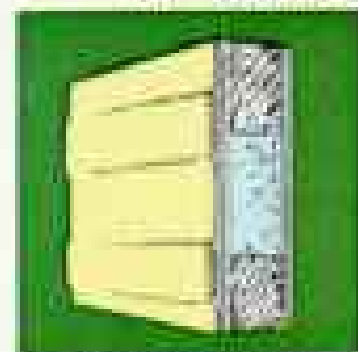
EMERY KRISTOF

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*Recreational Vehicle Institute "Facts and Trends" 1972.

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Beavers are busy again

PAUL BUNYAN might have hewn these six- to eight-foot stumps—but actually mere 40-pound beavers, standing atop snowdrifts, felled the aspens to reach tender branches. Once trapped to near extinction in many areas, these industrious architects are again damming streams across North America, helping check erosion, and maintaining the water table. Each family constructs a split-level lodge with sleeping and dining area above the surface and entrance and exit underwater. Below, a furry torpedo shoots from his back door. Your friends can enjoy a report on these skillful conservationists in a future issue; simply fill in the nomination form below.

EDITOR: DEAN DYER, PHOTOGRAPHED BY JEN AND DEE BARTLETT



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\$7⁵⁰ CALENDAR YEAR 1973 MEMBERSHIP DUES INCLUDE SUBSCRIPTION TO THE NATIONAL GEOGRAPHIC.

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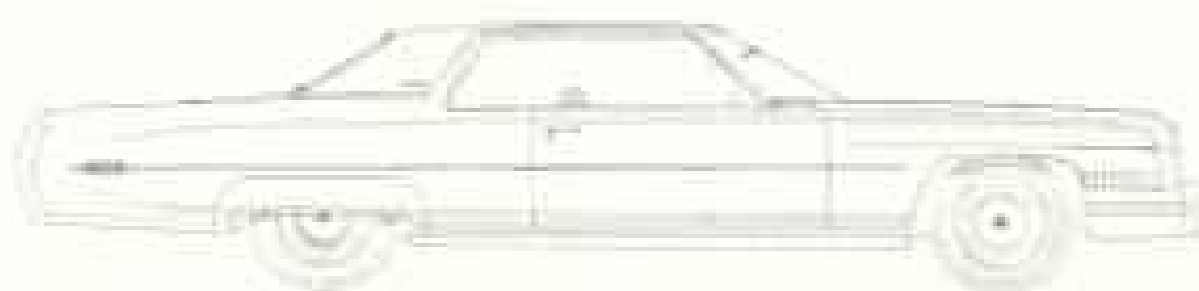
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To reserve your car at National call 800-328-4567 toll free. In Minnesota call 612-830-2345 collect. To reserve your Hilton Hotel room just call your nearest Hilton reservation service office. Ask for the Hilton Livery mini-vacation. Or call your travel agent to arrange for both car and room. *Certificate must be presented when you check-in. † If you wish to stay for 3 nights you pay for Thursday and Friday. We'll give you Saturday night free. © National Car Rental System, Inc., 1973. (In Canada it's Tilden Rent-A-Car.)

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SALAD A LA NICOISE

- | | |
|---|---|
| 1 package (9 oz) frozen whole green beans | 1 medium tomato, cut in wedges |
| 1/2 cup Mazola corn oil | 1 can (1 1/4 oz) pitted ripe olives, drained |
| 1/4 cup red wine vinegar | 1 can (2 oz) anchovy fillets, drained and chopped |
| 1 teaspoon sugar | 1 can (7 oz) tuna, drained and broken in chunks |
| 1/2 teaspoon salt | 2 hard cooked eggs, sliced |
| 1/2 teaspoon pepper | |
| 1 medium red onion, thinly sliced | |
- Cook beans; drain and place in 1-quart bowl. Measure corn oil, vinegar, sugar, salt and pepper into jar. Cover tightly and shake well. Pour half of dressing over green beans; toss. Cover and chill 1 hour. To serve, place beans in salad bowl. Add onion, tomato, olives, anchovy, tuna and half of egg slices; toss. Garnish with remaining egg slices. Drizzle remaining dressing over salad. Serves 4.

