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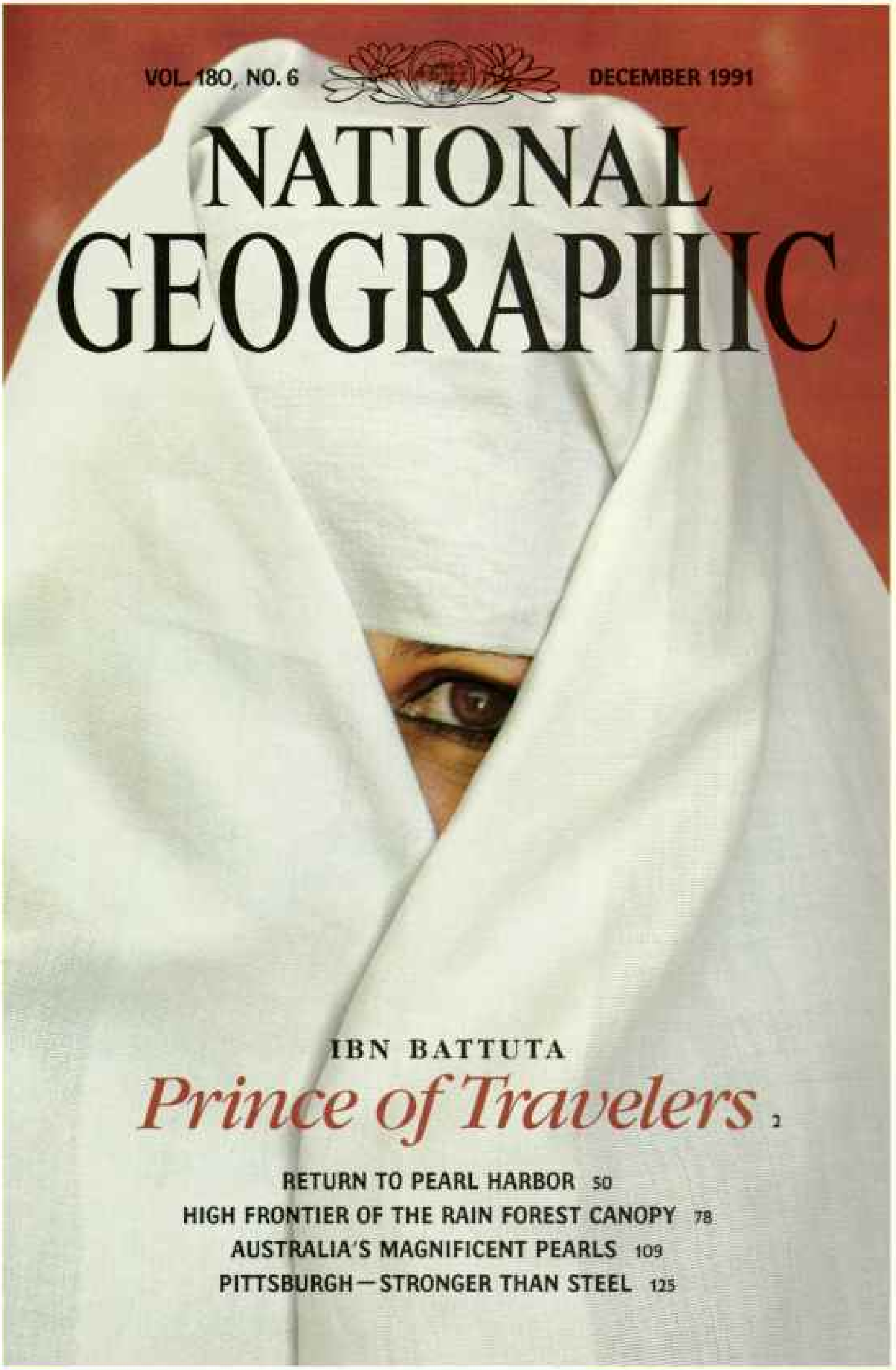

IBN BATTUTA
Prince of Travelers 2

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COVER: A veiled woman in Libya suggests the timelessness of the Islamic world explored by Ibn Battuta. Photograph by James L. Stanfield.

IBN BATTUTA

Prince of

By THOMAS J. ABERCROMBIE

NATIONAL GEOGRAPHIC SENIOR WRITER

Travelers

Photographs by JAMES L. STANFIELD
NATIONAL GEOGRAPHIC PHOTOGRAPHER

Almost two centuries before Columbus, a young Moroccan named Ibn Battuta set off for Mecca; he returned home three decades later as one of history's great travelers. Driven by curiosity and sustained by the Koran, he journeyed to the far corners of the Islamic world—from North Africa, where caravans still dare the Sahara, to China and back.

"IN THE NAME OF ALLAH, the Benevolent, the Compassionate," intones the blue-robed imam, his deep voice challenging the silence of the Sahara. Behind him, along a line he has scratched in the sand, men and boys of the caravan form a ragged rank, facing distant Mecca.

"Guide us on the straight path, the path of those you have blessed . . . not those who have gone astray," the imam prays, concluding the Koran's opening chapter, the *fatiha*, fitting invocation for a caravan departure. In unison the caravanners kneel, then bow, pressing their foreheads into the sand.

In the cool shadows of morning they rejoin the line of beasts tethered head to tail and wait for a signal. Beside me the *madougou*, or caravan boss, raises his staff, jerks the rope halter on his lead camel, and, to shouts and the clanging of pans and bowls, the half-mile-long train grudgingly lurches forward.

I walk along with madougou Idris Daouda. Like his grandfather, who led the prayers, Idris wears the long blue robes of a Tuareg tribesman and a voluminous black turban wrapped to veil all but his eyes. From a sling across his shoulder slaps a long broadsword in a dusty red scabbard. To my surprise when Idris drops back to inspect the beasts and their heavy loads of salt, he hands me his lead rope with only the briefest of instructions:

"Just don't stop," he says. "We would be all day sorting out the mess!"

I savor the glory of piloting such a menagerie. Pulling more than 400 camels behind me toward a stark horizon of sky and sand, I am right where I want to be: deep in the 14th-century world of an extraordinary traveler named Ibn Battuta. It is an Arabian Nights world of caravans, veiled harems, sailing dhows, whirling dervishes, and forbidden cities—a world of brigands and bow-and-arrow wars, of banquets with turbaned sultans and mirages wrought by threadbare fakirs. Most marvelous of all, much of it survives today.

As I tugged the lead camel, I reflected on how far Ibn Battuta had come at this stage of

Land Rovers of the Middle Ages, camels carried Ibn Battuta across the Sahara and beyond. In Cairo, where the pilgrim lingered on his first journey, camels at Imbaba market are hobbled to prevent straying.

his life. Already I had spanned half the globe retracing his incredible travels; there remained now only this final leg, across Niger in Saharan Africa. Thus would he and I complete a traverse of the diverse cultures linked by a common faith, in the powerful realm of medieval Islam.

In my own three decades in the Middle East I had often crossed the tracks of this pilgrim-jurist-courtier-mystic-politician-diplomat-explorer. Little celebrated in the West save in scholarly footnotes, his achievements are familiar among Arabs. In 29 years of relentless roaming, Ibn Battuta crossed two continents, logging some 75,000 miles (tripling Marco Polo's travels) through 44 countries in today's atlas.

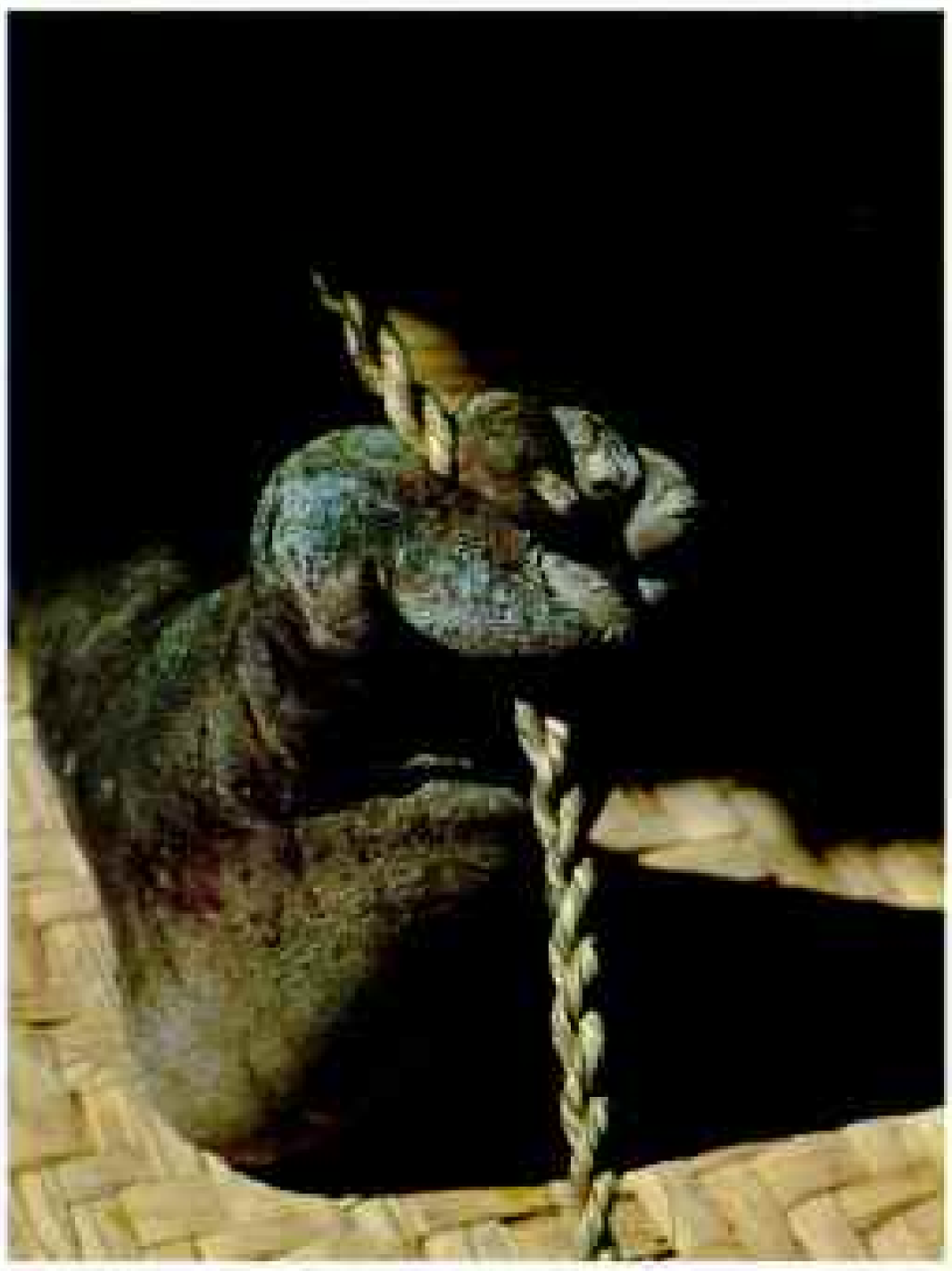
His memoirs brim with the flavor of his time, documenting a journey of hazard and hardship, opulence and adventure. It began in Morocco, when he was only 21.

"I LEFT TANGIER, my birthplace, the 13th of June 1325 with the intention of making the Pilgrimage to [Mecca]. . . . to leave all my friends both female and male, to abandon my home as birds abandon their nests." So begins his brittle Arabic manuscript, in the Bibliothèque Nationale in Paris, the 630-year-old narrative of Sheikh Abu Abdallah Muhammad ibn Abdallah ibn Muhammad ibn Ibrahim al-Lawati, also called Ibn Battuta.

Clearly he is famous in his own hometown.

Snarls and curses fill the air as Tuareg tribesmen launch a salt caravan in the oasis of Fachi, Niger. Cameleers weave their own ropes from palm frond, often using a callused foot to keep the braid tight (below).

Courtly and urbane, Ibn Battuta did not always relish the grinding hardships of travel. "An unattractive village," he complained of one Saharan town. "The water is brackish and the place is plagued with flies." Wherever he roamed, the traveler sought out educated, pious, or powerful Muslims, who usually showered him with hospitality. In turn, he regaled them with tales of distant lands and imparted his Koranic wisdom.



Near Tangier's stadium a modern globe marks the small Place Ibn Battuta. I found the Hotel Ibn Battuta on Rue Magellan closed for renovation, but just down the hill I munched an Ibn Battuta burger at Le Café Ibn Battuta. There, you can watch the yellow ferry M.V. *Ibn Battuta* arrive from Spain, just 19 miles across the Strait of Gibraltar.

At the Tangier Culture Center, director Ouasini Arafat was preparing an exhibit of Ibn Battuta portraits by Moroccan artists.

"Of course they had little to go on," Mr. Arafat said. "No likeness of our famous traveler exists." Most canvases showed a bearded scholar with penetrating eyes, cloaked in a hooded Moroccan robe and carrying a traveler's staff.

Commanding the African side of the strait, strategic Tangier had long been a cosmopolitan town ruled in turn by Phoenicians, Romans, Vandals, Arabs, and Spaniards. Perhaps tales told by passing merchants, soldiers, and sea captains fanned a wanderlust in young Ibn Battuta. Barely had he finished his studies when he set out across North Africa for Mecca, 3,000 miles away. Attaching himself to various caravans, he took ten months, crossing Algeria, Tunisia, and Libya, to reach Alexandria in Egypt. He describes its great harbors and famous lighthouse, one of the Seven Wonders of the World, already faded into ruin.

Always he sought out a region's savants and holy men. In the nearby Nile Delta

village of Fuwa he stayed at the retreat of a renowned mystic, Sheikh Abu Abdullah al Murshidi. While sleeping one night on a leather mat atop the roof of the sheikh's humble cell, Ibn Battuta saw his future unfold.

"I dreamed that I was on the wing of a huge bird," Ibn Battuta writes, "which flew with me in the direction of [Mecca], then made toward the Yemen . . . and finally made a long flight toward the east, alighted in some dark and greenish country, and left me there."

Next day Ibn Battuta was amazed to find that the mystic knew about his dream. The sheikh added interpretations, telling him that he would travel to the Orient. A miracle, Ibn Battuta considered it. The holy man then provisioned him with cakes and silver coins.

Ibn Battuta arrived in Cairo during the rule of the Mamluks, the "slave" dynasty. These sultans passed power not from father to son but through Circassian slave boys brought up to be generals and administrators. Yet Mamluk Egypt flourished. Ibn Battuta mentions the populace "flowing like waves of the sea through [Cairo's] narrow streets," and reports on the city's "12,000 water carriers," "its 30,000 porters," and "36,000 boats . . . that ply the Nile," as well as

"a free hospital . . . that dispenses treatment and medicines with reported endowments of a thousand dinars a day." A small government eye clinic now operates on the site.

Surprisingly, Ibn Battuta seems never to have visited Egypt's famed Pyramids. In the worst gaffe of his narrative, he refers to them as cone-shaped.

CAIRO IS A CITY for all centuries. Today it is only a five-minute taxi ride from the coat-and-tie crowd in the subway stations of Tahrir Square to the medieval suq around the Khan al-Khalili. I drifted with the pedestrian waves along Muizz Street, where vendors sold walking canes, glass-and-chrome hookahs, and saddlebags. Around the corner, amid prayer beads, belly dancers' costumes, and incense, the owner of the 1001 Nights Perfume Shop tried Harem, Tut-Ankh-Khamun, and Secret of the Desert on my wrist.

"Or, perhaps we can blend you a custom fragrance, sir?"

In Cairo I took to stopping for Turkish coffee and puffs on a charcoal-fired hookah at Fishawi's, a run-down café furbished with carved woodwork and cut-glass mirrors. A bootblack with a silver tongue ("A shame for such a handsome man to be wearing such dirty shoes.") kept my boots gleaming.

Fishawi's was peopled with old men in

Committing the Koran to memory—as Ibn Battuta is thought to have done by age 12—children recite for their faqih in Tangier, Morocco, the traveler's hometown. Ibn Battuta's memoirs left only one clue to his appearance: As a recent amateur portrait shows (left), he wore a beard.

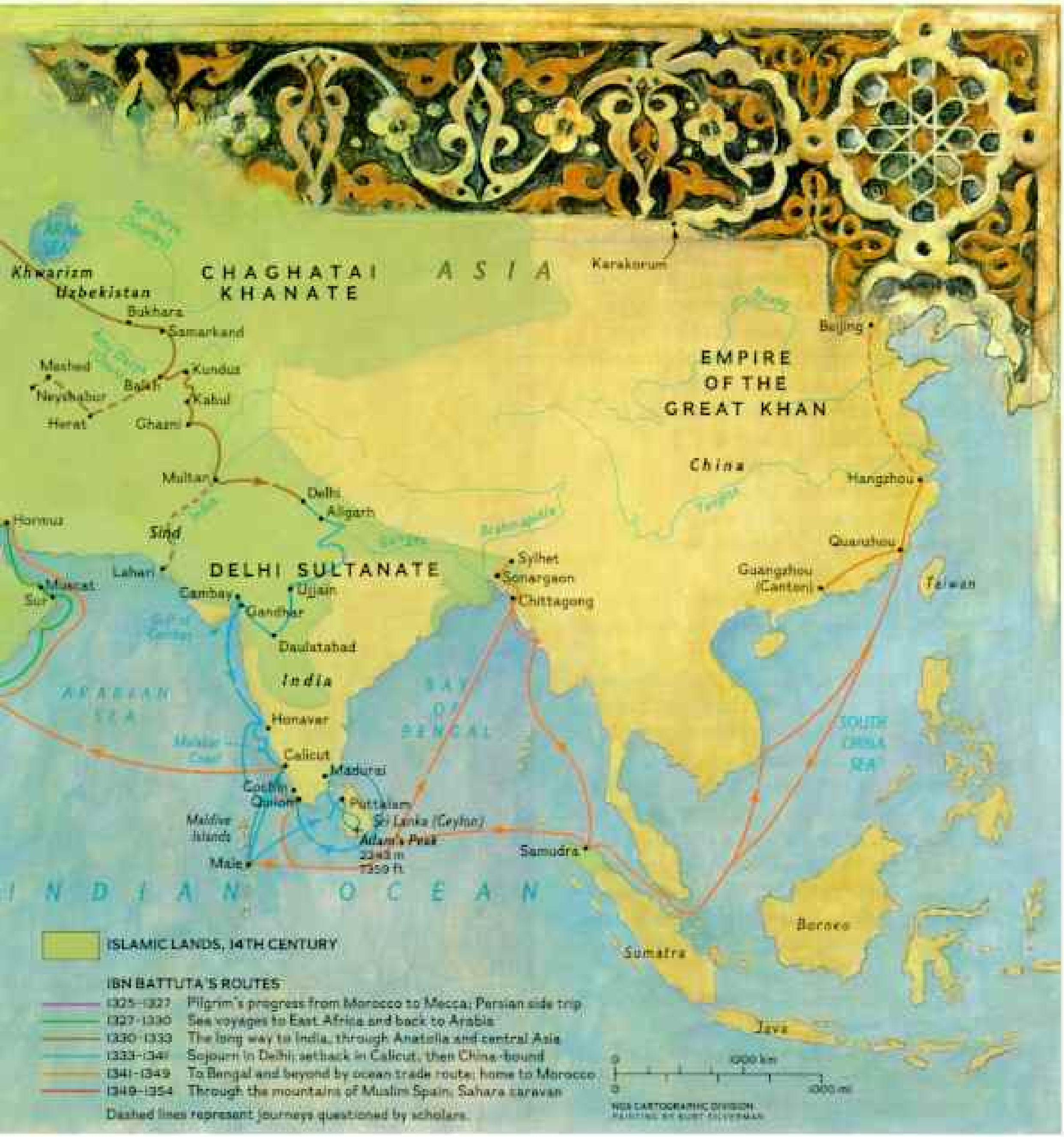
long galabias, chatty students from nearby Al-Azhar University, tourists in shorts and T-shirts. And then there was Mama Nazirah, a kind of resident mystic.