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(Hong Kong \$8.00)



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So, if you have something for the world to hear, make it your business, or pleasure, to spread the word by phone. It's the next best thing to being there.



We're famous for keeping
a light in the window.



We're old hands at hospitality and welcoming visitors.

In fact, we are the proud inheritors of the oldest established social club in North America.

It's official name was, and is, "The Order of the Good Times", and it was founded in Port Royal in 1605 by that dauntless navigator, Samuel de Champlain.

Today, we may no longer confront the visitor with hogsheads of rum and whole sides of venison, but the thought is the same: We want you to relax and have a good time.

Nova Scotia has the perfect places for it: famed resorts like The Pines at Digby and Keltic Lodge at Ingonish, with its mountain setting, sandy beach and championship golf course.

Whether or not you're ordinarily a seafood fancier, you'll want to enjoy at least one typical Nova Scotian shore dinner in one of the many characteristic inns and restaurants

you'll find along your way. Or, quite probably, someone will invite you home to dinner. Nova Scotians are like that.

Early settlers adapted traditional French, Scottish and German recipes to local foods, and the results are fascinating and varied. Be sure to try

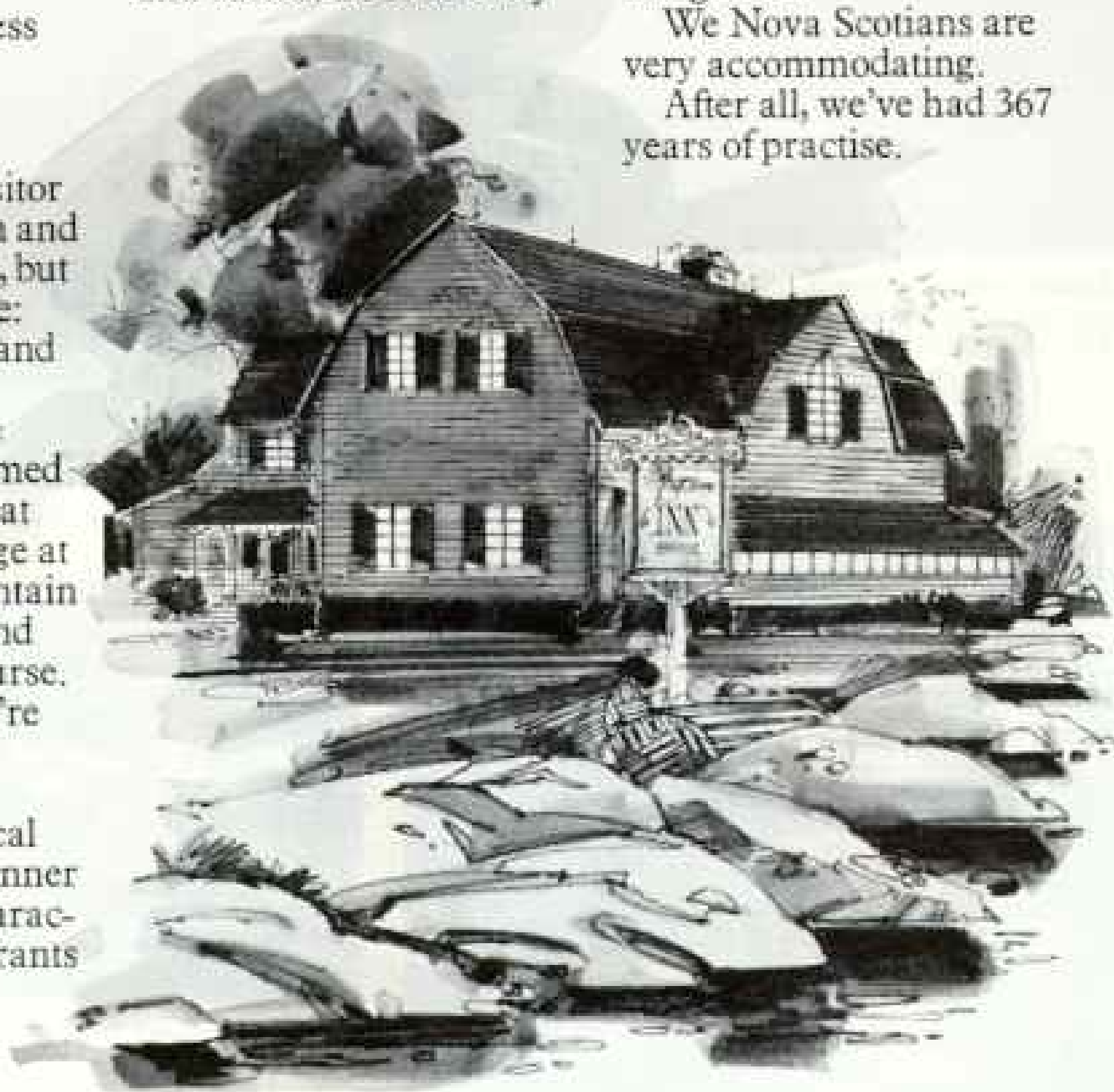
out such specialties as Digby Scallops, Solomon Gundy and Nova Scotia Fish Chowder.

You catch it, and we'll cook it.

Or, we'll catch it, and you cook it. Or, you catch it and cook it yourself. Or else, just leave the whole thing to us.

We Nova Scotians are very accommodating.

After all, we've had 367 years of practise.



Nova Scotia

Couldn't you use a little now?

For more information about Nova Scotia vacations, write to one of our Nova Scotia Information Offices, at the following addresses:

630 Fifth Avenue, Suite 3115, New York, N.Y. 10020. Area Code 212 581-2420/616 Forest Avenue, Portland, Maine 04101. Area Code 800 341-6709 (toll free in New England)/P.O. Box 130, Halifax, Nova Scotia.



Indians took their games seriously, for they carved gods on the monoliths which lined their playing fields.

Streets made of metal. They were paved with grey-blue blocks cast from residue of iron furnaces in Spain.



“Hey, Mom, did you know that Columbus discovered Puerto Rico on his second voyage?”

THAT'S WHAT our 10-year-old daughter, Cathy, told us when we arrived in San Juan last summer.

We rented a car and drove to the town of Aguadilla. That's where Columbus first touched land in 1493. Or so we thought, until we drove through several neighboring towns also making the same claim. Including nearby Aguada, which according to official records is indeed the place where Columbus first landed.



New friends came in all ages.

ACCOMMODATED BY MANUEL GONZALEZ



We all felt affection for this little schoolboy who turned out to be very camera-shy.



Everywhere in Puerto Rico we were greeted with bursts of color.



80 feet up. The rotunda of Puerto Rico's capitol has Venetian mosaics made in Italy from sketches by Puerto Rican artists.

"Well," my husband said, smiling, "I hope we've covered all the places where Columbus first landed."

We thought we were in Europe

In old San Juan, we saw early Spanish convents, colorful ships and narrow cobblestone streets that weren't made from cobblestone.

An elderly shopkeeper explained to us that they were made from the casting slag that was used as ballast on the Spanish galleons.

When these galleons left the New World filled with gold, the casting slag found use as road-building material.

From San Juan we went back even further in time. We drove to Utuado, a small coffee town, and visited a ball park that is guessed to be 700 years old.

It was believed that Indians under the great Chief Guarionex used to gather here from the surrounding mountains for ball games and important ceremonies.

We saw 700 years of history that day.

Flowering trees and sugar cane fields

The next day we drove to the beautiful tropical Rain Forest on El Yunque Mountain. And discovered the real highlight of the trip was the flowering trees that grew along the many winding roads throughout Puerto Rico.

Our daughter learned at school that sugar was one of Puerto Rico's main exports. So we decided to see how they made sugar from the sugar cane and visited one of the mills there.

On the way back, we came upon some school-children eating sugar cane by the edge of one of the fields.

Cathy saw this and exclaimed, "How come candy doesn't grow on trees at home?"

Our trip to Puerto Rico was an unforgettable experience. A vacation that we shared together. And we'd like to go someplace different again this year. Together.