Mama Nazirah steered me to some of Cairo's Islamic mystics, the Sufis. Members of various Sufi orders, found throughout the Islamic world, seek reality beyond the grasp of intellect in a direct, loving communion with Allah. Following Ibn Battuta's example, I often sought out such esoterics.

Saturdays, in the courtyard of Zein al-Abdin Mosque near Cairo's City of the Dead, devotees from the poorer quarters gather under colored lights to the cadent spell of flute and drums. Wearing agate prayer beads and a red fez wrapped with a green turban, the tall, clean-shaven master led the emotional *dhikr*, a "memorial service to God," waving the rhythm with a gilded baton.

"Allah! Allah! Allah!" the chant continued for half an hour, with hypnotic effect, then veered from prayer to poetry:

Stranger in this world
Shepherding the night stars
Sleepless, forlorn. . . .



Emotions flowed. Before the evening was over I saw women swoon, grown men break into tears.

"I believe in all religions," one elder told me. "Muslim, Christian, Jew—are we not all sons of Adam? What matters is Allah, the one God." Gray locks tinted with henna, he carried a crooked staff, the badge of a wandering dervish. He invited me for tea at his home-of-the-moment in the City of the Dead.

An estimated million of Cairo's swelling population, short on money or unable to find lodgings in the crowded metropolis, dwell in

"Swayed by an overwhelming impulse," 21-year-old Ibn Battuta left Tangier for Mecca in June 1325. Over the next 29 years that impulse carried him to Islamic outposts from Sumatra to Mali and returned him at least four times to the sacred city. His journeys totaled 75,000 miles—three times the distance logged by his European predecessor, Marco Polo.

cemeteries that border the city's eastern flanks. They sometimes hook up to power lines; they find water where they can. The elder and I walked through a labyrinth of

Honeycomb of vegetable dyes awaits the tanners of Fez, who dress sheepskins and cowhides in earthen vats. Returning to Morocco after decades on the road, Ibn Battuta stopped briefly in this city—and found there is no place like home. When he retired from travel in 1354, he settled here and dictated his memoirs.

tombs to the crate-lumber shanty he shared with a gravedigger's family, set around a mausoleum built in elegant Turkish style. The shack was furnished with only a mattress and a small black-and-white television.

His name, the dervish told me, was Abu Abdu. But of his life he revealed little.

Where are you from originally?

"Only Allah knows."

How do you make your living?

"I commit myself to Allah's hands."

Will you stay long in Cairo?

"Allah will decide. It is written—everything, down to the tiny teacup in your hand."

ALONGSIDE FELUCCAS, the same lateen-rigged dhows that haul pottery or limestone along Nile shores today, Ibn Battuta marched to Upper Egypt and crossed the desert to the Red Sea to embark for the hajj, or pilgrimage. Mecca now lay only 200 miles across the sea, but all ships had been destroyed in a local revolt. Frustrated, he returned to Cairo and resolved to take the pilgrim caravan from Damascus. He set out across the Sinai, entering Palestine at the seaside oasis of Gaza.

"It is vast and well populated, decorated with beautiful squares and many mosques. No walls circle it," he writes of the town.

He wouldn't recognize today's Gaza, an urban battlefield in the *intifada*, the continuing struggle between Palestinian nationalists and the Israelis.

It took me an hour to pass through the checkpoint in the wall of soldiers that surrounds Gaza, security control for the thousands of Arabs who file in and out each day to work in Tel Aviv. In Gaza I drove down stark thoroughfares littered with stones and burned-out cars. Shops were welded shut and sprayed with Arabic graffiti: "Arafat is our ruler!" or "Shamir, back to Poland!"

"Dir balek! Hijarah!" a man suddenly shouts from the street: "Watch out! Rocks!" A band of schoolboys unleashes a hail of stones that dent my rental car. It bears yellow

(Israeli) license tags, not the blue ones issued to Palestinians. An Israeli Army 4x4 full of soldiers with rifles arrives and becomes the boys' target. The soldiers order me to follow them, and I hurry to comply, lest I provoke another incident.

Ibn Battuta's account of Palestine reads like a pilgrim's guide. "I visited Bethlehem, the birthplace of Jesus (on him be peace)." In Hebron he inspected the tombs of Abraham, Isaac, and Jacob, prophets holy to Muslims, Christians, and Jews; in Jerusalem he describes the Mount of Olives and the church where the Holy Virgin was said to be buried.

He prayed in the Haram al-Sharif mosque, in Ibn Battuta's time the largest in the world, built on the ruins of Solomon's Temple. The

mosque's golden dome, today the very symbol of Jerusalem, dazzled the traveler, who wrote that it "glows like a mass of light and flashes with the gleam of lightning."

In normal times busloads of tourists, as well as worshipers, crowd the Dome of the Rock. But I found it nearly deserted.

"Since the intifada began, business has dried up," tourist guide Khalil Abuhamdeh shrugged.

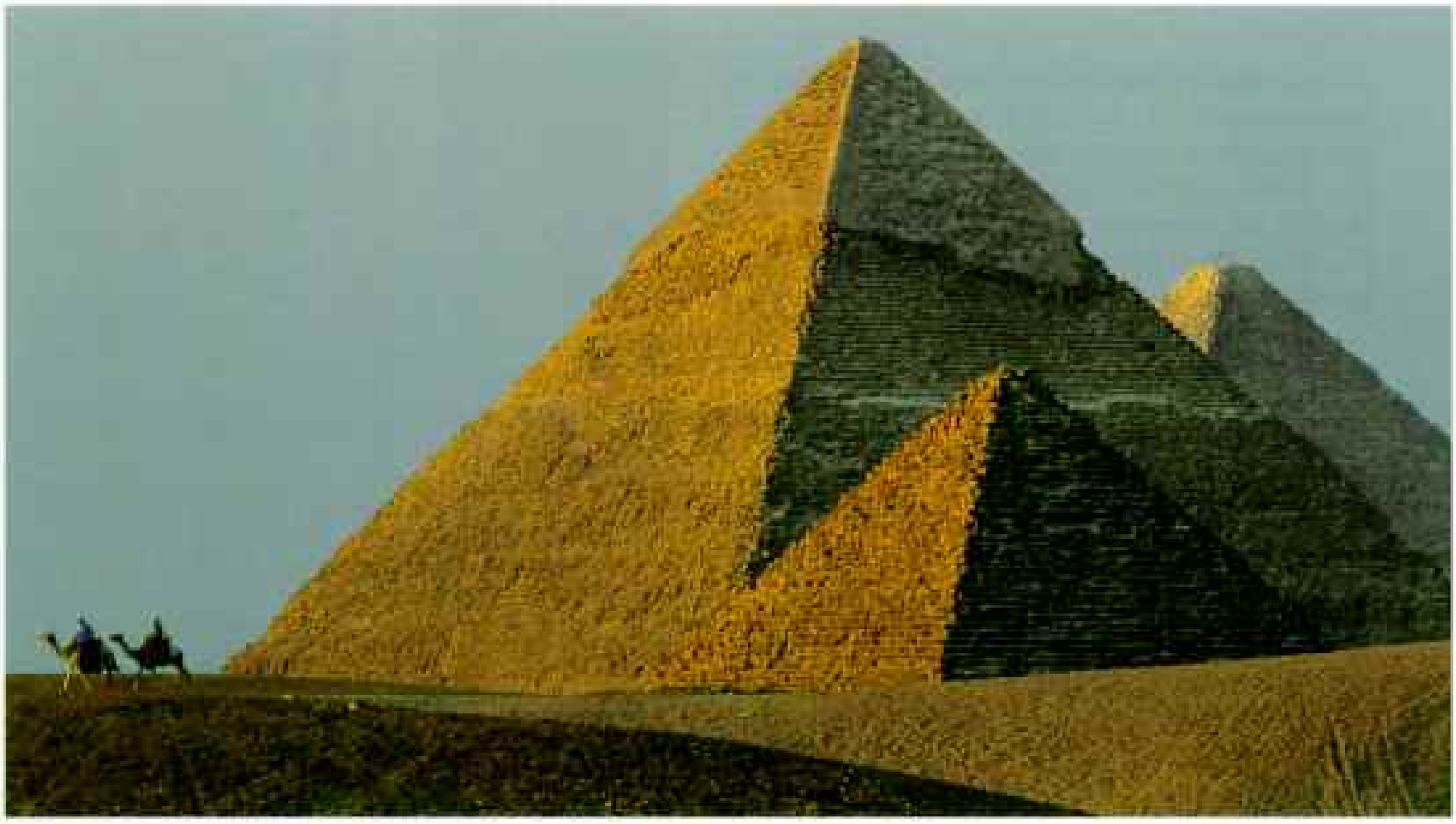
From Jerusalem Ibn Battuta's journal follows the Mediterranean coast through Acre and Tyre to Beirut, "a small place but fine bazaars," and Tripoli, where he climbed inland again to Hamah, one of the "elegant cities of Syria . . . surrounded by orchards and gardens, supplied by water wheels."

Today a few of these wooden giants still creak and groan, lifting water to aqueducts 50 feet above the Orontes River. He agrees with an earlier traveler who compared Aleppo's charm to that of a woman who "shines like a bride." From Antioch in Turkey he journeyed south through Latakia and the Lebanon Mountains to join the hajj caravan in Damascus.

The large, well-organized caravans marched 55 days across the Arabian desert to Mecca, halting for a few days to refresh themselves under a crusader castle at Al Karak in what today is Jordan. Thirst and bands of robbers made it a hazardous trail. Small forts and cisterns still punctuate the toilsome stretch. *(Continued on page 19)*

Like a hot desert wind, prize steeds race past onlookers at a horse club in Benghazi, Libya. Ibn Battuta's caravan crossed North Africa in 1326, escorted by a hundred horsemen to protect

against marauding tribes. Battling disease and loneliness, the pilgrim took comfort in his destination: "If God decrees my death, it shall be on the road with my face toward Mecca."



The road to Mecca took Ibn Battuta through Egypt and up the Nile, to villages like Deir el-Gharbi (left), where residents craft jugs made of Western Desert clay. Scholars question whether he actually visited the famed Pyramids, which he described as cone-shaped.

I spent the night at one such reservoir with a clan of Bedouin who lifted water for their camels and sheep using a 40-gallon leather bucket hauled up by their Toyota pickup.

Clad in the ihram, the seamless white cloth of a pilgrim, Ibn Battuta and his companions arrived in the Holy City of Mecca. "We presented ourselves forthwith at the Sanctuary of God Most High. . . . and saw before our eyes the Kaaba (may Allah increase its veneration) . . . surrounded by companies that had come to pay homage. . . . we made around it the seven circuits . . . kissed the Holy Stone . . . drank water from the [sacred] wells of Zamzam . . . then took up lodging in a house near the Gate of Ibrahim," he writes.

He goes on to describe the many rites pilgrims perform: the day of prayer under the Mount of Mercy at the nearby Plain of Arafat, the stoning of the pillars at Mina symbolizing rejection of the devil, the killing of a sheep for Islam's principal holiday, the Feast of the Sacrifice. As is his habit, Ibn Battuta introduces us to local notables: a devotee who spent his waking hours piously circling the Kaaba, another who cut off the hand of a ruffian caught stealing from pilgrims.

He praises the Meccans for "consummate generosity . . . liberal to the poor . . . kindly to strangers." The qadi, or judge, of Mecca, one Najm al-Din Muhammad, "distributes an immense quantity of food on the occasion of great festivals."

SIX CENTURIES LATER I found this tradition had not waned. Last year, on my third pilgrimage, I was invited to a lunch with His Majesty Fahd ibn Abdul Aziz, the Saudi King, at his hilltop fortress just outside the Holy City.

Arabic coffee was served in the 200-foot-long audience hall from gleaming brass pots, poured by robed attendants armed with daggers sheathed in gold. After His Majesty greeted each of us, the Saudi Minister of Pilgrimage blessed the occasion with a passage from the Koran, and we sat down to the intimate lunch—His Majesty, myself, and 588 diplomats, journalists, and religious leaders in the white marble dining room. One hundred roast sheep were set out on giant trays of steaming rice, along with fish, shrimp, salads, and baskets overflowing with fruit.

I had already completed the orthodox rituals of the pilgrimage, unchanged since set by the Prophet 14 centuries before, when I was invited aboard a Royal Saudi Air Force helicopter by Capt. Khaled al-Mugbil.

"From up here you see all two million pilgrims at once," the American-trained pilot said over the intercom. The marble minarets of Mecca's Grand Mosque appeared behind the granite hills, then its crowded roof

Allah's name rolls from the tongues of Muslim mystics, or Sufis, seeking God through rhythmic chants at Cairo's Sayida Zeinab Mosque. Ibn Battuta often sought counsel from mystics during his journeys; a seer in Alexandria was the first of two Sufis to predict that the pilgrim would travel far beyond Mecca.

and courtyard flowing with half a million white dots circling the black, cube-shaped Kaaba. Instinctively perhaps, the pilot banked counterclockwise around the pious spectacle, and seven times we circled the center of the Muslim universe.

"What better way to enter paradise than with the angels," he said.

Ibn Battuta would have recognized many of the landmarks that slipped beneath our magic carpet, but he would be stunned by the vast changes. The Saudis have spent billions to keep up with the growing tide of pilgrims. For the one-day ceremony at Arafat they set up 100,000 tents, many of them with air conditioning. Beneath us passed a mile-long caravan of trucks loaded with bottled water; a body marching in this sun needs a gallon a day. We swept over the new freezer plant at Mina that processes the million-plus sheep sacrificed by the celebrants, the Lost-Pilgrim Compound manned by Saudi Boy Scouts, the Sunstroke Center. New 12-lane expressways from the sandy outlying sites tunnel straight through the mountains that surround Mecca and its mosque. All were chockablock with buses, cars, and pedestrians.

Next day, the crowding provoked one of Mecca's worst tragedies. As a throng of 50,000 was surging forward, seven people fell from a bridge leading to a pedestrian tunnel; in the ensuing panic 1,400 died.

PERHAPS TALES by fellow sojourners in the Holy City urged Ibn Battuta on. He signed up with a caravan of hajjis returning to Baghdad. The trail snaked northeast to the Euphrates, over the same deserts crossed by the troops of Operation Desert Storm last February.

Ibn Battuta left his caravan to spend time in An Najaf, Iraq's southern gateway, a pilgrim city in its own right for followers of Islam's Shiite sect. Here the Shiites, a majority in Iraq and Iran, attend the gold-domed tomb of their martyr, Ali.

Ali, the Prophet's son-in-law, had been appointed his fourth caliph, or successor, but in A.D. 661 he was fatally stabbed by opponents and buried here. The fundamentalist Shiites, partisans of Ali, although constituting only 10 percent of the world's nearly one billion Muslims, pose a potent political force. Ayatollah Khomeini spent a 14-year exile in An Najaf, in a large shuttered house near the mosque, plotting his Iranian revolution.

Ibn Battuta notes, "People . . . if attacked by illness vow to make a votive offering to the mausoleum when they recover. . . . a man suffering . . . in the head will make a head of gold or silver . . . and the mosque official puts it into the treasury; likewise with a hand or foot, or any other member. . . . a quantity of riches as defies exact computation."

The tomb chamber, faced with mosaics of cut-glass mirrors and polished silver grill-work, still bespoke opulence when I visited it before the gulf war. "The dome is overlaid with 7,777 solid gold plates," Sheikh Salih al-Hakim, one of the tomb's guardians, said, adding proudly, "to shine like a second sun."

All day I watched funeral processions circle the elegant tomb. The corpses, wrapped in red carpets, arrive on the roof racks of taxis from all over Iraq to be borne around the sepulcher on a wooden stretcher trailing a wake of mourners, before interment among the green and white tombs of An Najaf's vast Valley of Peace, the sacred cemetery that dwarfs the town itself.

After the gulf war cease-fire the Iraqi Shiites rose up against Saddam Hussein but were crushed in a brutal campaign that badly damaged An Najaf and its holy mosque.

From here the peripatetic Ibn Battuta veered south along the Euphrates to Basra. He remarks on Basra's date groves, until recently the largest in the world. The Iran-Iraq war left only charred stumps. From there, our traveler crossed the Shatt al Arab to zigzag through western Persia as far as Isfahan before gaining Baghdad.

Under the eighth-century Abbasid caliphs, Baghdad became queen of the civilized world. Bejeweled with poets and scholars, she ruled an empire greater than Rome's. Her court scientists were perfecting algebra (from an Arabic word for calculating—*al-jabr*) and

the measurement of a degree of latitude while, as one historian put it, "Charlemagne and his lords were reportedly dabbling in the art of writing their names."

Mongols put Baghdad to the sword in 1258, a century before Ibn Battuta's visit. It would languish for seven centuries more, four as a Turkish provincial capital, before modern oil discoveries sparked a building frenzy.

There was little of beauty except the sparkling Tigris that curved between the city's eastern and western banks, "like a necklace between two breasts." His manuscript quotes foreboding lines from a ninth-century Arab poet—lines that echo hauntingly today:

"Death's messenger has risen against the city . . . along her river war ignites."

FROM BAGHDAD Ibn Battuta trekked back to Mecca for a second pilgrimage and two years of study. By then his feet were itching once more. From nearby Jiddah he set out on his first long sea voyage, to Yemen and the East African coast as far south as Kilwa, 600 miles below the Equator, in today's Tanzania. He returned to Mecca—by way of Oman, the Persian Gulf, and Bahrain—for still another pilgrimage.

Tales from Indian pilgrims continued to fire his imagination. At the splendid royal court in Delhi, it seemed, generous stipends awaited Muslim scholars. But he had little stomach for sea travel. He decided to take the back door to India, overland across Anatolia and the steppes of central Asia; perhaps he would find fortune on the way.

Ibn Battuta summed up Anatolia with an Arabic adage of the time: Arabia for its blessings, but in kindliness Turks excel. "Wherever we stopped in this land, at hospices or private homes, our neighbors, both men and women (who do not veil) came to ask after our needs," he writes. People brought him bread, begging in exchange a prayer from the Arabic-speaking scholar.