How your children see the world depends on what you show them.

This summer you can afford to take your family someplace different. To Puerto Rico. To Walt Disney World. Mexico. The Caribbean. Florida or the Bahamas.

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30-foot fern trees and wild orchids abound in Puerto Rico's tropical Rain Forest.



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We believe in the customs of yesteryear. Like having tea and scones after tennis. Like saying "belki" and "thank you." And doing something nice even when we aren't required to.

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ATC 70



CT-70 K2



ST-90

Motorcycles for people who think they hate motorcycles.

Misgivings about motorcycles? Visit your nearby Honda dealer and give him a chance to change your mind. He'll show you good family fun in three models—ATC 70, CT-70 K2 and ST-90. Motorcycles as easy to ride as they are fun to ride.

You'll enjoy teaching your son to ride the little ATC 70 almost as much as he'll enjoy the learning. The three balloon tires roll happily over many kinds of terrain. For trail riding, it's hard to top the CT-70 K2. It comes with either hand (CT-70H K1) or automatic clutch. A snap to carry in car trunk or camper. The new mid-sized ST-90 handles roadways as well as trailways. Perfect companion for shopping trips in town, fishing trips in the country.

Every one of these little Hondas gives you some-

thing more than just the fun and excitement of riding. Each comes equipped with a certain feeling of confidence—Honda confidence. Famous dependable Honda four-stroke engines. Quick, sure brakes. Sturdy frames. The Honda warranty. And spark arrestor/mufflers to help keep the country quiet and green for all of us.

There are many different worlds of motorcycling at your Honda dealer—trail bikes, minibikes, dirt, on/off road and road bikes. The ATC 70, CT-70 K2 and ST-90 are in the Trail Section. Bring your whole family in and get to know these three motorcycles. Once you do, you'll learn to love them.

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From Mighty to Mini, Honda has it all.

For safety, we recommend that you always wear a helmet and eye protection, keep your lights on and check the local laws before you ride. "K" numbers in Honda model designations indicate model changes. For a free color brochure, write: American Honda Motor Co., Inc., Department RP, Box 70, Gardena, California 90247. ©1977 AHM.



Minolta helps you enjoy lunch with friends.

It takes a quick eye and a responsive camera to see the pictures that are everywhere.

If you have the insight, a Minolta SR-T could be the camera. This is a 35mm reflex you'll be comfortable with from the moment you pick it up. It lets you concentrate on the picture, because the viewfinder shows all the information needed for correct exposure and focusing. You never have to look away from the finder to adjust a Minolta SR-T, so you're ready to catch the one photograph that could never be taken again.

And when subjects call for a different perspective, Minolta SR-T cameras accept a complete system of interchangeable lenses, from "fisheye" wide angle to super telephoto.

Next time you come across some friends, be ready with a Minolta SR-T. For more information, see your photo dealer or write Minolta Corporation, 200 Park Avenue South, New York, N.Y. 10003. In Canada: Anglophoto Ltd., P.O.

Minolta SR-T 101/Minolta SR-T 102



When identified by a factory-sealed "M" tag, Minolta 35mm reflex cameras are warranted by Minolta Corp. against defects in workmanship and materials for two years from date of purchase, excluding user-inflicted damage. The camera will be serviced at no charge provided it is returned within the warranty period, postpaid, securely packaged, including \$2.00 for mailing, handling and insurance.



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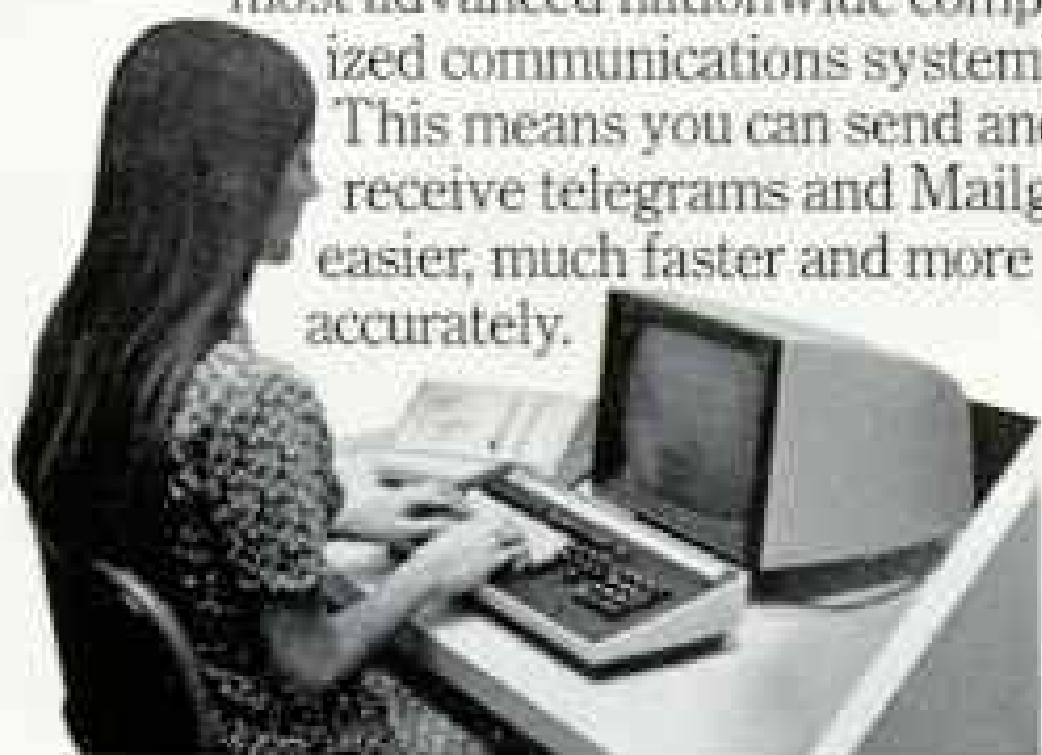
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How Western Union is improving the nation's communications.

Over the past seven years, we've invested one billion dollars to rebuild our century-old company.

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Ecology is everybody's baby...

It's not just the concern of the fellow with the big smoke stack or the one polluting the stream, but everybody's job, to keep America beautiful.

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Figureheads are almost as old as sailing itself. Early Egyptians used them. So did Phoenicians and Vikings. They decorated prows of their ships with carved heads of horses, birds, and wild-eyed dragons. These, the ancient mariners believed, invoked the protection of guiding spirits.

Dawned the age of exploration, the spirits were largely forgotten. But not the figureheads. In England trained hands carved everything from Poseidon with his trident to St. George in wooden armor.

Colonial craftsmen brought the skills to America. In a vacant sail loft near the wharf the ship-builder would chalk on the floor full-scale plans for the figurehead he envisioned below the

bowsprit. The carver marked out the design on a block of seasoned wood and shaped it with mallet and chisel. Some figureheads he drew from live models, perhaps the shipowner's daughter.

Often a carving personified the ship's name—*Twin Sisters*, for example. Or *Joseph Conrad*, whose figurehead is portrayed here.

A tribute to the renowned writer-seaman by another of the same breed, the magnificent head came into being shortly after Capt. Alan Villiers acquired the old Danish square-rigger *Georg Stage* and renamed her in honor of Captain Conrad.

"A sailing ship had to have a figurehead," he declared. "The lovely sweeping lines of her cut-water looked wrong without one." So he asked his friend Bruce Rogers, the renowned typographer, to carve the bearded likeness.

Captain Villiers sailed *Joseph Conrad* around the world—a 57,800-mile voyage that lasted 555 days. He followed in the wake of early navigators, rounding Cape Horn under sail, as they did, and with their zest for exploration.

Villiers described the voyage

Woodcarver's art rode with captains courageous in the days of sail.

in the February, 1937, *GEOGRAPHIC*, echoing a haunting passage from an even earlier issue: "The unchangeable sea preserves for one the sense of its past, the memory of things accomplished by wisdom and daring among its restless waves."

The writer? Joseph Conrad. To Conrad those restless waves were peopled "with unforgettable shades of the masters in the calling which . . . was to be mine, too."