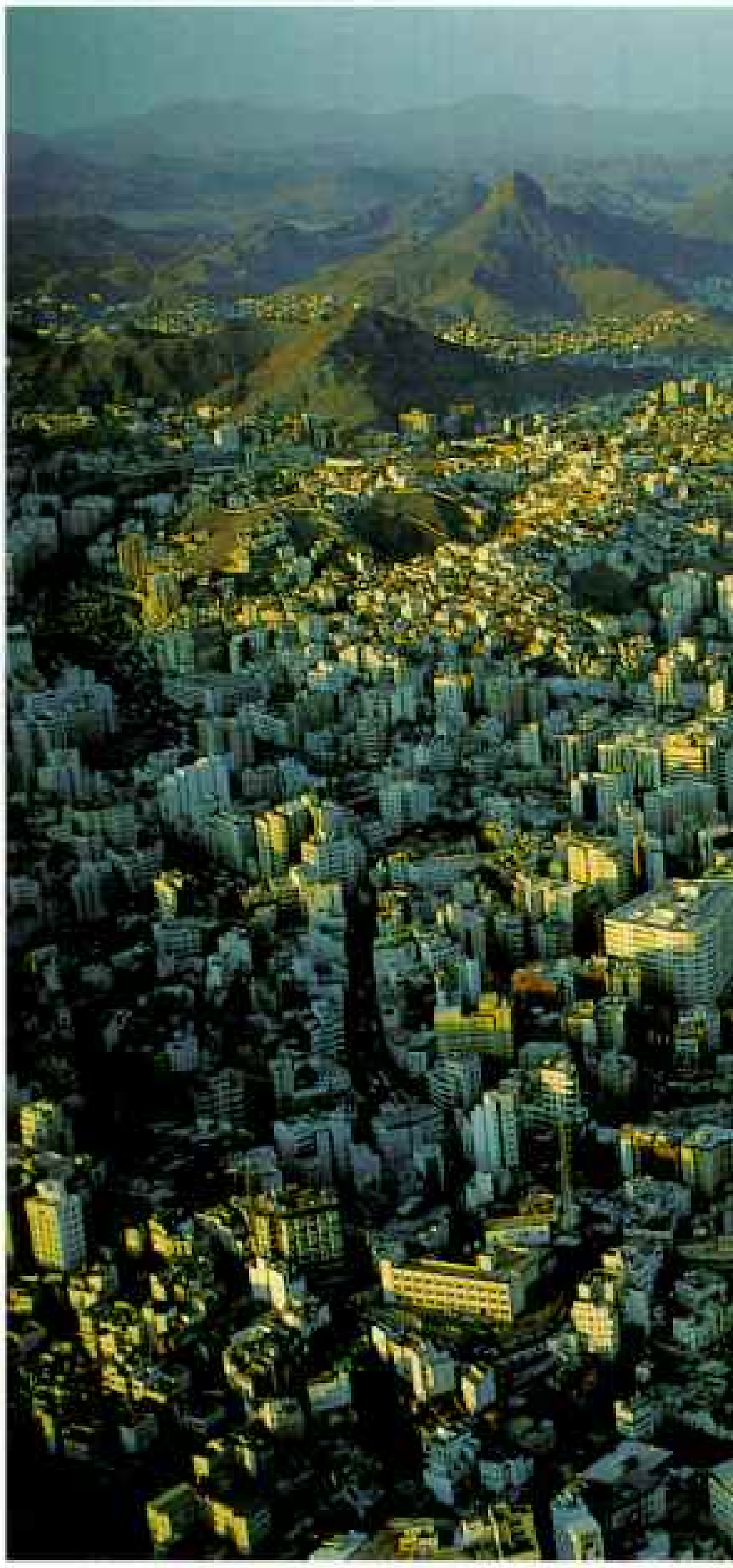
Ibn Battuta sojourned in Konya, city of Jalal al-Din al-Rumi, the Sufi poet who founded the order of dervishes, the religious group whose members whirl and dance as part of their worship. Jalal al-Din was "a saint of high rank," Ibn Battuta writes. Followers refer to him simply as Mevlana, literally, "our master."

Vibrant music, Koranic chants, poetry, and rapturous dances blend the ethics and aesthetics of his teachings. His disciples raised Konya to a powerful religious center—in the end, too powerful. In his drive to secularize, Kemal Atatürk, father of modern Turkey, closed the Sufi lodges in 1925.

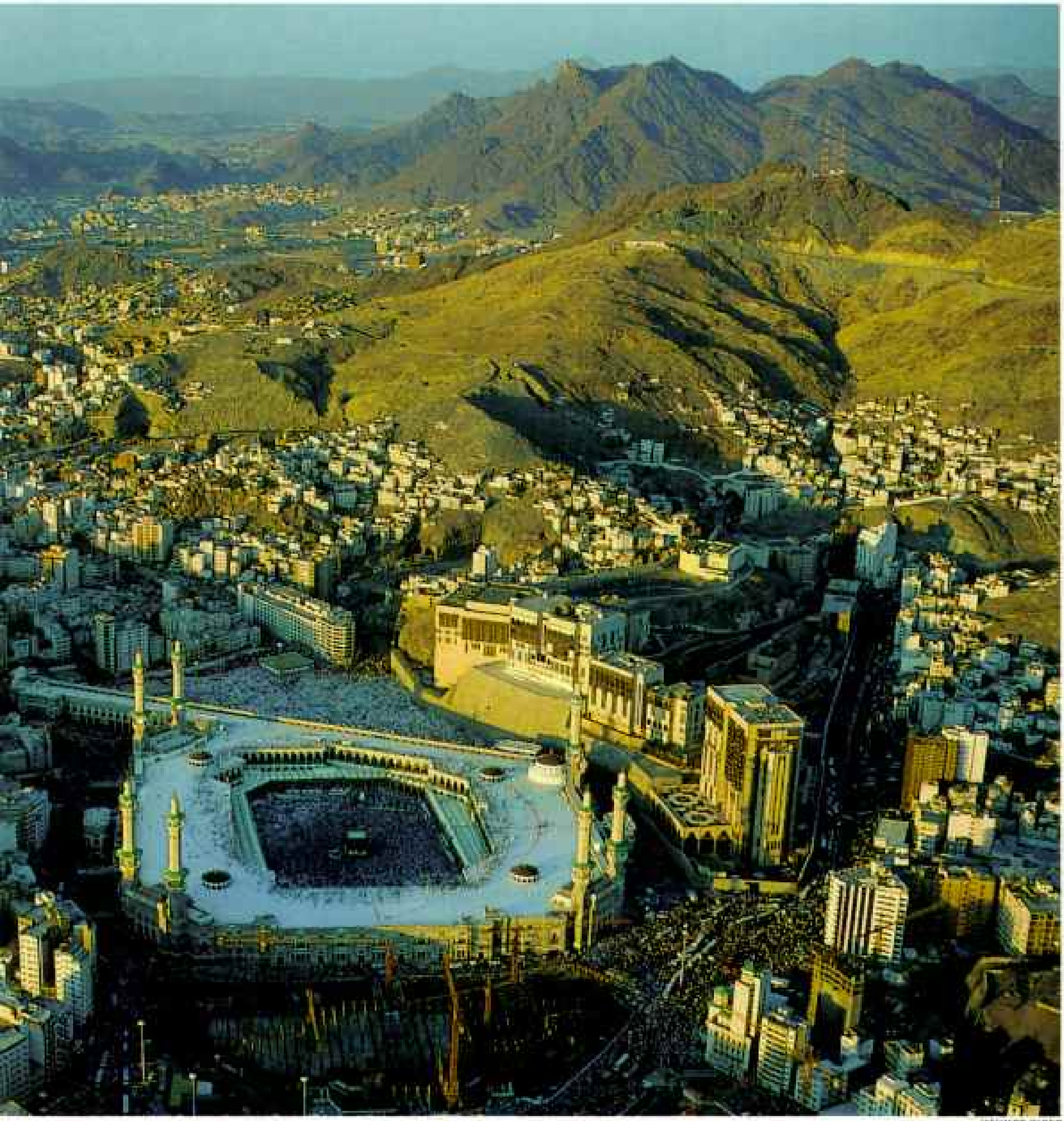
A Konya dervish, Mevlevi Celaleddin Loras, told me, "Besides the government ban, Muslim fundamentalists also oppose our rites. But 11 major Sufi orders survive in Turkey, and some 400 sub-orders. We meet in small groups now in private homes.

"They can lock our lodges but not our hearts," he added.

I enjoyed a welcome fit for an Ibn Battuta



Donning the pilgrim's white ihram—two pieces of seamless cloth symbolizing man's equality before God—Mecca-bound passengers in Syria switch from street clothes at the Damascus airport. Ibn Battuta entered Mecca (below) with a Damascene caravan 16 months after leaving Tangier. Here he earned the title of hajji—one who has performed the sacred city's rituals.



MEHMET BIBER

A swirl of humanity in Mecca's sacred mosque encircles the cube-shaped Kaaba, which holds the black stone that Muslims believe was given to Abraham by the angel Gabriel. "The kissing

MEHMET BIBER

of the stone . . . is particularly pleasing to the mouth," reported Ibn Battuta. Leaving Mecca, most pilgrims headed home; the young Moroccan headed north, hungry for new horizons.

at the Nurettin *tekke,* or lodge, in Istanbul's Karagümrük quarter. A Sufi friend, Edip Eroglu, introduced me to some of the 200 faithful gathered for Mirac, a Turkish fete marking the Prophet's conception. After the meal of lentil soup, rice, beans, and quinces, Edip led me toward the octagonal prayer hall in the lodge.

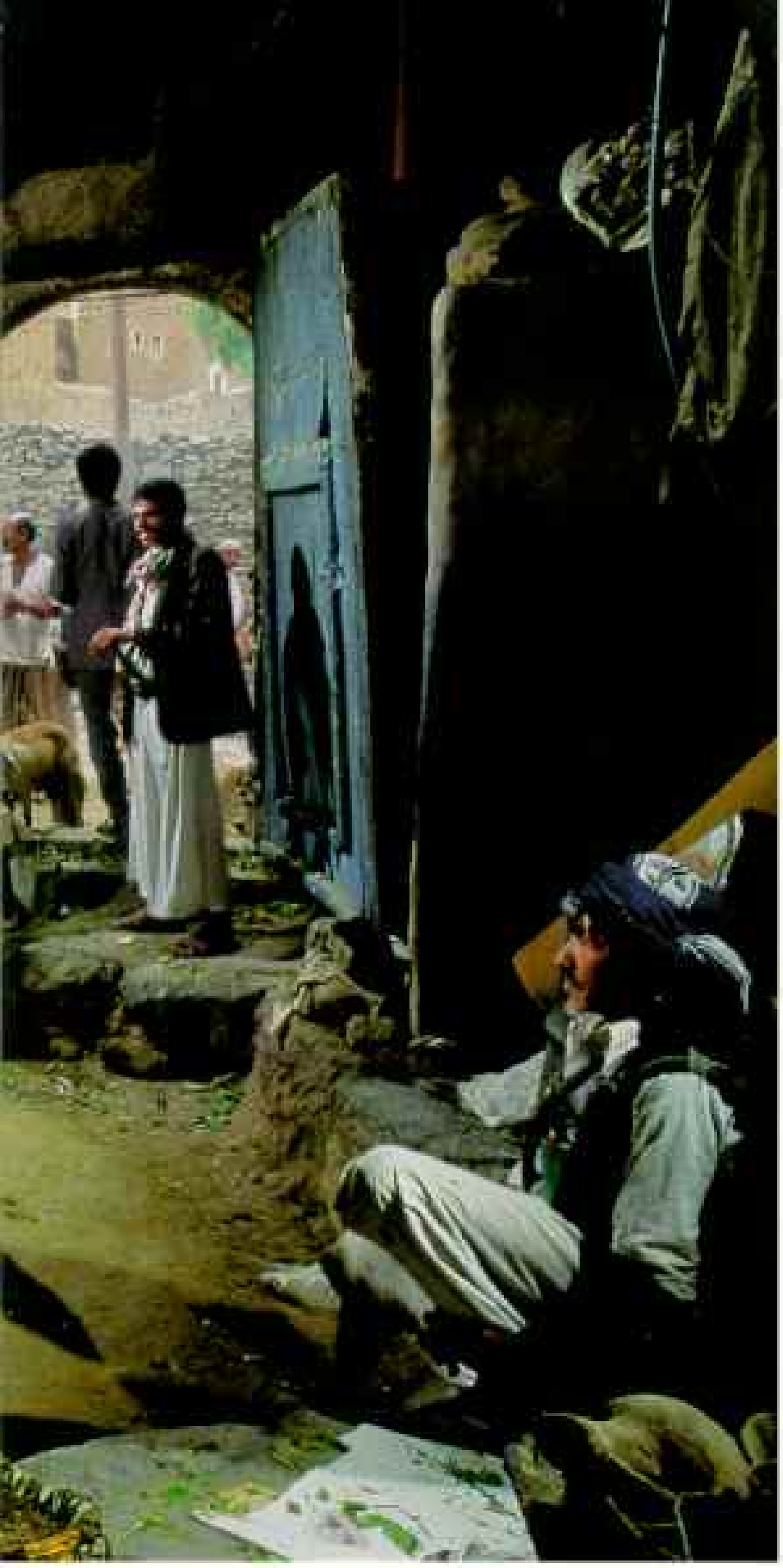
"Come, all are welcome," Edip urged. "Join us in an exercise that frees the soul."

The service began with a kind of deep breathing exercise, the congregation repeating, "Alll-ahhhh, Alll-ahhhh, Alll-ahhhh." Then, to the rhythm of a slow drum, a young dervish in conical felt hat and skirted robe began to spin counterclockwise, arms outstretched, right palm up, left palm down, in the center of the octagon. Edip pulled me into the congregation forming concentric circles around the dancer, shoulder to shoulder chanting the sonorous Muslim creed, *"La ilaha illa llah!"* slowly at first, then faster and louder: "There is no god but Allah." We circled the spinning dervish, in the opposite direction.

Faster and faster we circled, at one with the atoms and the planets, cosmic sleepwalkers belying time and space, lost in the whirl and the rhythm of the chant:

La ilaha—illa llah
La ilaha—illa llah

Only afterward, glancing at my watch in the master's sitting room, did I realize we had spun for nearly an hour. Where did this time



In plodding steps as old as time, a camel drives a sesame mill in the highland city of Sanaa, capital of today's Republic of Yemen. Visiting Taizz, the region's capital, around 1330, the traveler complained bitterly: "Its people are overbearing, insolent, and rude."

go? I took my place on the carpet at the foot of the master, or effendi, Safer Dal. Nightly he leads discussions on mystic subjects. He wore a white skullcap and, over simple slacks and sweater, the gray mantle of the Sufi.

"Time. Yes, time," Safer Effendi spoke slowly to my thought, lighting a cigarette in his long black holder. "Is time real? Or merely an illusion, something man has fashioned to measure his progress in a timeless universe?

"In one's inner self, time takes a different form. Not flowing like a river but calm like a lake," he said. "Have you noticed, for instance, that in dreams, past, present, and future blend freely?"

Before we parted—it was nearly one in the morning—the effendi surprised me with a presentation steeped in tradition: the skullcap and black cloak of a Sufi initiate.

Through dark January drizzle Edip drove me back across the Golden Horn to the other world of the Hilton.

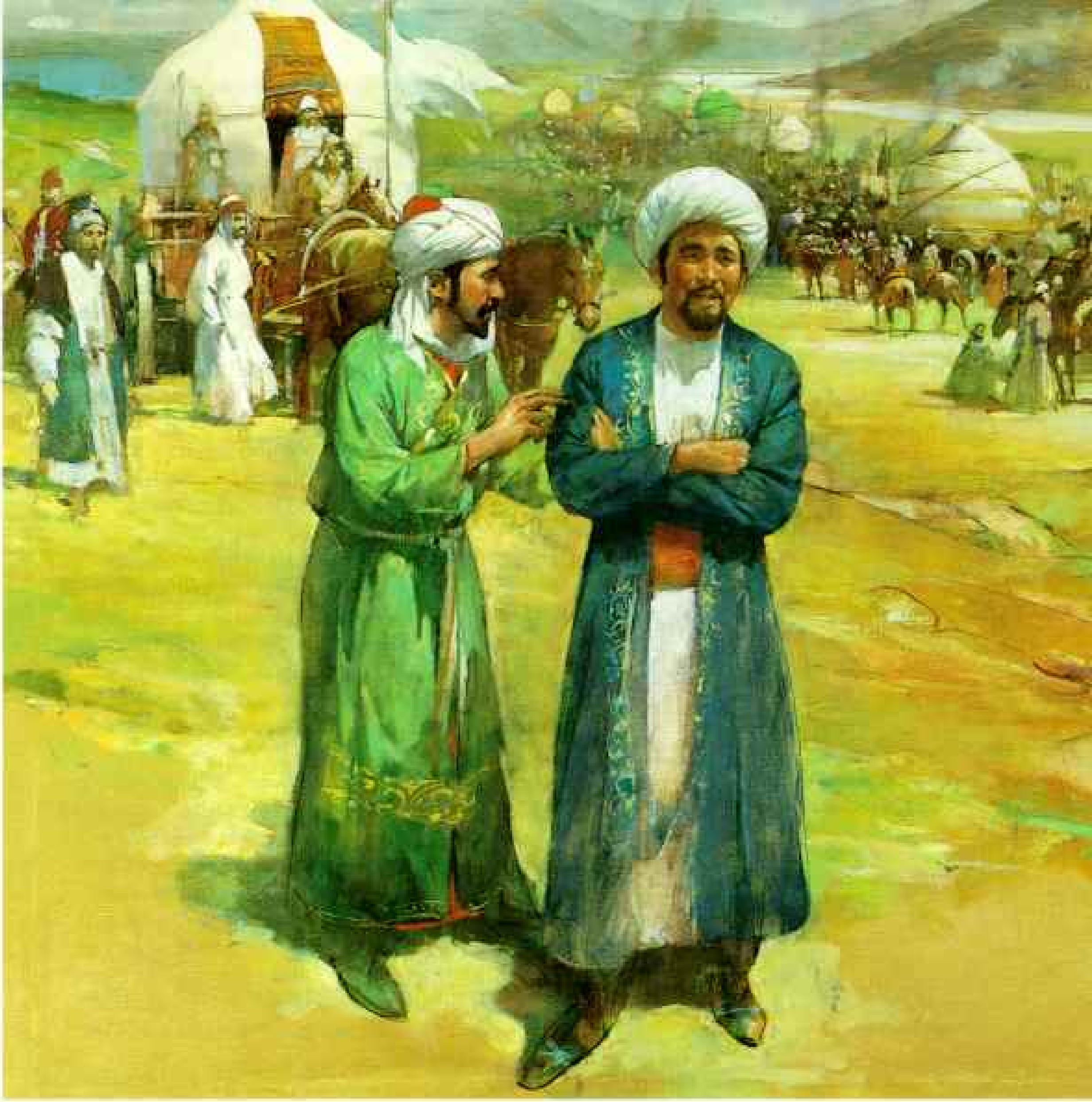
"Love, brotherhood, and generosity—our Sufi ideals," he said. "Like Ibn Battuta, you will never be without a friend in Turkey."

TIME WAS NO OBJECT to Ibn Battuta, who preferred overland travel to the perils of the sea. For 51 days he waited at the fortified Black Sea port of Sinope for a ship and fair winds to Russia, then survived a nightmare crossing that set him and his companions to praying for deliverance.

In the Crimea he found respite in trading towns established by the Genoese, sojourning among the Christian "infidels." He was honored at a special banquet given by the Christian emir in Feodosiya. Lodging in a small mosque surrounded by churches, he reveals how uneasy he felt: "We heard the sound of [bells] on every side, and never having heard them before I was alarmed at this and bade my companions climb the minaret and chant the Koran."

Journeying inland across the windswept Russian steppe, he entered the vast nomad territories of Muhammad Öz Beg Khan, the Mongol emperor of the Golden Horde. For the adventure Ibn Battuta and his growing entourage traveled in style with giant four-wheeled wagons called arabas, which carried felt tents. He writes that one "can employ himself in it as he likes, sleeping or eating or reading or writing on the way. I prepared for my own conveyance a wagon covered with felt, taking with me in it a slave girl of mine, another small wagon for my associate . . . and for the rest of my companions a large wagon drawn by three camels."

In Bish Dagh (present-day Pyatigorsk) he was dazzled by the khan's royal encampment, "a vast city on the move . . . with mosques and bazaars in it, the smoke of



kitchens rising in the air (for they cook on the march)."

Ibn Battuta was befriended by one of the khan's wives, daughter of the Byzantine emperor, Andronicus III. When she planned a trip home to Constantinople, Ibn Battuta decided to accompany her, even though it cost him a 2,500-mile detour. Besieged for centuries by armies of Turks and Arabs, Christian Constantinople was difficult for a Muslim to visit without introductions. He could hardly have found a better one.

There he met Emperor Andronicus and, through a Jewish interpreter, gave him his impressions of Bethlehem and Jerusalem. Pleased, the emperor bestowed on him a robe of honor and a horse, then arranged a tour of the capital under royal protection. Ibn Battuta writes, "Anyone who wears the king's robe of honor . . . is paraded through the city bazaars with trumpets, fifes, and drums. . . . so that they may not be molested; so they paraded me."

Today Istanbul's vaulted Kapalı Çarşı, or "grand bazaar," winds for 13 miles under one roof. Its 4,000 well-kept stalls of carpets, gold jewelry, pottery, leather goods, and copperware—served by banks, restaurants, and mosques—make it one of the world's largest shopping malls.

The famous Church of the Holy Wisdom—Hagia Sophia—Ibn Battuta saw from the outside only. "They allow no person to enter it until he prostrates himself to the huge

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India beckoned, and Ibn Battuta, never in much of a hurry, took a circuitous route that led him through Syria, Anatolia, and central Asia, where the great traveler, at right, was welcomed to the camp of Mongol ruler Öz Beg Khan. "A vast city on the move," he marveled.

cross. . . . set in a golden frame." This, of course, he refused to do. Informants told him of a concept strange to a Muslim mind, the nunnery: "Inside is another church exclusively for women, containing more than a thousand virgins consecrated to religious devotions," he writes.

AFTER A FIVE-WEEK STAY in the Byzantine capital Ibn Battuta retraced his route across the frigid Russian steppeland toward Öz Beg Khan's capital, New Sarai. Marching along the frozen Volga, he chopped ice to melt for his drinking water. "I used to put on three fur coats and two pairs of trousers," he writes, "and on my feet I had a pair of woolen boots, with a pair of boots quilted with linen cloth on top of them, and on top of these again a pair of horsehide boots lined with bearskin." So bundled, he admits, he had to be lifted onto his horse.

I too bundled up when Soviet archaeologist Evgeny Myskov led me on a windy, sub-zero tour of excavations at New Sarai, along the poplar-lined Akhtuba River, a two-hour drive east of Volgograd. I needed KGB permission to go there; Soviet rockets are tested nearby. We slogged through drifts to reach some of the 150 grave sites that Dr. Myskov had excavated over the past dozen years.

"As Ibn Battuta relates, New Sarai was a hub—solid houses for a day's ride along the riverbank," Dr. Myskov said. "We found bronze mirrors, pottery canteens, and silver coins inscribed in Arabic to Öz Beg Khan.

"But, as you see, nothing is left of the Golden Horde's capital except a few scattered bricks," he said, picking one out of the snow. "Even most of these were carried away, scavenged for other buildings after Tamerlane leveled the city in 1395."

Nearby Volgograd, the former Stalingrad, was leveled more recently, heroically resisting the Nazi siege in World War II, but it rose quickly to its feet. Hundreds of statues commemorate the bloody house-to-house battles. Volgograd, like New Sarai, is a ribbon city, curving along the Volga through miles of heavy industry to the new Volga-Don Canal.

Volgograd today, like much of Russia, is under economic siege. Food markets stand bare and deserted; in a department store I found all shelves empty except those for chamber pots and violins. Everything costs more rubles.

From the Volga, 40 days by his lumbering wagon (shared now with three slave girls) brought Ibn Battuta to Khwarizm, a rich, crowded oasis south of the Aral Sea. It cost him 18 days more, on camelback, across the empty deserts of Uzbekistan to reach fabled Bukhara and Samarkand.

He found Bukhara still reeling from the ravages of Genghis Khan's Mongol hordes a

century before. He praises its garden but notes "its mosques, colleges, and bazaars are in ruins."

On my first visit in the early 1970s, I too found Bukhara cloaked in melancholy, a Persian beauty in Russian peasant clothes. State collectives had plowed under private orchards; atheism was official ("There is no God, and Lenin is his prophet"); the Russian language was choking out local Uzbek and Tajik idioms.

Now, 20 years later, I found that Islam in Soviet Uzbekistan had come out of hiding. At Mir-i-Arab seminary in Bukhara the young rector, Sheikh Salah al-Din Sheripov, showed me around his 16th-century, blue-domed college carefully restored by Soviet archaeologists, through classrooms, a mosque, busy kitchens, and arched cloisters. In the main courtyard paced students dressed in turbans, *chapans*—the long Uzbek robes of quilted cotton—and black boots, memorizing lessons on religion, law, and Arabic.

"More than a thousand mosques have reopened in Uzbekistan," said Sheikh Salah al-Din. Korans are no longer forbidden. Last year 1,500 pilgrims went to Mecca, the most since the revolution."

TRADITIONS of Islamic hospitality that sustained Ibn Battuta on his long journeys are not wanting in Samarkand. When Uzbek friend Hafiz Khalimov invited me to his Samarkand home for tea, I was not surprised. But I was hardly prepared for what followed. With his three brothers we sat down to a banquet, most of which came from the courtyards of their houses: apples, pears, apricots, grapes, almonds, chick-peas, oven-fresh bread.

"It is only our duty," Hafiz insisted, when I tried to protest.

He opened a bottle of Uzbek champagne, then cognac (although Islamic law prohibits alcohol, some modern Uzbeks are liberal drinkers), before signaling the women to bring the main courses: onion soup, pickled tomatoes, cold kabob, cucumbers, yogurt, steaming mutton pilaf. After the meal Hafiz switched on television to play us a video he had recently made of 200 guests feasting and dancing in his garden, to celebrate a nephew's circumcision.

From Samarkand, Ibn Battuta reports, he and his party turned south across the Oxus

Blurring the line between body and soul, Mevlevi dancers spin toward ecstasy in Istanbul. Known in the West as the whirling dervishes, this Sufi brotherhood was less than a century old when Ibn Battuta passed through Anatolia. At Konya he visited the grave of poet Jalal al-Din al-Rumi, founder of the Mevlevis.

River, now the Amu Darya, toward his goal, India. As usual, he took the most roundabout route, this time through Meshed and Neyshabur in Persia and the desert plateau of northern Afghanistan. At Kunduz he camped for six weeks to pasture his horses and camels for the snowy foot passes of the Hindu Kush and the deserts of Sind beyond.

At Multan, on a tributary of the Indus River between Sind (present-day Pakistan) and India, he borrowed funds from local merchants to stock up on presents for the Mogul sultan, then dispatched notice of his impending arrival to Delhi by courier. These runners were even faster than the local pony express: "From the province of Sind to the Sultan's Capital . . . it is fifty days' journey, but . . . the letter reaches him in five."

Ibn Battuta traveled handsomely across the populous subcontinent with a party of Persian noblemen and their families, slaves, eunuchs, and 20 cooks serving up chicken, sweetmeats, and persimmons, the fruit of the ebony tree. But the road held danger as well. He describes being "attacked in the open country there by eighty infidels on foot with two horsemen. . . . we fought stoutly . . . killing one of their horsemen and about twelve of the foot soldiers. . . . I was hit by an arrow and my horse by another, but God in his grace preserved me. . . . We carried the heads of the slain to the castle of Abu Bak'har . . . and suspended them from the wall."

In Delhi Ibn Battuta met the storied Indian sultan Muhammad ibn Tughluq at his palace in Jahanpanah, in the Hall of a Thousand Pillars. The ruler was attended by his vizier, dozens of chamberlains, officials, and slaves—including the "keeper of the fly whisk," who stood behind him—all against the background of 200 soldiers in armor, 60 horses in royal harness, and 50 elephants in silk and gold.

He describes the quirky sultan, pious, generous, courageous, but often unpredictable, "of all men the most addicted to the making of gifts and the shedding of blood. His gate is

never without some poor man being enriched, or some living man executed."

Despite the sultan's moods Ibn Battuta spent seven years at his court, becoming a judge in Delhi. When lavish spending sank him into debt, the sultan's gold bought him solvency. But an ill-timed visit to a local mystic put him in jeopardy after the holy man offended the sultan. Ibn Battuta found himself under house arrest.

"I fasted for five days on end reciting the Koran cover to cover each day," he relates. The mystic was executed, but Ibn Battuta was freed. Thanking Allah, he gave away his possessions, even trading clothes with a beggar, to adopt the life of a religious ascetic.

Five months later he was again summoned before the changeable sultan. This time the sultan suddenly appointed him ambassador to the kingdom of China! The wandering scholar, who had departed Tangier with a few coppers in his pocket, set out in 1341 at the head of an opulent train: a hundred Thoroughbreds, a hundred each of concubines and Hindu dancing girls, gold candelabras, brocades, swords, gloves embroidered with pearls, and scores of returning Chinese emissaries. One thousand royal horsemen accompanied the party.

The new ambassador marched his princely entourage southward toward the Indian Ocean. Once again, near Aligarh, he was ambushed by Hindu rebels. Stripped of his clothing and his sword, he was released but

nearly perished in the wilderness before he was rescued by his Muslim troops.

He installed his great embassy in four large dhows at Gandhar on the Gulf of Cambay and sailed down the cosmopolitan Malabar Coast to Calicut, which, he notes, "is visited by merchants from China, Sumatra, Ceylon, the Maldives, Yemen, and Fars [Persia]." He engaged three Chinese junks for the long passage to the East—two giant vessels with 12 sails and crews of nearly a thousand for the royal presents, and a smaller ship for himself and his retinue.

On departure day Ibn Battuta lingered on shore for Friday prayer, when disaster struck. A sudden, violent storm forced his fleet to flee the shallow harbor; the clumsy junks grounded and broke up, scattering treasure and drowning all the slaves and horses. As he watched, the smaller ship with all his worldly goods and his slaves, one of them carrying his child, tacked desperately out to sea, never to be heard from again. Ibn Battuta was left on the beach with ten dinars in his pocket and his prayer rug.

The age of steam relegated this monsoon coast, roughly India's Kerala state today, to charming obscurity, leaving its ports steeped in many cultures.* The spice center of Cochin embraces Hindu temples, mosques, a Dutch palace, a synagogue, and the Portuguese church where Vasco da Gama was buried—

*Peter Miller wrote of "Kerala, Jewel of India's Malabar Coast," in the May 1988 GEOGRAPHIC.

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"Every time he said any encouraging word to me, I kissed his hand," said Ibn Battuta of his first meeting with the Delhi sultan Muhammad Ibn Tughluq, believed buried in the ruins of Tughluqabad (left). Such fawning helped him survive seven years as a judge under the sultan, an unpredictable tyrant who decreed three days' public display of those he executed. Ibn Battuta's friendship with a defiant Sufi nearly cost him his life; yet within months Ibn Tughluq named him ambassador to China.

The new ambassador and his party met disaster in Calicut, a southern Indian port. As Ibn Battuta watched from shore, a storm swept away his ship bearing horses, slaves, and gifts for the Chinese. In Calicut today, workmen still use hand saws (below) to build the sailing ships called dhows, while fishermen haul a living from waters off the Malabar Coast.

all administered by the only freely elected communist government in the world.

IN PREDOMINANTLY Muslim Calicut, I followed the sound of saws and hammers through palm groves to visit a vignette of the past, the shipyard of E. P. Chanthukutty. Near a pile of teak logs, I found the master builder and his 60-man team laying the keel, by rack of eye, for a new 600-ton wooden ship. In one hand Chanthukutty held a homemade bevel square; in the other, his "blueprints," a tiny half-hull model. Nearby waited another vessel, finished for a Persian Gulf client, its launching delayed by the tides of war.

"Our family has been in the business of building ships forever," Chanthukutty said. "When Kerala's first Muslim prince made his pilgrimage to Mecca in the seventh century, we like to say, he sailed in one of our ships."

Fearing Sultan Ibn Tughluq's tortures, Ibn Battuta decided not to return personally to Delhi to report his failed mission but to continue to China on his own.

First he sailed to the Maldive Islands, some 400 miles off the southern tip of India, for a short visit. But when Khadija, the queen of the Maldives, learned of his scholarship and court credentials, she persuaded him to stay, with gifts of gold and slave girls. For a time he played at local politics, marrying the daughter of a noble family. He was named a judge in Male. All the while he collected

details of the trees, the fish, the price of cowrie shells—and women's fashion.

"Most wear only a loincloth," he records. "In this fashion they stroll in the markets. . . . As a judge in the islands . . . I tried to order . . . the women to dress, but without success."

He considered fish and coconuts the source of the islanders' "extraordinary vigor in love-making," adding, "as for me, I had four wives, not counting the concubines. Each day I made a general tour . . . and I passed the night with each in their turn."

Altogether, Ibn Battuta married—and divorced—six times during his brief visit.

"The Maldives," said assistant tourist director Ibrahim Manik, "has one of the world's highest divorce rates but also one of the lowest crime rates."

Male, the capital of the 2,000 low-lying specks that make up today's Republic of Maldives, is a square mile of sand where many of the country's 213,000 people live. There I visited some of the government ministries. It is easy enough; they are all housed in one building.

The Maldives' main industry nowadays is catering to jet-set tourists, about 200,000 each year. The 60-some modern hotels are sprinkled around the 400-mile-long archipelago, each to its own palm-shaded island. A bouncy two-hour speedboat ride took me to the Angaga Island Resort, in Ari Atoll, 60 turquoise miles southwest of Male. Here a

visitor can act out his Robinson Crusoe fantasies in luxury.

"We are completely self-sufficient—our own electric plant and water maker," said assistant manager Abdullah Naseer.

After a lunch of ocean perch in coconut milk in the air-conditioned dining room and a look at the thatched guest cabins, each with private mini-beach, we walked completely around his island. It took seven minutes.

IN CEYLON, now Sri Lanka, Ibn Battuta became the pilgrim once more. "Since reaching this island, I have had but one desire, to visit the blessed foot of Adam," he writes of Adam's Peak, the tropical Matterhorn that holds an imprint in rock revered by many faiths. A hospitable Hindu ruler in Puttalam provided "a palanquin which was carried by slaves, and sent with me four Yogis, three Brahmans . . . and fifteen men to carry provisions."

Chains and stanchions on the dizzying rock faces helped his party to the summit shrine, where he found "the blessed footprint . . . of our father Adam. . . . sank into the rock far enough to leave its impression hollowed out."

At Nalatani I engaged a young, bearded Tamil, Shivasundara, to guide me upward. We set out in late afternoon.

"Of course, we Hindus believe the footprint is that of Siva; the Buddhists, that of Lord Buddha," Shivasundara explained, as we hiked up past small wayside temples and stupas. Day was fading when we reached the narrow summit, where we met only a visiting Japanese Zen monk and two local guardians, who assigned us a place to sleep in the temple storeroom.

The sacred footprint was "eleven spans long"—just as Ibn Battuta reports—but the impression in the rock was badly worn by centuries of reverent caresses.

I gazed at the panorama below. Thickening clouds had flooded the valley, sealing our peak off from reality. On that distant planet, Hindus battled Sikhs and Muslims; Sinhalese fought Tamils. But here I rested peacefully in a temple of unity, a stone ship adrift in a sea of stars.

Mishap piled upon adventure throughout Ibn Battuta's decades of wandering. One vessel was shipwrecked in Indian waters, and another was plundered by pirates before he dropped anchor at a small port called Samudra, from which Sumatra, the island of camphor, cloves, and sandalwood, is named.

Indian Muslim merchants had brought Islam to the island only a half century earlier. Ibn Battuta found its ruler, Malik al-Zahir,

"One of the wonders of the world," said Ibn Battuta of the Maldives, island gems strewn in the seas southwest of India. The Islamic republic is home to health worker Aishath Mahfooza, who evokes the setting Ibn Battuta found so alluring. In eight months here, he became chief judge and married six times.

"When we climbed it, we saw the clouds below us, shutting out our view of its base," reported Ibn Battuta of Adam's Peak in Sri Lanka. Pressing on to China after losing his ships, he detoured to

this center for pilgrims of four faiths, where Muslims say Adam first set foot on earth. Some 650 years after the traveler's visit, Buddhist monk Sadhu Murakami carries his prayers to the top.

"The Chinese infidels eat the flesh of swine and dogs," observed the roving Moroccan, who in China never felt so far from home. Cats, dogs, pigs, and turtles await buyers at the bustling Qingping market in Guangzhou, the southern Chinese city Ibn Battuta visited in 1346.

"a humble-hearted man who walks on foot to the Friday prayer. His subjects . . . take a pleasure in warring for the Faith. . . . They have the upper hand over all the infidels in their vicinity."

Indeed. The traveler could hardly have imagined that the new religion would spread across Sumatra and the whole archipelago to define Indonesia, the world's most populous Islamic country, with 160 million Muslims.

When I set out for Samudra—deserted now, save for a few fishermen—I had difficulty finding a traveling companion. The town lies in Aceh, one of Indonesia's richest provinces, producing 75 percent of its oil and gas, but also its most militantly orthodox. The central government has been trying to settle farmers from crowded Java in Aceh, but local Muslim fundamentalists have killed some 200 of the homesteaders. Five minutes into the province our car was delayed while soldiers removed another body from the road.

"We northerners have a reputation for fierce independence," a native of Aceh told me. "We fought the Dutch colonizers for 47 years, then Japanese occupiers. They even tried to force us to pray toward Tokyo instead of Mecca," he said with disgust. "Like many, I took to the hills to fight." He has the scars to prove it.

I could not follow Ibn Battuta to "Mul-Jawa," a land scholars have yet to pinpoint, nor to the port of Tawalisi—not found on any map, old or new. There he rowed ashore to meet an Amazon princess who led an army of slave-girl warriors "who fight like men." She presented him gifts of lemons, rice, pepper, and two buffalo to stock his ship.

IBN BATTUTA made his first landfall in Cathay at Quanzhou on the southeastern coast of China, just across the strait from Taiwan. Here, where China established its first foreign-trade enclave, the great "silk road of the sea" began. The port impressed him as "one of the largest. I saw in it about a hundred large junks."

From an ancient stone lighthouse I saw only a few fishing smacks and a rusty coastal freighter in the once bustling harbor. Ashore, I noticed that many of Quanzhou's Muslims still cling to their old quarter on Tumen Street around the Qingjing Mosque.

"Ours is China's first mosque, already 350 years old when Ibn Battuta prayed here," said the imam, Abdola Huang Qiu Run, as we sipped tea under the pagoda-like roof of his office. A motto in flowing Chinese calligraphy over his door read *"Tu Yi Zhen Zhu"*—which roughly translates, "There is no God but Allah."

Even in Ibn Battuta, a man who had seen the world, this land struck wonder: "China is the safest and best regulated of countries for a traveler," he writes. "A man may go by

himself a nine-month journey, carrying with him large sums of money, without any fear." He notes, "Silk . . . is used for clothing even by poor monks and beggars." And its porcelain, "the finest of all makes of pottery." Even its poultry amazes him: "The hens . . . in China are . . . bigger than geese in our country."