And so they also are to Captain Villiers, as witness his many adventure-filled narratives about men, ships, and the sea. In August, 1968, he took *GEOGRAPHIC* readers to Mystic Seaport, Connecticut, living museum of America's sailing past.

"I rubbed my eyes and looked again," he wrote. Among a maze of spars and rigging he had spied the jutting figurehead of the *Joseph Conrad*, now permanently moored as a training vessel.

It was a memorable moment he shared, this sequel to a saga that appeared more than 30 years ago. But such moments have come to be expected in the pages of *NATIONAL GEOGRAPHIC*.


Someday, you're going to need a Nikon



John Launois had a once-in-a-lifetime chance to photograph the Tasaday people, a "lost" stone age tribe in the Philippines. He was on an expedition to visit these cave-dwellers, who had been isolated from the world... perhaps for as long as 2,000 years.

The Tasaday live in a remote region of Mindanao Island—so inaccessible that to get there, Launois actually had to jump from a helicopter onto a platform on top of a 60 foot tree! He was the only photographer on the expedition, there'd be no chance to reshoot. His cameras had to be totally rugged and reliable. He chose Nikon. And only Nikon. The results tell the story.

Most people won't get even a first chance to photograph the Tasaday. But if photography's important to you, someday somewhere, you're going to see the photograph of your lifetime. Then you'll need a Nikon. Because you can depend on it to work in any extreme of cold, heat, humidity or lack of it. Or just for the feeling of confidence Nikon will give you. Over 40 superb Nikkor Lenses—unapproached in sharpness, number and originality—and the most complete system in all of 35mm photography, let you do anything that's photographically possible.

Nikon Cameras are used by a surprising majority of the world's photojournalists. But also by an awful lot of people who do most of their picture taking at home. They need a Nikon. If you're serious about photography, you do too. See your dealer, or write. Ask about Nikon School. Nikon Inc., Garden City, N.Y. 11530. Subsidiary of Ehrenreich Photo-Optical Industries, Inc.  In Canada: Anglophoto Ltd., P.Q.



**If it was just a station wagon,
it wouldn't be a Travelall.**



The INTERNATIONAL TRAVELALL may look like a station wagon. It may ride like a station wagon. But it isn't. It's much more.

For example, the Travelall has a durable, truck-built frame. Ordinary station wagons have ordinary station wagon frames.

The Travelall has more room inside than an ordinary station wagon—more room for kids, cargo, camping gear, groceries—whatever you have to carry. Over 125 cubic feet of cargo capacity when all the back seats are down.

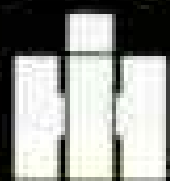
The Travelall has excellent visibility, because you sit higher than in most station wagons.

The Travelall has a low rpm, high-torque engine. You get to choose from four—including a big 392-cubic inch V-8.

The Travelall has an extra large cooling system to help avoid overheating, especially when towing. Which brings us to the final big difference between a Travelall and an ordinary station wagon—towing capability.

The Travelall is built to tow. Ordinary station wagons aren't. The Travelall's rugged frame, engine, and cooling system help make it an especially durable towing vehicle. And the Travelall gives you a tremendous choice of towing options—including a 5-speed transmission you can't get on any ordinary station wagon. But then, that's the whole point. There's nothing ordinary about it.