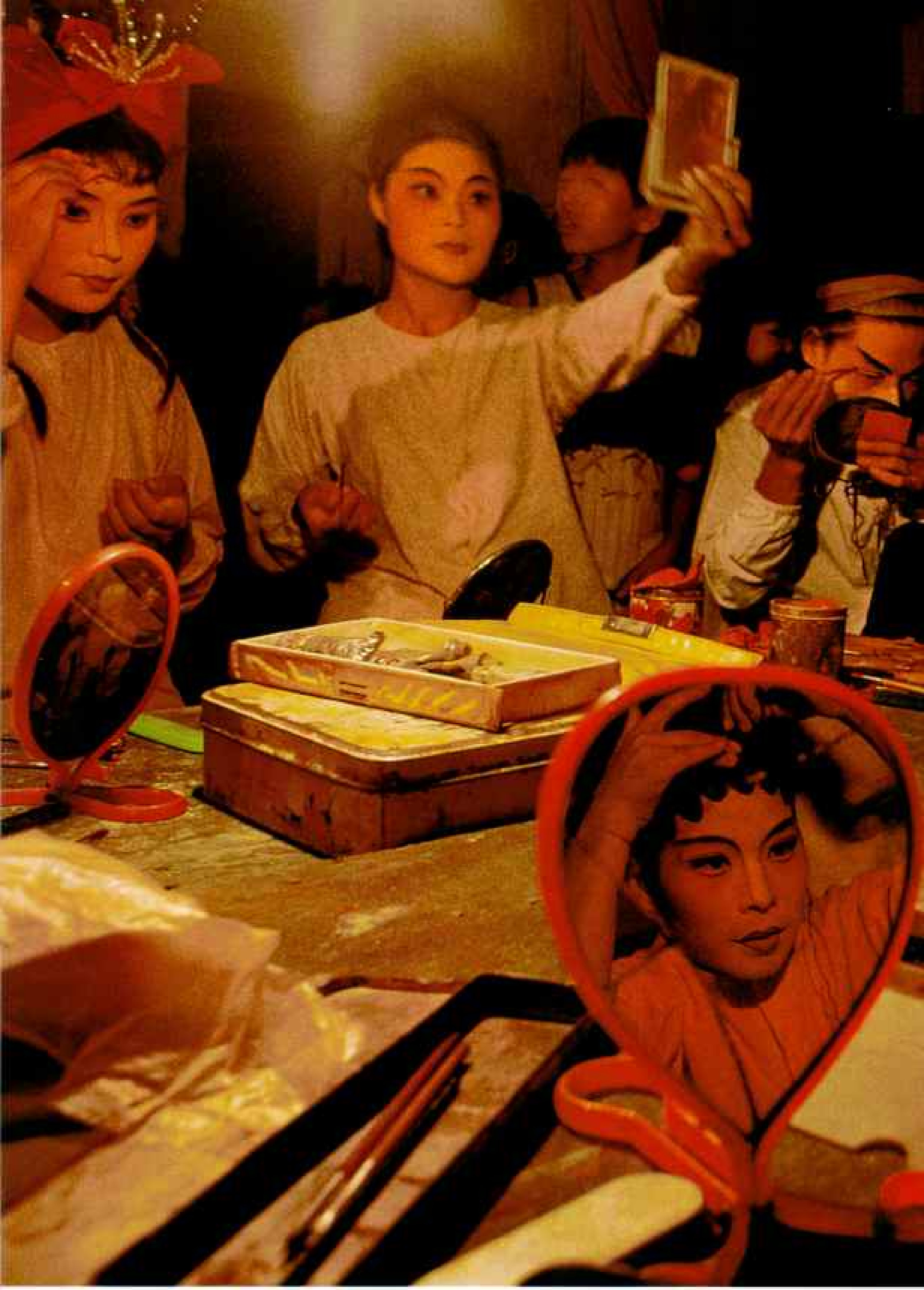
Despite all this, China shocks his Muslim sensibilities: "The Chinese themselves are infidels, who worship idols and burn their dead like the Hindus. . . . eat the flesh of swine and dogs, and sell it in their markets."

The drama of China's cuisine still challenges the visitor, whatever his dietary persuasions—especially in Guangzhou (Canton), the second city Ibn Battuta visited.

"Here we eat everything that moves across land, sea, or sky," said Zhou Kui Hua, deputy director of Qingping market near the Pearl River, "except trains, boats, and planes. We offer over 600 varieties of vegetables and meats, the largest selection in China."

The narrow, covered street of the butchers struck me as a macabre zoo. Monkeys, tortoises, foxes, dogs, wild boar, pangolins, owls, and giant toads waited for the knife. Beyond the cages of coiled snakes, one merchant specialized in house cats.

"Probably just a pet shop," my Chinese guide ventured. Perhaps he missed the freshly skinned felines hanging behind the glass counter. And what about the fish, were they fresh? The vendor lifted up a fillet sliced from



The scene behind the scenes is one of mirrors and finishing touches for actors about to perform an opera near Quanzhou. "The Chinese are of all the peoples the most skillful in the

arts," said Ibn Battuta. Elsewhere in this port city Muslims greeted him gladly: "Merchants, living as they do in a land of infidels, are overjoyed when a Muslim comes to them."

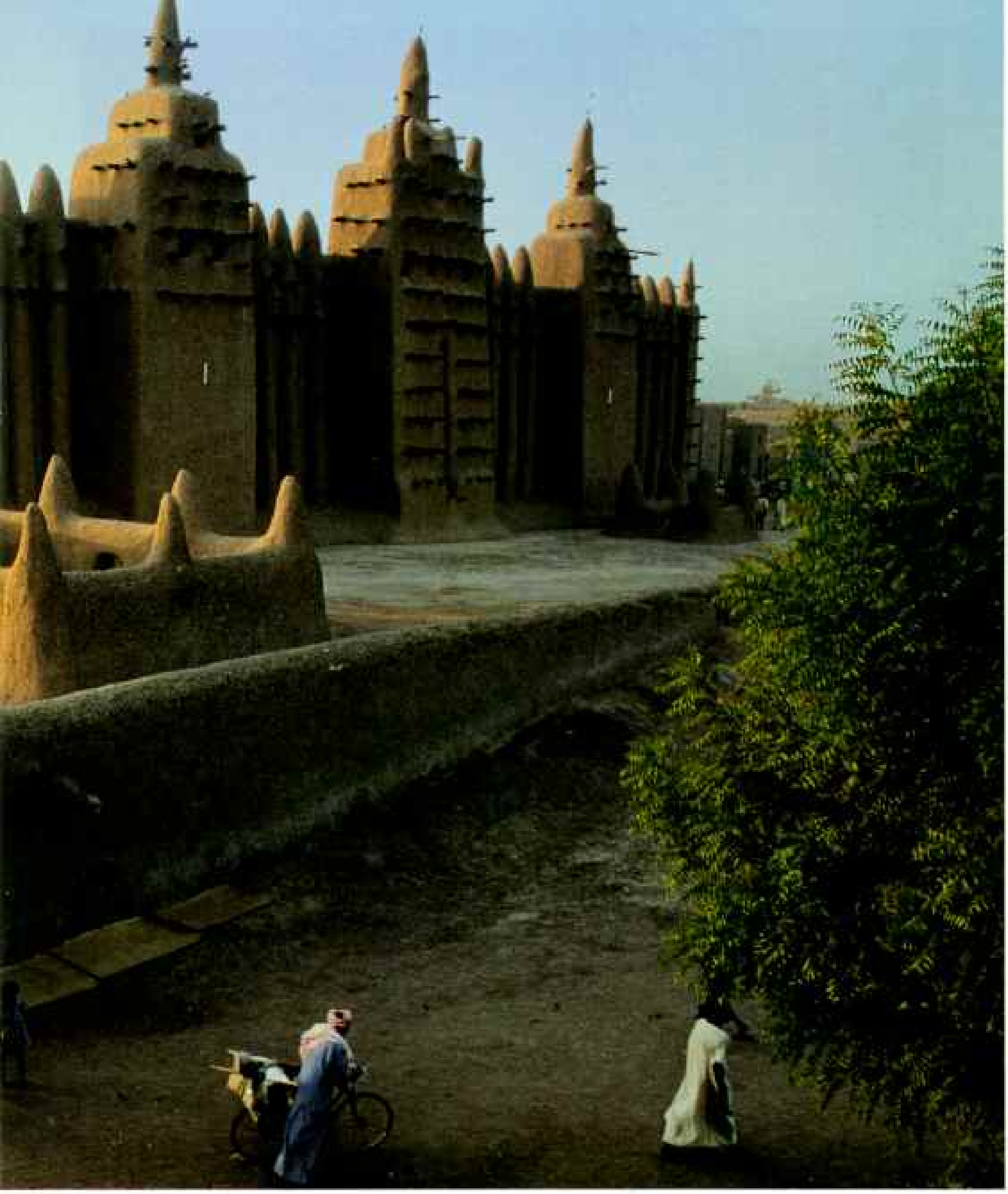
a fat red snapper, to reveal its heart, still beating beneath.

Returning to Quanzhou, Ibn Battuta found a junk ready to sail for India and departed on the autumn monsoon. Of his three-year voyage home he writes sparingly. It led through familiar territory—Sumatra, Calicut, Hormuz, Baghdad, and again the rites at Mecca. Along the Levant he detoured around outbreaks of plague. He arrived in Morocco to learn the scourge had claimed his aging mother only a few months before.

MORE THAN a quarter of a century after he had quit his native land, he visited the sultan of Morocco: "I presented myself before our most noble master (may Allah enlarge his greatness and humble his enemies). . . . I laid down the staff of travel in his glorious land."

But not for long.

He was soon off to Spain's south coast, then still Muslim, with a regiment of Moroccan volunteers crossing to defend Gibraltar



from gathering Christian armies. When the crisis faded, he visited Málaga and Granada, then returned to explore cities in his own country—Asilah, Salé, Marrakech.

Three years after his return from the Far East, he set out on an arduous camel trek across the Sahara, perhaps at the request of his sovereign in Fez, Sultan Abu Inan Faris. Morocco had trade interests in the "Negro-lands," as Ibn Battuta calls them, 1,500 miles across the sand sea. Besides, it was the one part of the Muslim world he had missed.

A mud masterpiece, the turreted mosque in Djénné, Mali, harks back to the 14th century, when the town thrived as a center of trade and Islamic learning. Ibn Battuta's final journey brought him through the West African empire of Mali, where he lauded the piety of Muslims.

With a caravan of merchants from Sijilmasa, Morocco's gateway to the Sahara, he plodded 25 days south to the salt mines of Terhazza, in present-day Mali. "No one lives here except the slaves . . . they dig for the salt

and find it in thick slabs," he reports, adding that their "houses and mosques are built of salt, roofed with camel skins."

Terhazza's mines are still worked by forced labor: Mali's political prisoners. I found the whole region closed to foreigners by the government. Rebellious Tuareg tribesmen had recently killed soldiers at several outposts as well as a hapless driver in the Paris-Dakar auto race.

On the parched ten-day stretch south of Terhazza, travelers would send ahead a *takshif*, or scout, to Oualâta to arrange for a party there to meet the plodding caravan with precious skins of water. Ibn Battuta writes, forebodingly, "It often happens that the takshif perishes in the desert, with the result that the people of Oualâta know nothing about the caravan, and all or most . . . perish."

At another Saharan salt oasis, Fachi, in Niger, I took refuge in a salt-block house after an all-night sandstorm had completely buried my tent and equipment. It was here in Fachi that I joined Idris Daouda and his camel caravan.

Once under way the caravan boss deftly mounted his moving camel, pulling its head down and bending a knee into the crook of its neck. Straightening, the beast vaulted him into the saddle without missing a step.

"We won't stop until ten tonight," Idris declared in his mixture of Arabic and French. "By making long marches we can expect to make it to our next well, Arbre du Ténéré, in five days."

Behind us the oasis and its salt mines disappeared under the dune horizon; only its rock hills shimmered in a midday mirage. Straight up, the sun scoured the last shadows from sandblown footprints marking the faint trail. Now and again we passed other road signs: the bleached bones and leather of a fallen camel.

From his swaying flagship, a tall, white mehari with powder blue eyes, Idris could survey the whole line of plodding beasts, each balancing four or six 60-pound cones of salt—altogether some 50 tons on the move. Lashed on top were bundles of fodder and firewood, sacks of dates and flour, and glistening goatskins of water—provisions enough for 40 days. Afternoon temperatures climbed toward 120 degrees, too hot for talk. Day after day we marched to the rhythmic murmur "swish, swish, swish, swish"—a thousand feet padding through the sand.

In mid-Sahara, two days east of Agadez by

jeep, I bade farewell to Idris and watched the salt caravan slowly vanish into the horizon.

SAHARAN SALT STILL FINDS eager markets in lands south of the Niger River. For centuries Timbuktu, "where camel meets canoe," dominated the trade, but Ibn Battuta had arrived a hundred years too soon. Timbuktu had barely begun to prosper. At its zenith, in the 1500s, the city could boast of three universities and perhaps 50,000 residents.

I was too late. Dunes again occupied the streets; half the houses seemed empty and crumbling. In the pitiful market, I watched one man cobble sandals out of truck tires; another sold me bread spiced with sand. By the cemetery, where old pots mark sand graves under dead thorn trees, nomads camped, refugees from the rebellion up north. Police had clamped a sunset curfew on the town.

In Mali, Ibn Battuta sought out the ruler, Mansa Sulayman, at his capital. This king's grandfather had earned a reputation for himself with lavish gifts he bestowed while passing through Egypt on a Meccan pilgrimage. He handed out so many coins—a ton and a half by some estimates—that he depressed the Cairo gold market. Ibn Battuta learned

Apparel—or the lack of it—was carefully noted by Ibn Battuta. He praised Mali's men (facing page) for their clean garments. "Even if a man has nothing but an old worn shirt, he washes it . . . and wears it to the Friday service." Nudity, though, rankled his conservative sensibilities. Girls, he fumed, "go about in front of everyone naked, without a stitch of clothing."

that generosity is not a hereditary trait.

Mansa Sulayman, he wrote, "is a miserly king." Not for two months did the royal "hospitality gift" arrive: "three loaves of bread, and a piece of beef fried in native oil, and a calabash of sour curds. When I saw this, I burst out laughing."

During dry season along the shrunken channels of the Niger River it is easy to drift back to Ibn Battuta's century. Egrets and kingfishers rule the shallows. Each thatched hamlet gathers its huts around a tiny mosque, hand-sculptured like some gingerbread sand castle.

Just downstream from Mopti, at Sekou, we ran the bow of our pirogue onto the bank where a man was smoking catfish over a fire and a small boy was watering a herd of longhorns. The settlement seemed deserted. "Since the drought, men have gone to Mopti

Heeding Mecca's call, cameleers with a Saharan salt caravan seek Allah's guidance for the days ahead. Wherever he roamed, Ibn Battuta sought similar counsel. From his first pilgrimage until his death in Fez in 1369, the great traveler lived the words of the Koran: "Allah has laid out the earth for you like a vast carpet so that you will travel its endless roads."

and Djénné looking for work," Inka Sori, one of the town elders, told me. He wore a white robe and a battered red fez.

Upriver stands the masterpiece of African-Muslim architecture, the great mosque in Djénné, the massive sweep of its mud ramparts broken by patterns of protruding beams. Its tall spires are crowned not with the traditional Islamic crescent but with ostrich eggs, symbol of fertility and fortune.

Every year, after the rainy season, the town turns out 4,000 people to replaster the walls of the mosque with their bare hands. It is done in a day.

From the roof, I could see out across the Monday market—where women wrapped in rainbows of calico sold dried fish, bananas, salt, kerosene, gourd pots and ladles, and cola nuts from palm-mat stalls—and to houses along the curving river beyond.

In one I greeted Hajji Niani Maiga, a descendant, it is said, of the last Mali kings, an ebony-faced old man leaning on his gold-topped staff. He still shuffled out each week to lead the town to Friday prayer. His house, like others in the quarter, was a work of art.

"Djénné today is still an important center of religion and tradition," the old hajji said. "Our building codes keep it that way."

Ibn Battuta had forewarned me. Here among Muslims, where hospitality rhymes with duty, Hajji Niani's reception proved to be something less than royal. He admitted me only as far as the doorway. He did not even pour tea. As I departed, he pressed me for a *cadeau*—a present.

IBN BATTUTA CIRCUITED the Sahara, plodding eastward, then northward through today's Niger and the Hoggar Mountains of southern Algeria to the Moroccan frontier. When he crossed over Umm Junayba Pass, near Fez, December gave him a final slap: "I have in my life seen bad roads and quantities of snow . . . in Afghanistan, and the land of the Turks, but never have I seen anything worse than the road of Umm Junayba."

But after a lifetime of travel, he concluded that his own was "the best of countries, for its fruits are plentiful, and running water and nourishing food are never exhausted."

After lonely miles, under vast and punishing skies, I too felt strangely at rest walking the narrow cozy streets of scholarly Fez. Here wheels are banned and the call from the minaret scores the day's passage.

In the suq you can choose from 30 kinds of dates, and master craftsmen invite you to tea—"not to buy, monsieur, only for the pleasure of your eyes." Here the shoemaker cobbles you a pair in fine leather on a day's notice; a carpenter in the Suq al-Najjarine

will fashion you a custom cradle, a palanquin for a bride, a chair, and, when the time comes, even a fine cedar coffin—all this in the shadow of venerable Qarawiyin, a university founded in the 800s.

Here Ibn Battuta, at his sultan's command, worked two years with an Andalusian poet named Ibn Juzayy to frame his amazing narrative in *rihla*, or travel book, form. From Arabic sources we learn he spent his last years quietly serving as a judge somewhere near Fez. He died in 1369 at age 64. The whereabouts of his grave remains a mystery. A small tomb in Tangier makes its claim, but it has never been substantiated. I suspect Ibn Battuta would agree with Mevlana, the Turkish Sufi he admired: "When we are dead, seek not our tomb in the earth but find it in the hearts of men."

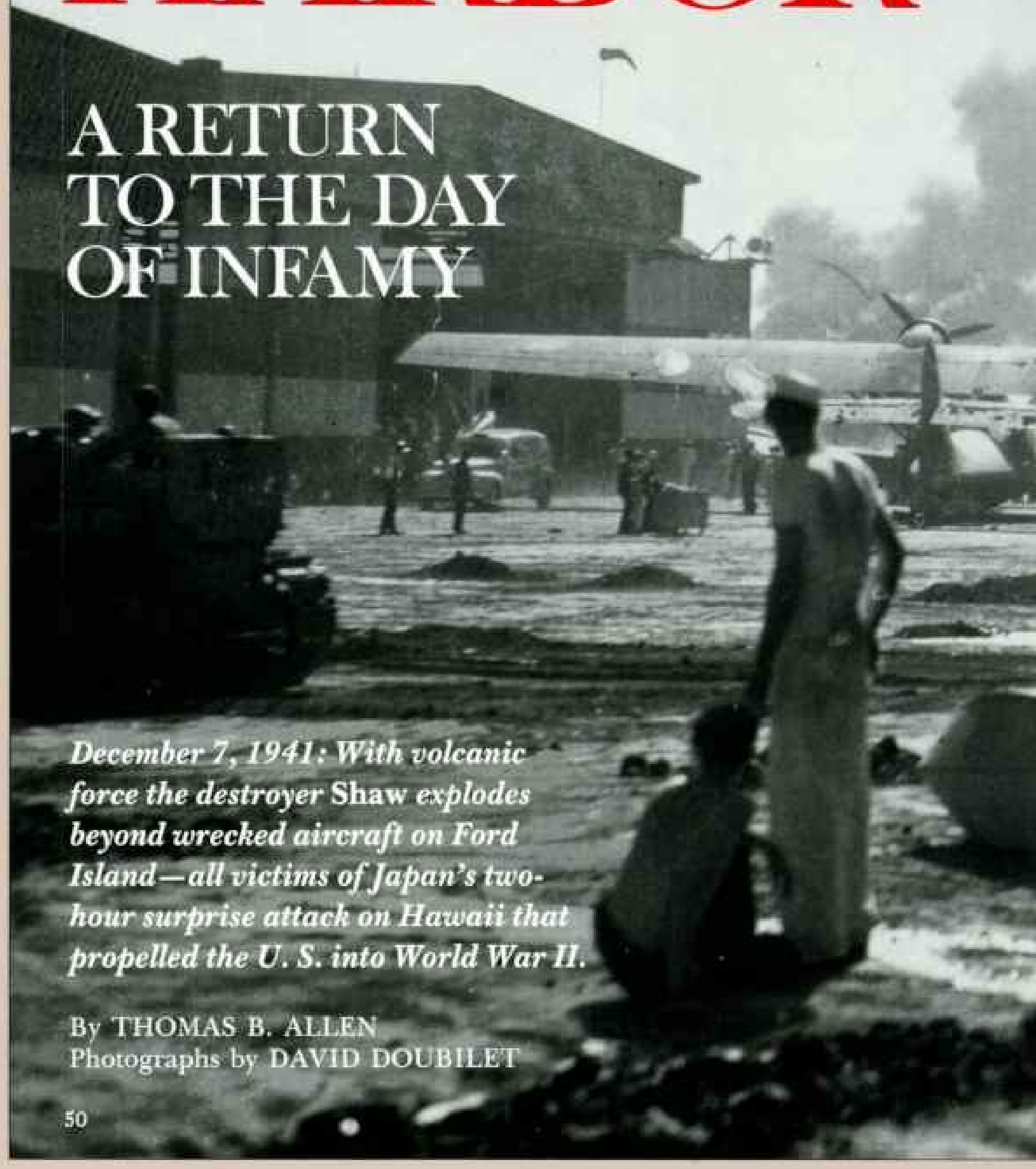
Ibn Battuta never dwells on what drove him on. Curiosity? Perhaps it was to greet the stars with a sage on a remote mountaintop, to suffer the majesty of a turquoise horizon aboard an equatorial isle, to seek spiritual shelter with the pious throngs of Mecca, to breathe the white winter winds of the Russian steppes or the spices of a Persian bazaar, to dine with kings or share a crust with a passing nomad.

More likely it was a quest for knowledge. One never seduced by a foreign culture can never appreciate the fetters of his own. Life, after all, is a journey—a voyage of discovery.

Why not take the high road? □

PEARL HARBOR

A RETURN TO THE DAY OF INFAMY



December 7, 1941: With volcanic force the destroyer **Shaw** *explodes beyond wrecked aircraft on Ford Island—all victims of Japan's two-hour surprise attack on Hawaii that propelled the U. S. into World War II.*

By THOMAS B. ALLEN
Photographs by DAVID DOUBILET

U. S. NAVY FROM NATIONAL ARCHIVES

ALMOST 50 YEARS HAVE PASSED since the bombs fell on Pearl Harbor. The sweet, warm dawn spreads across the sea and grazes the white stone shrine athwart the sunken *Arizona*. On a marble wall the 1,177 names begin to emerge from the darkness. Bates, Crowley, Kidd, Lake, Moore, Van Valkenburgh. . . . The dead men of the *Arizona*—the captain and the seamen, the admiral and the ship's band, the dozens of brothers and the father who died with his son. They are entombed here, the men who went down with their ship, many not realizing in the last moments of their lives that their country would soon be at war with Japan.

Now it is 7:55, and, as they do each year on December 7, boats begin to come from shore, bearing flowers to cast upon the sea. In the ceremonies at the *Arizona* Memorial, people once more will remember Pearl Harbor. Among them will be men and women who were here, in the flames and screams. Among them too will be the kin who carry the memories handed down by those who lived through that day and died on another day of war or peace. This is a place that clutches the sights and sounds of a single morning, December 7, 1941, a date President Franklin D. Roosevelt said "will live in infamy."

I had gone to the *Arizona* Memorial on a pilgrimage of memory to mark the anniversary of the Japanese attack. My travels took me to Japan, where I talked to the officer who conceived of the *to ra* surprise attack signal, and to Iyozo Fujita, one of the few surviving Japanese pilots. In Albuquerque, New Mexico, I met many of the 13,000 members of the Pearl Harbor Survivors Association at their annual reunion. I also found weavers of memory who bring together American and Japanese survivors.

At one such gathering was Kazuo Sakamaki, the captain of a midget submarine that failed to torpedo the battleship *Pennsylvania*. I saw Sakamaki touch the submarine for the first time since he abandoned it on a reef off Bellows Field nearly half a century

Ghostly war grave, the Arizona lies in 40 feet of water, bridged by a memorial to the 1,177 men who died when the great battleship exploded. A bomb ignited its forward magazines, collapsing the bow section, at far left. Now 1.5 million visitors, many of them Japanese, pay their respects each year. National Park Service divers (above) survey 14-inch guns that fell silent that December morning.

Japan's grand strategy

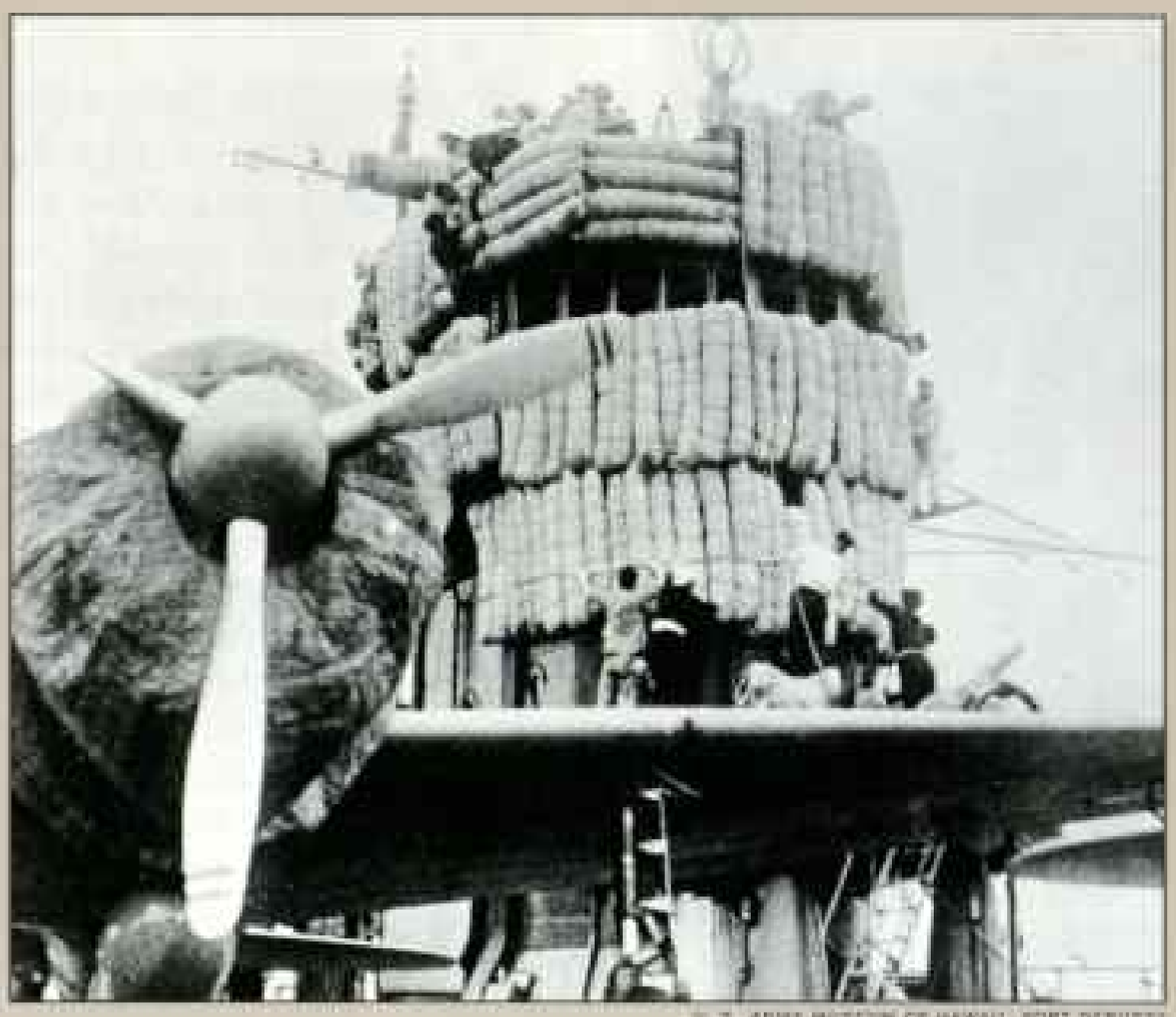
Mastermind behind the attack, Adm. Isoroku Yamamoto (far right) was a gambling man. Though opposed to a war with the United States, he was ready to take a chance if it came—betting that "a fatal blow" against the U. S. Pacific Fleet, stationed at Oahu, would free Japan to seize resource-rich colonies in southeastern Asia.

Yamamoto understood that Japan could not win a protracted war against American power. He had lived in the U. S. as a student and as a naval attaché in Washington during the 1920s. A preemptive strike, he reasoned, would force the U. S. to negotiate concessions.

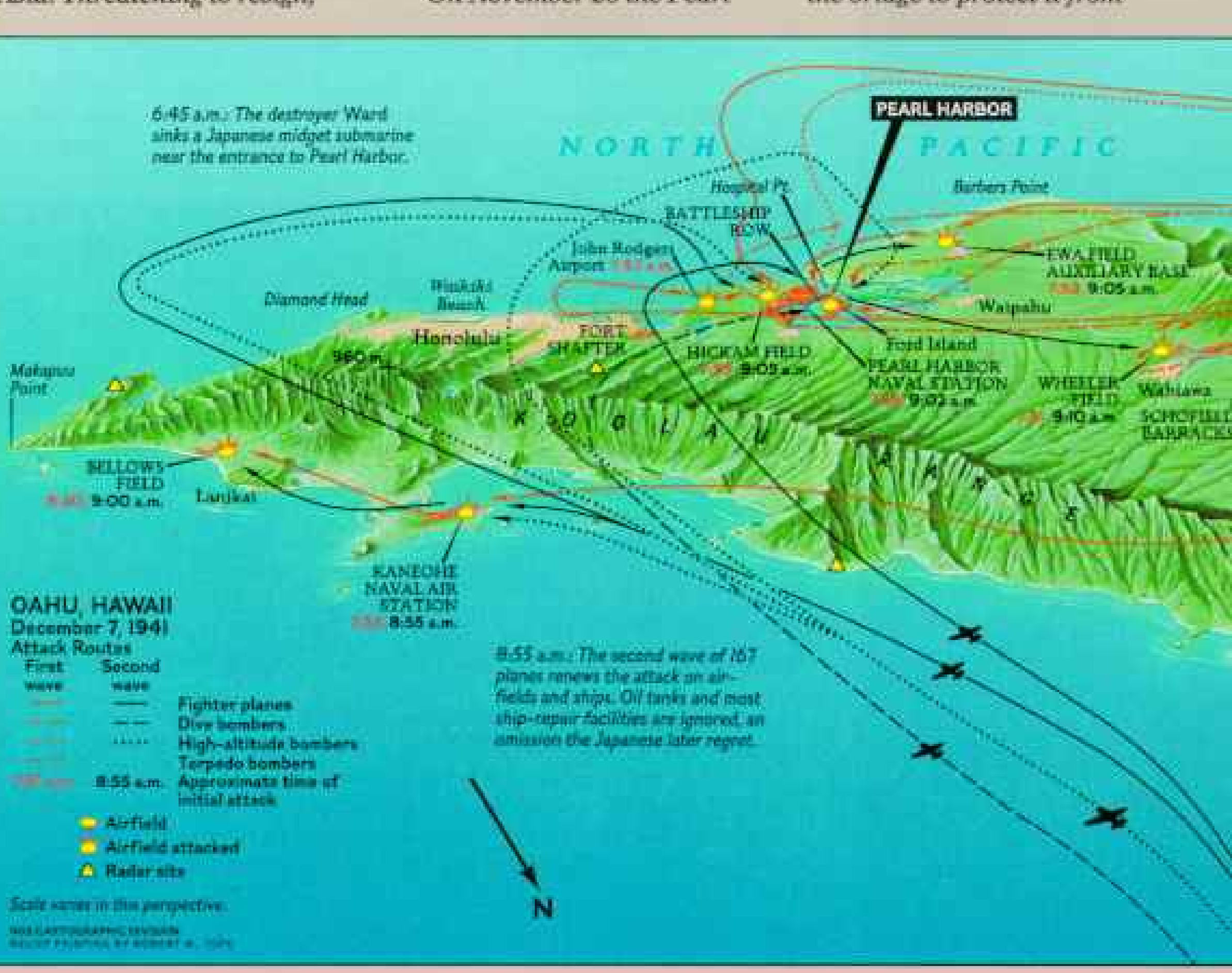
In 1941 many Japanese officers opposed the Hawaii Operation, preferring to concentrate on the invasion of southeastern Asia. Threatening to resign, Yamamoto held to his bold plan to strike Pearl Harbor.

To attack Hawaii, he turned to carrier-borne airplanes. His torpedo-bomber pilots trained relentlessly on the island of Kyushu, at a bay that resembled Pearl Harbor.

On November 26 the Pearl Harbor strike force left Japan for Oahu. For the next ten days the Japanese vessels steamed across the northern Pacific in radio silence to 235 miles north of Oahu (see map supplement). Crewmen on the flagship Akagi placed rolled hammocks on the bridge to protect it from



U. S. ARMY MUSEUM OF HAWAII, FORT DERUSSY



MAINICHI SHIMBUN

shrapnel and gunfire during combat (above left).

At dawn on December 7 an air fleet of 350 planes was launched in two waves from six carriers. At 7:51 a.m. the first wave descended on Oahu, called by a 1941 U. S. military report the world's strongest fortress.

before. And I witnessed his reunion with Stephen Weiner. When last they met, Weiner had held a .45 pistol to Sakamaki's head.

Sakamaki, a new Japanese ensign, was facing Weiner, a new second lieutenant, who made him America's first prisoner of war. Weiner, still holding the pistol, gave Sakamaki a hard-boiled egg and a slug of whiskey. Sakamaki begged for an "honorable death." His submarine was salvaged and later sent off on a tour to sell war bonds. Weiner, Sakamaki, and the midget submarine all met on the grounds of the Admiral Nimitz Museum State Historical Park in Fredericksburg, Texas.

Later, I spoke with crusty John Finn, who was grievously wounded when he stood his ground firing up at Japanese planes on December 7. John was awarded the Medal of Honor for his valor that day. As we chatted, we both overheard a former Japanese pilot, Zenji Abe, talking about his day over Pearl Harbor. Abe, like fellow veteran Iyozo Fujita in Tokyo, knew a Japanese pilot who flew off to "self-bomb" after his plane had been hit by ground fire. Finn, who has a lifelong sailor's rolling gait, ambled over to talk to Abe. Finn later told me he thought he might have shot down that plane.

SURVIVORS WHO TELL of the attack usually begin by looking away and staring into some inner space where moments live as reality, not recollection. An American sailor grabs an invisible stanchion as he describes how his ship rolled over. A Japanese pilot moves his hands as if they still hold the controls of his plane. An American nurse turns her head and points to a blank wall as if it is the ward full of the dying on that endless day.

Ray Emory, on board the cruiser *Honolulu*, had just finished breakfast and was in his bunk reading a newspaper when he heard the alarm for general quarters. He sprinted to his battle station, an antiaircraft gun three decks above the main deck. "I saw a plane go by, then another," he remembered. The ammunition box was locked. He grabbed a wrench and pounded the lock until it broke. "We started firing. A lot of people will tell you they saw the whole thing. But if you're firing a machine gun, you get tunnel vision."

One of the planes flying past Ray Emory launched a torpedo into the battleship *Oklahoma*, and her agony began. Trapped in a sealed compartment, 19-year-old George

DeLong felt his ship roll over. He wondered if death was imminent.

Radio operator Dwayne L. Eskridge, in the FBI office in downtown Honolulu, was sending Morse code test messages to an FBI colleague in San Diego when he heard low-flying planes. He tapped out QRX—"stand by"—and ran up the stairs to the roof of the two-story building. "I could clearly see airplanes with a red ball on each wing," he remembers. "I could see the pilots in the planes. I ran downstairs and sent a message that we were being bombed by Japanese planes. Then I went into the vault and got the only weapon I could find—a .45 pistol—and I ran back up to the roof and fired off a whole clip."

At Ford Island, in the middle of Pearl Harbor, Comdr. Logan C. Ramsey was standing by a window at the Command Center when a plane swooped into a dive. Ramsey saw something drop from the plane and explode. He ran across the hall into a radio room and ordered the operators to send out an uncoded telegraph message on all frequencies: AIRRAID ON PEARL HARBOR X THIS IS NO DRILL.

ON SATURDAY, DECEMBER 6, 1941, Honolulu station KGMB did not cease broadcasting at the close of day. A communications officer of the U. S. Army Air Forces had paid the station to play music through the night. Twelve B-17 Flying Fortress bombers, heading for Oahu from San Francisco, would home in on a radio beam of Hawaiian songs and an occasional jazz record.

The B-17s, en route to the Philippines, symbolized a U. S. decision to curb Japanese expansion and strengthen defenses in the Pacific. The planes, their dismounted guns packed in grease, also symbolized a nation hovering between peace and war, a nation of guns unloaded, of fate awaited.

Relations between the United States and Japan had been deteriorating since the spring of 1940, when Germany's defeat of France and the Netherlands left French Indochina and the Netherlands Indies vulnerable to takeover by Japan. British Malaya was also in jeopardy because Britain *(Continued on page 64)*

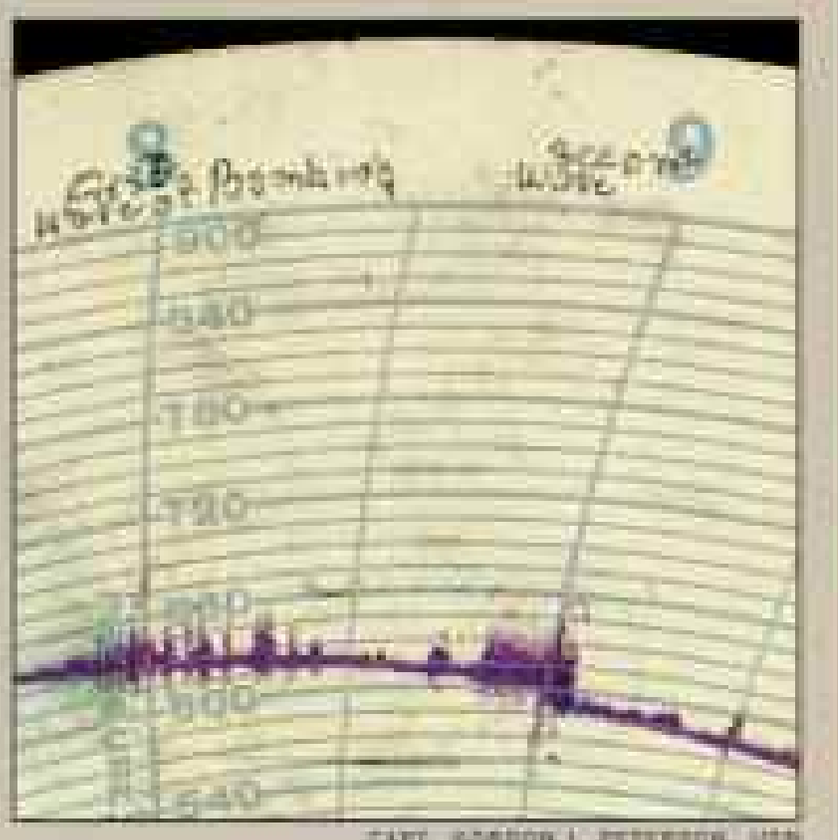
TOM ALLEN is co-author of *World War II: America at War, 1941–45* (Random House, 1991). His last GEOGRAPHIC article was on Mongolia (February 1985). Photographer DAVID DOUBILET is a frequent contributor to the magazine. His story on "Australia's Magnificent Pearls" appears in this issue.

Jinichi Goto, flight leader

COURTESY JIRICHI GOTO

8:00 a.m.: "Atarimashita!—It struck!" This victory cry erupts from torpedo pilots swarming over Battleship Row on the east side of Ford Island. A Japanese photograph (above) captures a rising waterspout marking a hit. The climbing plane to the right of the spout probably made the strike. Moments earlier Lt. (jg.) Jinichi Goto (above) scored the first hit on the Oklahoma, dropping to 60 feet above the water to release his torpedo. "Antiaircraft fire was heavy," Goto recalls, but his plane took no hits. Goto, visiting Yasukuni (right), a Tokyo shrine to war dead, is one of the few surviving Japanese flight leaders.

U.S. NAVAL HISTORICAL CENTER, WASHINGTON, D.C.



CAPT. GORDON J. PETERSON, USN

8:10 a.m.: The Arizona explodes in a hellish fireball. A 1,760-pound projectile, dropped by a high-altitude bomber, has pierced the forward deck, setting off more than a million pounds of gunpowder. The explosion snuffs out fires on the repair ship Vestal alongside, sends up tons of debris, and claims hundreds of lives.

Less than a mile away the needle on a water-temperature gauge in a power plant jerks as bombs fall. Its chart becomes a seismograph of history, recording the two attack waves (top).

Back on their carriers, supercharged Japanese pilots argue futilely for a third wave. Their mood is reflected in a taunting cartoon (below) recovered from a downed plane, showing the bombing of a U. S. battleship and aircraft carrier. In reality, Japan failed to destroy its primary targets—three American carriers, which were not in port.