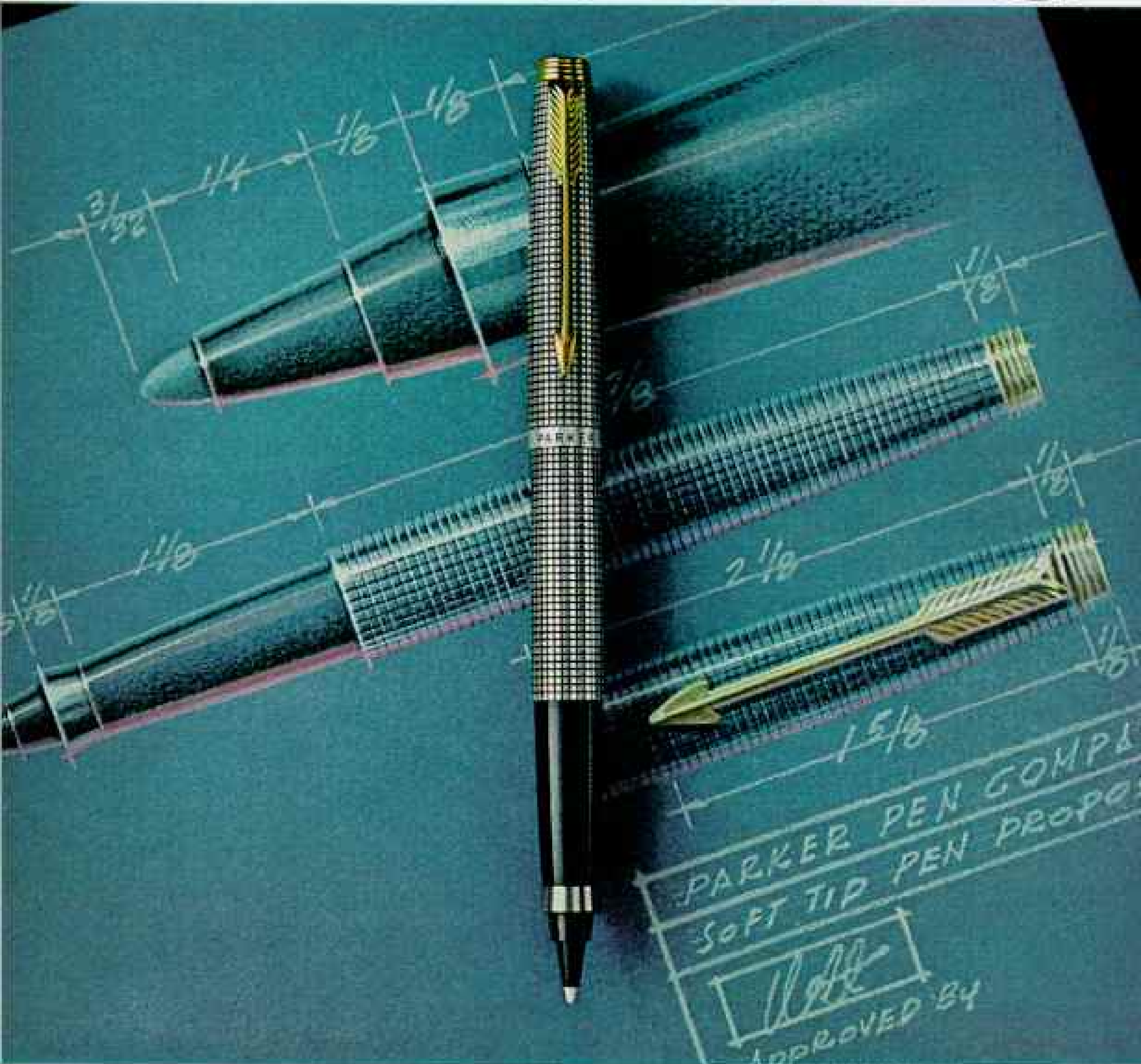
If there was, it wouldn't be a Travelall.



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It makes a memorable gift because you don't own it for a few weeks, or months. It's a long-term proposition. Guaranteed. In writing. If it fails to perform due to defects we will repair or replace it, free.

Go ahead, pick it up. The heft tells you it's solid silver.

Silver that grows more beautiful the more it's handled. Grid-patterned silver that gives the pen balance through hours of comfortable use.

Now get to the real pleasure. Write with the Parker 75 Soft Tip Pen. This pen is natural in hand, quick on paper, and free in its response. The simple act of writing becomes a new experience in self-expression.

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To make it extraordinarily accurate, we began with a tiny crystal of quartz.

When electric current is passed through this crystal, it vibrates exactly 49,152 times every second, so regularly that it becomes the heart of an excep-

tionally accurate time-keeping system.

To keep the watch accurate and dependable, we then incorporated this vibrating crystal of quartz into a highly sophisticated micro-computer system, packed with over 300 transistors.