NATIONAL ARCHIVES

George DeLong, trapped in the *Oklahoma*

When Jinichi Goto's torpedo struck the Oklahoma, *a 19-year-old seaman was just waking up—to a 32-hour nightmare.*

"My bunk was above the four emergency steering wheels," recalls George DeLong as he tours the after steering compartment on the Texas (above), similar to his quarters on the Oklahoma.

"A mate yelled: 'Man your battle stations and set watertight conditions!' So our compartment was sealed. After

COURTESY GEORGE A. DELONG

NATIONAL ARCHIVES

AT THE BATTLESHIP TEXAS, LA PORTE, TEXAS

more explosions, the ship leaned and went over. Its masts stuck in the shallows, keeping the hull from going under. But the lights went out and water rushed in through the air vent."

DeLong and his seven shipmates plugged the vent with a mattress and game board. Rescuers (left) had to cut through the hull; 429 of the crew died—more than a sixth of the day's losses.

Mary Ann Ramsey, officer's daughter

AIRRAID ON PEARL HARBOR X THIS IS NO DRILL.

"My dad sent out that warning," reports Mary Ann Ramsey (below), here with a patrol bomber like the PBYs her father, Navy Comdr. Logan C. Ramsey, commanded in 1941. The family was housed in quarters on Ford Island, a stone's throw from Battleship Row.

"Ships were berthed about us in a seemingly invincible necklace of gray steel," Ramsey recalls. When the first bombs fell, the 16-year-old took a moment to snatch the tin curlers from her hair before hurrying with her mother to shelter in the basement of an admiral's quarters nearby.

"I remember the sound of exploding bombs and the whine of planes—the fragments of exploding ships and great billows of black smoke everywhere. We were gripped by shock, fear, and anger. Every newcomer to the shelter was deluged with questions like 'Have they gotten the Panama Canal yet?'

COURTESY MARY ANN RAMSEY

"Then our wounded arrived—some with filthy black oil covering shredded flesh. We placed them on mattresses and gave cigarettes to those who wanted to smoke, even holding them for the ones who could not use their hands. We tried to reassure them.

"With the first sailor, so horribly burned, personal fear left me; he brought me the full tragedy of that day."

For years Ramsey's father had authored articles on America's military preparedness. He wrote prophetically in 1937 about the vulnerability of a fleet in port—"a perfectly marvelous target for . . . hostile torpedo planes."

In 1941 both the Army and the Navy were woefully underequipped on Oahu. Pearl Harbor's final toll: 2,403 dead, 1,178 wounded; 169 aircraft destroyed; 3 ships destroyed, 18 damaged.

AT THE NATIONAL MUSEUM OF NAVAL AVIATION, PENSACOLA, FLORIDA

(Continued from page 58) had to concentrate its forces on the war against Germany. Japan, coveting the oil, minerals, and rubber of the Pacific colonies, considered them part of an empire it called the Greater East Asia Co-Prosperity Sphere.

As a deterrent to Japanese moves against the colonies, in May 1940 President Roosevelt shifted the United States fleet from southern California to Pearl Harbor. In July he cut off two vital exports to Japan—top-grade scrap iron, the basis for most Japanese steel, and aviation fuel, upon which Japan was highly dependent. In September Japan signed the Tripartite Pact with Germany and Italy, gaining their recognition of a "new order in Greater East Asia." The United States saw the pact as proof that Japan planned to conquer the Pacific colonies.

When the commander in chief of the U. S. fleet protested the transfer of his ships to Pearl Harbor, Roosevelt fired him. Bypassing many admirals, the President named a replacement: Rear Adm. Husband E. Kimmel. Promoted to admiral, Kimmel took command of what now was designated as the U. S. Pacific Fleet, an armada of some 200 ships.

By the time Kimmel assumed command on February 1, 1941, the military establishments of the United States and Great Britain had begun work on a worldwide joint war plan. Adm. Harold R. Stark, Chief of Naval Operations, told his fleet commanders, "The question as to our entry into the war now seems to be *when*, and not *whether*." In the Atlantic, German U-boats intensified an undeclared war, attacking U. S. destroyers. One, the *Reuben James*, sank with a loss of 115 men.

The month before Kimmel took over at Pearl Harbor, Adm. Isoroku Yamamoto, Commander in Chief of Japan's Combined Fleet, wrote a letter to the navy minister. Yamamoto had aligned himself with factions counseling against war with the United States and had so opposed the Japanese Army's drummers for war that his naval friends had feared for his life. Yet his startling letter favored a massive attack on Pearl Harbor by carrier-borne aircraft.

By the end of 1940, when war seemed inevitable, Yamamoto saw that if the U. S. Pacific Fleet could be destroyed in one bold strike, Japan might be able to buy time to build its Co-Prosperity Sphere, then negotiate an end to the war. A habitual gambler, he bet on a surprise attack in hopes of a quick bonanza.

Yamamoto hedged his bet, however, by warning that if the war lasted longer than a year, "I have no expectation of success." Shrugging off the warning, Japan's military-dominated government gave him authority to begin secret planning.

Among the problems facing the planners was the 40-foot average depth of Pearl Harbor. A torpedo bomber needed a long, level run to aim and release a torpedo, which then plunged at least a hundred feet into the sea before rising to a shallow depth and heading toward its target. U. S. Navy officers, who well knew the physics of aerial torpedoes, saw Pearl Harbor's shallow waters and narrow, twisting entrance as natural protection.

KYUSHU, the southernmost major island of Japan, had in its scalloped shores a model for Pearl Harbor. The aircraft carrier *Akagi* sailed to Kyushu, and her pilots began flying a course laid out by Comdr. Mitsuo Fuchida, who would lead the attack.

Unaware of their ultimate target, the pilots did not see what Fuchida saw as he flew over the southern tip of Kyushu. To his eyes the lush, rolling land between two bays became the terrain of the Hawaiian island of Oahu. The port of Kagoshima became the shores of Pearl Harbor. A volcano thrusting from the sea off Kagoshima became Ford Island. Fuchida could even imagine the battleships moored along its eastern edge. A spy in the Japanese Consulate in Honolulu was already supplying the locations of U. S. warships and the pattern of their arrivals and departures.

Fuchida told the pilots to follow a curving river valley and dip down over Kagoshima. At times they flew so low they blew away laundry drying in the broiling sun. "As you pass over the Yamagataya Department Store," he said, "to port you will see a large water tank on the shore. As you pass over it, come down to 20 meters [about 65 feet] and release a torpedo." It was a daredevil maneuver, not in the books. And at first there were not even any practice torpedoes to release. The pilots were as mystified as the townspeople, who complained about their scattered laundry.

By the end of October there were new torpedoes modified with wooden stabilizers. Fuchida ordered each pilot to make his run at 184 miles an hour and keep his plane absolutely level when he released the torpedo.

These torpedoes dived only 35 feet below the surface before speeding toward their targets.

In mid-November the carrier *Akagi* secretly left port, as did the other ships of the Hawaii Operation. (A Southern Operation invasion fleet, coordinated to strike immediately after the Pearl Harbor attack, would leave Japan near the end of November for the Philippines, Malaya, and the Netherlands Indies.) The Pearl Harbor strike force—six carriers, two battleships, three cruisers, nine destroyers, and eight oilers for refueling—converged in Hitokappu Bay at Etorofu, one of the bleak Kuril Islands north of Japan's home islands. Just before the carriers left for Etorofu, "torpedo-adjusting crews" came on board to inspect the new "near-surface torpedoes."

On November 26, with transmitters sealed to preserve radio silence, the strike force headed east. On the *Akagi* Lt. Comdr. Tadakazu Yoshioka worked out signals for Commander Fuchida. The bombers had telegraph keys, not microphones. Yoshioka chose two easily recognized signals: - - – - - for *to* and · · · for *ra*. He told Fuchida to send *to* as a signal to launch the attack and then *to ra* to signal that the attack was a surprise—*to ra, to ra, to ra!* Each signal was to be tapped out three times for insurance. Years later Yoshioka would explain that he had not intended for the signal to mean "tiger," *tora* in Japanese.

The course took the fleet far from usual shipping lanes, through high seas that swept several men overboard. Three submarines accompanied the force. A score of others headed for Oahu to torpedo any U. S. warships that managed to escape Pearl Harbor. Five submarines each carried a midget submarine to slip into the harbor before the attack.

On December 2, Tokyo time, Yamamoto sent the fleet a message: Climb Mount Niitaka 1208. The message, naming Japan's highest mountain (on Formosa, then part of Japan), authorized the attack and ordered its date: December 8. In Pearl Harbor that date would be Sunday, December 7. The fleet changed course to the south, toward the aircraft launch site 235 miles north of Oahu.

The Mount Niitaka message was sent in a code penetrated but not yet cracked by U. S. code breakers. For some time, however, they had been intercepting messages sent in other codes. And these intercepts had alerted U. S. policymakers to the realization that Japan, while negotiating in Washington for an end to the crisis, was simultaneously preparing for war. But where was the Japanese fleet?

Secretary of the Navy Frank Knox thought he knew where the Japanese were. On December 5, during a Cabinet meeting, he told President Roosevelt, "Well, we have very secret information that mustn't go outside this room that the Japanese fleet is out. They're out of harbor. They're out at sea. . . . Every indication is that they are going south, Mr. President. That's the obvious direction."

"But," Roosevelt questioned, "it's not absolutely certain."

"That's right . . . but we must conclude that they are going south."

South, the likely direction, was toward the riches of Malaya and the Netherlands Indies.

Around 11 p.m. on Saturday, December 6, the captain of the Japanese fleet submarine I-24 looked through his periscope and saw the skyline of Oahu. A radioman twisted a dial to pick up KGMB and its unfamiliar music.

Ens. Kazuo Sakamaki was captain of the two-man, 79-foot-long midget submarine secured to the I-24's deck. He wrote a letter of farewell to his father, bathed as best he could, donned a clean uniform, and sprayed on perfume, in keeping with samurai tradition. He knew that the gyrocompass on his submarine was not working. But he decided he would continue with his mission: Get through the antisubmarine net at the entrance to Pearl Harbor and risk death by mines or depth charges as he sought his chosen target—the *Pennsylvania*, flagship of the U. S. fleet.

When the I-24 surfaced, Sakamaki saw the glow from neon lights on Waikiki Beach and heard music from the Royal Hawaiian Hotel wafting through the moonlit night. Then Sakamaki and his crewman squeezed into their black-hulled craft. The I-24 descended, and clamps snapped open, releasing the midget submarine. It slid away, plunged downward, and Sakamaki began struggling to level it and head toward Pearl Harbor.

SHORTLY BEFORE 4 A.M. on Sunday a minesweeper at the entrance to Pearl Harbor sent a blinker-light message to the destroyer *Ward*. The message had hardly gone beyond "sighted submerged submarine" when Lt. William W. Outerbridge, the *Ward*'s captain, ordered general quarters. Outerbridge, on his second day as a commanding officer, eagerly searched but found nothing.

John Finn, ground-crew chief

Yamamoto's "eagles of the sea"—his carrier pilots—warm up Zero fighters (above) for the second wave. Their mission: To run interference for the bombers launched after them. With few U. S. planes in the air, Zero pilots were free to concentrate on strafing ground targets. But at Kaneohe Naval Air Station they met unexpected ferocity from men like chief aviation ordnanceman John Finn.

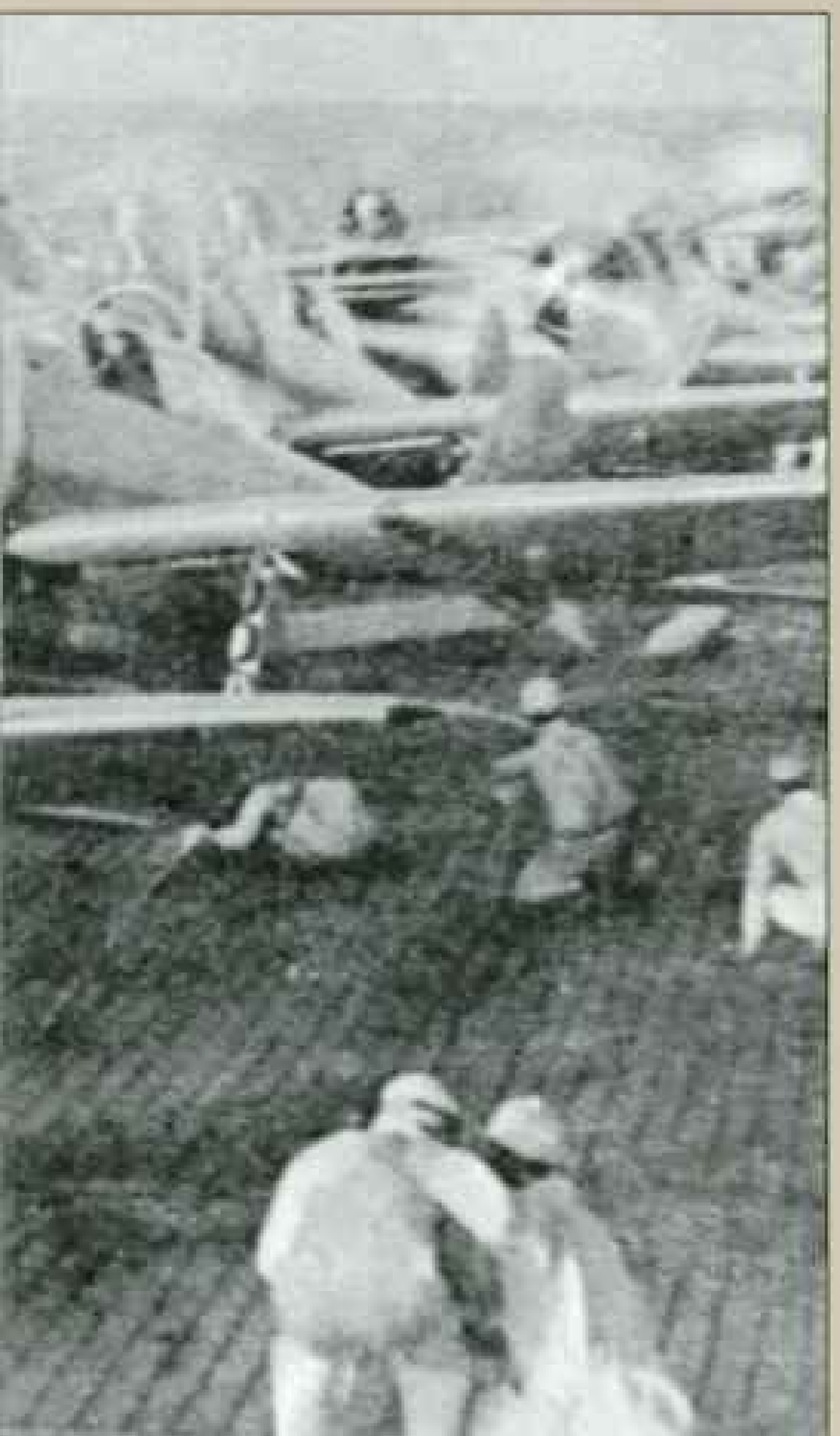
The base had been on limited alert for a month, with patrol planes kept fueled and fully armed. Surprised by the first wave of attack planes, men yanked some machine guns and ammunition from parked planes before Japanese incendiary bullets set the aircraft afire.

"I was so hopping mad; I wanted to shoot every damned plane out of the sky," Finn recalls. Caught without gun mounts, defenders braced their 30-caliber weapons on timbers, picked up pistols and shotguns, and ripped off antiaircraft fire "so thick in places you could almost walk on it," said a Japanese pilot.

U. S. NAVY

Mounting a machine gun on a makeshift stand, Finn kept shooting during both waves, although his body "stopped a lot of shrapnel." One of his last hits may have been Lt. Fusata Iida, who dived his disabled plane toward his attackers and crashed into a hillside, one of 64 Japanese to die that day. Finn finally checked into a hospital with wounds in his stomach, chest, arms, and foot. "It was not my day to die," he says.

Finn received the esteemed Medal of Honor for "extraordinary heroism" in a ceremony attended by his wife, Alice (left), who witnessed the Kaneohe attack from their living quarters.



Then, at 6:40, the *Ward* again went to general quarters, this time racing toward a conning tower. At 50 yards the *Ward* fired two shots and dropped a pattern of depth charges, sinking a midget submarine. By the time Outerbridge's report reached Admiral Kimmel, the attack was almost under way.

Around the time the *Ward* fired the first shots of the war against Japan, it was noon in Washington. That morning U. S. code breakers had deciphered the last part of a 14-part message sent from Tokyo to the Japanese Embassy. The message ended with a declaration that negotiations were to be broken off at 1 p.m. Washington time (7:30 a.m. Hawaii time). To U. S. officials this amounted to a threat of imminent war.

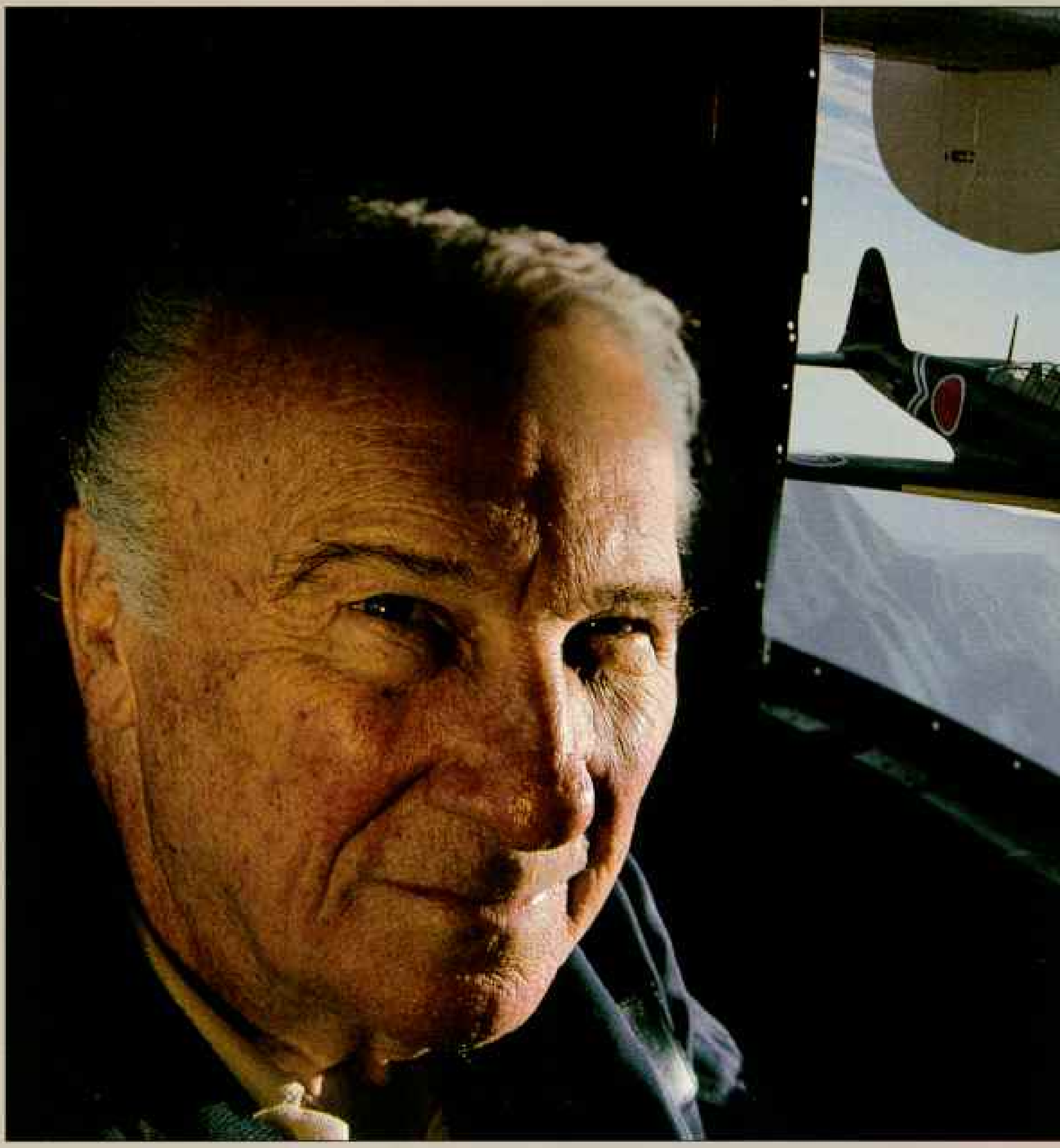
A little more than an hour before the deadline, Gen. George C. Marshall, Army Chief of Staff, sent Lt. Gen. Walter C. Short, commander of U. S. Army forces in Hawaii, a coded message to "be on alert" because Japan had issued "what amounts to an ultimatum." Atmospheric static had blacked out communications with Hawaii. So the message was sent via the more powerful but slower Western Union and RCA commercial systems.