The micro-computer system serves as the brain of the watch, to control its accuracy. If, for any reason, this accuracy should vary, the micro-computer system readjusts and restores the watch to its programmed accuracy. And the TIMEX Quartz Watch is engineered to be as rugged and dependable as you expect a TIMEX to be. The watch has an

adjustable metal band and a water and dust resistant case. Equipped with an automatic day-date indicator and sweep second hand, it's powered by a replaceable energy cell† that lasts for a year, so you never have to wind it.

At \$80 the TIMEX Quartz Watch is a tribute to American leadership in automation and electronic technology.

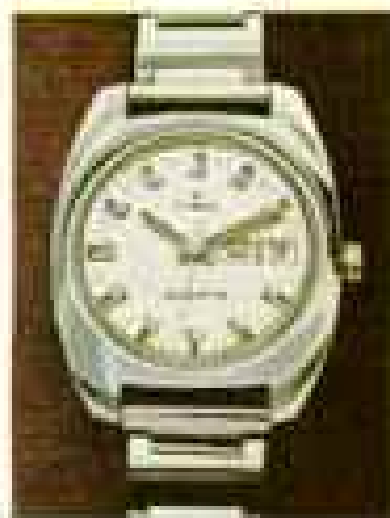
And chances are, if someone ever makes a less expensive quartz watch, it will probably be us.

THE TIMEX® QUARTZ WATCH. \$80

Large illustration: Model 968002, Small illustration: Model 969502.

*Regulation may be necessary to achieve this accuracy.

†We recommend genuine TIMEX Energy Cells. Other cells not meeting Timex specifications may cause a malfunction.



Central air conditioning is more than just equipment, it's the



Model shown is High Efficiency Series Model No. 81643 or 81684. Available at most Sears, Roebuck and Co. stores and through the catalog.

Treasures from the tomb reveal Chan Chan's past

Carbon-impregnated black ceramic vessel bears witness to an ancient kingdom as rich as a pharaoh's. Chan Chan, pre-Columbian capital of Chimor on the coastal desert of northern Peru, has yielded treasures for 500 years. Conquering Incas looted it in the 15th century. Conquistadores mined it for gold artifacts. Pedro Pizarro found a doorway slabbed with silver. *Hunqueros*—grave robbers—have been tunneling into the ruins ever since. A maze of mud-brick walls enclosed nine spacious compounds. These served successive monarchs as palaces in life,

as shrines in death. Huge adobe platforms honey-combed with chambers entombed kings, hoards of treasure, and human skeletons "stacked like cordwood"—bones of young women. They were apparently sacrificed to tend royal needs in the afterlife. Threatened by squatters, Chan Chan might have remained an enigma had not archeologists sponsored by the Society completely mapped and extensively excavated the city, puzzling out its past. Digging for facts rewards readers every month in the pages of NATIONAL GEOGRAPHIC.



people who stand behind it. And Sears has the Air Men.



The Sears Air Men are made up of almost 10,000 trained central air conditioning experts who can plan a central air system that exactly meets your needs. So you get an effective, efficient and economical cooling system for your home. Then they make sure the system is installed with care. So it works right and as trouble-free as we can make it . . . the first time. And when you need service, the Sears Air Men are only a phone call away.

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- 16-inch Globe with stand \$36.00

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"Pandamonium" reigns in the Nation's Capital. Hsing-Hsing, shown nibbling a stalk of bamboo, and his look-alike, Ling-Ling, are packing them in at the Washington Zoo. First giant pandas seen in America in 20 years, they came as ambassadors of goodwill from the

People's Republic of China. In return, the United States sent two musk-oxen—Milton and Matilda—to Peking. Rare as moon rocks, pandas in captivity number fewer than 20, most of them in China. It is hoped that the Washington pair will increase the number when

they reach maturity in 1976. Now two-year-plus juveniles, they frolic and fatten in separate quarters, eyeing each other through mesh fencing. To meet these and other exotic creatures, readers regularly turn to the pages of NATIONAL GEOGRAPHIC.

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