As Marshall's message went out, the six Japanese aircraft carriers turned into the wind. Within 15 minutes, 183 fighters, bombers, and torpedo planes were aloft. Fuchida, in his high-altitude bomber, tuned his radio direction finder, found KGMB, and took a bearing on "some light music." Then he tuned in another station and heard a Honolulu weather report: "Averaging partly cloudy. . . . Visibility good. Wind north, ten knots."

A new distant-detection device called radar had come to the Army on Oahu not long before. The six radar units were usually turned on at 4 a.m. and off at 7 a.m. At about 6:45 on December 7, several sites picked up—and ignored—signals indicating planes off the northern coast. The blips were produced by echoes from two Japanese scout planes.

The transport truck arrived a few minutes late at the Opana radar unit, on the northern edge of the island. An Army private was still looking at the oscilloscope at 7:02 when he saw a cloud of blips—"something completely out of the ordinary." He estimated that "probably more than 50" aircraft were 132 miles away, on a bearing toward Oahu.

The unit reported the sighting by telephone to an information center at Fort Shafter. The



Kenneth Taylor, P-40 pilot

With memories on his wing, Kenneth Taylor cruises over California in a B-25, in formation with a Japanese Zero and a P-40 similar to the fighter he once piloted.

Fifty years ago, Taylor and George Welch (right, at right), both second lieutenants in the Army Air Forces, had just returned from a night on the town when Japanese bombers began to bomb and strafe Wheeler Field.

The young pilots raced to the airfield at Haleiwa, where their squadron had been practicing aerial combat. Once airborne in their P-40s, the duo found themselves embroiled in the real thing.

"As I was rearming at Wheeler, the second wave suddenly came up the valley," Taylor recalls. "I turned on the grassy field and took off right into them. Then I got in the middle of their line—the P-40 was very good at dogfighting." The two pilots were credited with six of the 29 Japanese planes lost that day. Welch died testing an F-100 after the war.

AIRCRAFT FROM PLANES OF FAME, CHINO, CALIFORNIA

COURTESY KENNETH M. TAYLOR

lieutenant on duty had been there only once before and knew little about radar. But he did know that the B-17s were soon due. After some discussion the lieutenant said, "Well, don't worry about it." When he hung up, the planes were 88 miles away.

A few minutes later the warning from Marshall arrived at the RCA office in Honolulu. Because it was not marked urgent, it was treated as an ordinary telegram. About 7:30 a messenger picked up the telegrams, hopped on his motorcycle, and began his deliveries.

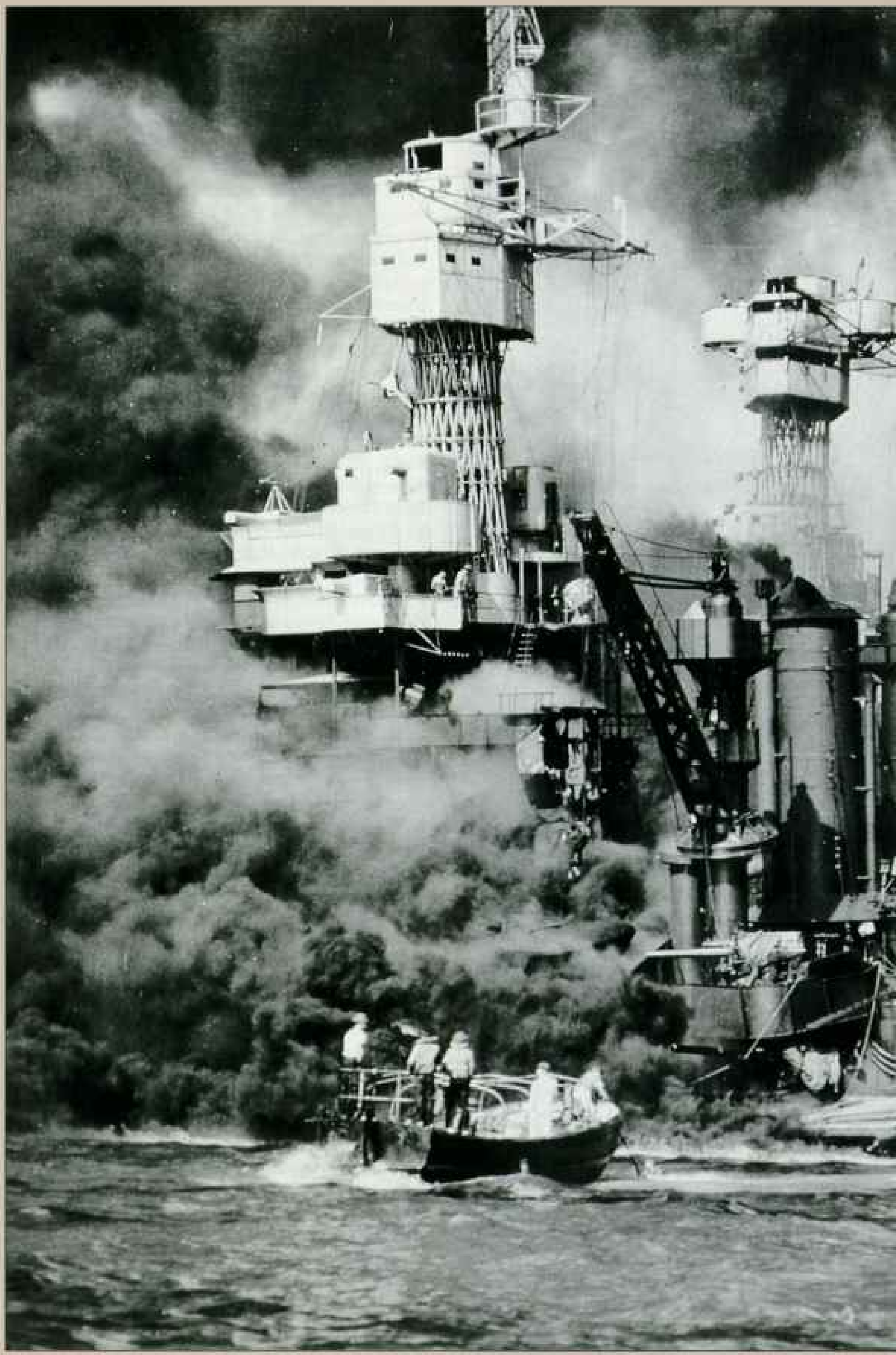
At 7:49 Fuchida, looking down on Pearl Harbor through binoculars, saw no antiaircraft fire, no sign of an alert. He counted seven battleships moored at Ford Island but, disappointed, saw no aircraft carriers. He ordered his radioman to tap out *to to to:* the signal to attack. Then, a few minutes later, *to ra, to ra, to ra:* Surprise achieved. Dive bombers flying at 12,000 feet streaked down on the Army Air Forces' Wheeler Field, north of Pearl Harbor, and Hickam Field, southeast of Battleship Row.

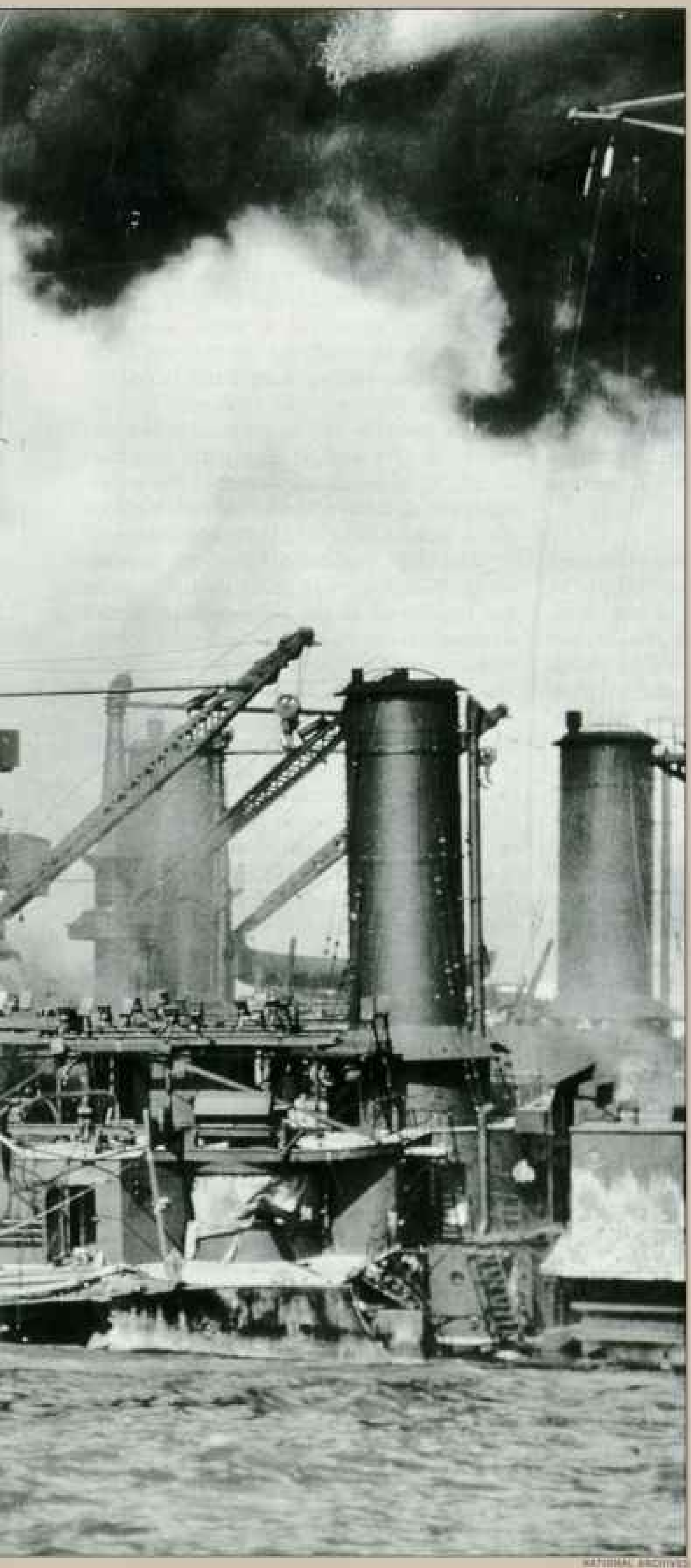
A 550-pound bomb pierced the roof of a 3,200-man barracks complex at Hickam and exploded in the dining hall, killing 35 men at breakfast. The bombers returned again and again to Wheeler and Hickam, flying so low that their landing gear ripped down utility wires. Americans saw the faces of the pilots as the planes strafed after dropping their bombs.

Most U. S. planes were parked wingtip-to-wingtip in neat lines to make it easier to guard against sabotage by Japanese or Japanese-Americans in Hawaii. General Short had reacted to a November war warning by ordering the antisabotage move. He had also asked, in vain, for more antiaircraft guns.

WHEN THE FIRST JAPANESE PLANE roared down on Wheeler, 2nd Lt. Kenneth Taylor thought, *Here comes the Navy again.* Then he saw the machine-gun bullets thudding into the planes on the flight line and ripping along the wall of the officers' club. He sprinted to a phone and called Haleiwa, a small auxiliary field ten miles north of Wheeler. Taylor ordered the fueling and arming of its P-40s. He and 2nd Lt. George Welch jumped into Taylor's Buick and, through the strafing, sped to Haleiwa. They were airborne in minutes.

"We had absolutely no trouble at all finding plenty of targets," Taylor recalled. "We





NATIONAL ARCHIVES

Americans respond—picking up guns, rescuing survivors, and fighting fires, like those engulfing the West Virginia (left). A launch from the California pulls in a sailor.

U. S. gunners fired at Tomoe Yasue, causing him to jettison his missile, meant for the Oklahoma. The torpedo nosed into the mud. Last May, dredging brought a live torpedo (below)—most likely Yasue's—to the surface, giving Americans their first look at a secret weapon developed for the attack.

Pearl Harbor was only 40 feet deep—too shallow for conventional aerial torpedoes, which sank at least a hundred feet before heading toward the target. In autumn of 1941 the Japanese found that adding wooden stabilizers and launching from very low altitudes solved the problem.

Too dangerous to preserve, Yasue's torpedo was later exploded. The surviving rear section will be on display at the Arizona Memorial.

DAVID MARTINEZ, NATIONAL PARK SERVICE

caught up with them at Ewa, a Marine base. They were in a strafing lineup, and George and I merely got into the line." They ran out of ammunition, landed at Wheeler, loaded up, and took off to fight again. They are credited with shooting down six Japanese planes.

While dive bombers and fighters ravaged Wheeler and Hickam, a string of torpedo planes, flying three to a V, shifted to single file for the long, steady descent, curving down on Ford Island just as they had done at Kagoshima. As each plane leveled off, its pilot saw a sight familiar from models and drawings. Still, Lt. (jg.) Jinichi Goto "was shocked to see the row of battleships in front of my eyes." In his excitement he flew toward his target diagonally, "not knowing which was the bow and which was the stern."

IN A LINE OF BERTHS along the eastern edge of Ford Island were seven battleships: the *California*, the *Oklahoma*, the *Maryland*, the *West Virginia*, the *Tennessee*, the *Arizona* with the repair ship *Vestal* moored outboard, and the *Nevada*. Goto's torpedo and one from another in his three-plane group hit the *Oklahoma*. Two torpedoes hit the *California*; at least three more struck the *Oklahoma*, and one hit the *Nevada*. On the other side of the island two bombers, contrary to orders, torpedoed the aged target ship *Utah*, which the U. S. Navy had been using for gunnery training.

On the *West Virginia*, Dick Fiske had been relieved early of his four-to-eight watch and was on the quarterdeck, anxious to get ashore again that weekend. "We saw the dive bombers coming in, and we thought they were Army planes. Just another exercise," he remembered. "A friend of mine said, 'Let's go over to the port side and watch them dropping torpedoes on us.' We saw three planes come in, about 15 feet off the water. They dropped torpedoes. My friend tapped me on the shoulder and said, 'Now all you're going to hear is a little thud when it hits the ship.'

"The next thing I remember was a hellacious loud noise, and a wall of water that looked like a 50-foot wave came across the deck and washed us both to the other side of the ship. Six more torpedoes hit us. A bomb came down, and it hit the *Tennessee*. A large piece of shrapnel took out most of the captain's stomach. We started carrying him down, and he was still giving orders until he died."

One of the sailors who helped carry Capt. Mervyn Bennion was a mess attendant, Doris Miller, the *West Virginia*'s heavyweight boxing champion. Miller then manned a machine gun and, although untrained as a gunner, began firing. "It wasn't hard," he said later. "I just pulled the trigger, and she worked fine." He became the first black to be awarded the Navy Cross.

On Saturday night George DeLong, back to the *Oklahoma* from liberty, had watched an acey-deucey game for a while and then crawled into his bunk, the top of three, in the after steering station, three decks below the main deck. Soon after he awakened on Sunday, he heard a call to battle stations and explosions. He had no idea what had happened. Then somebody slammed the watertight door shut from the outside and dogged it down, locking eight men in the compartment.

"The ship shuddered," DeLong remembered. "She started to list to port. Furniture and equipment in the compartment started crashing around the deck. I climbed back up to my bunk and held on to my bunk stanchion." The lights went out. The ship kept rolling. "I realized my head was where my feet had been. By the time the ship settled down and we let go of the things we were holding on to, we knew that the ship had turned over."

They could hear water rushing in through an air vent from the main deck, which was now far below them. Water lapped around their ankles, their knees. They stuffed the vent with everything they could find, but nothing would stop the water. "Then the acey-deucey board came floating over to us, and we put that on top. It just fit, and we tied it down with a piece of heavy line."

But the water still trickled in. It was above their waists when they began taking turns pounding a wrench on the bulkhead, signaling SOS in Morse code.

MINUTES AFTER the torpedo planes swooped down, Fuchida's high-altitude bombers formed into a line, the planes closely spaced in groups of five—"a gorgeous formation" to Fuchida's eyes. The bombers carried 1,760-pound armor-piercing projectiles made for 16-inch battleship guns but converted to aerial bombs. Antiaircraft fire veered the planes away from their target, the *Nevada*. As Fuchida led a second pass, the shock waves of a massive explosion welled up from the harbor and rocked the planes. A

NATIONAL ARCHIVES

Slain by friendly fire, shipyard workers John Adams, his father, and a friend were five miles from Pearl Harbor when their Packard was hit by shrapnel from errant five-inch Navy shells. American antiaircraft guns rained damage on Honolulu, untouched by Japanese bombardment.

column of red-tinged black smoke shot a thousand feet into the sky.

A bomb had stabbed the *Arizona* through to her forward magazines and then exploded, touching off more than a million pounds of gunpowder. A sailor on the *Nevada* watched the *Arizona* "jump at least 15 or 20 feet upward in the water and sort of break in two." In that instant more than a thousand men died. The ship sank in less than nine minutes.

At about 8:30 the Japanese planes began forming up to return to their aircraft carriers. Under the suddenly empty sky, the *Nevada,* crippled and afire, stirred at her moorings. She was trying to get away from the inferno. Because her boilers had been fired up, she was under way in 40 minutes; a cold start would have taken three and a half hours. She passed the flaming *Arizona* and her few survivors, engulfed in oil and flames. Three of them grabbed lines and clambered aboard the *Nevada*. She passed the sunken *West Virginia,* passed the hull of the capsized *Oklahoma*. She was near the turn to the harbor entrance and escape to the open sea when the second wave of Japanese planes arrived over Oahu.

Several planes pounced on the *Nevada;* at least five bombs struck the battleship almost simultaneously. Rather than block the channel, the *Nevada* deliberately ran aground at Hospital Point. In the dynamo room deep in the ship, Don Ross ordered his men out of the smoke and steam and worked alone, burned and blinded. Topside, antiaircraft gun crews kept firing. Ross flipped a switch to turn on another generator and, suffocating, collapsed. A shipmate heard his gasps on the phone system and dragged him out. Revived but still temporarily blinded, he stumbled back to his post.

Dive bombers and high-altitude bombers attacked the battleship *Pennsylvania,* helpless in dry dock. Other dive bombers aimed for the ships returning the fiercest gunfire. The second wave crippled cruisers and destroyers, but Americans shot down 14 dive bombers and six fighters. Fuchida, his plane hit several times, kept circling over Pearl Harbor through "very heavy" fire.

Zero fighters strafed Bellows Field, a small training base in eastern Oahu, killing a P-40 pilot as he stepped into the cockpit, downing two other P-40s just as they got off the ground, and chewing up one of the B-17s, which had crash-landed moments before. Shot at by friend and foe, the B-17s landed wherever they could. Eight made it to Hickam.

Japanese planes swarmed over Kaneohe Naval Air Station, near Bellows. The flight

Kazuo Sakamaki, midget-submarine pilot

"We had fully expected to die in battle. Then something went wrong." Ensign Kazuo Sakamaki later wrote of his experience piloting one of five midget submarines ordered to steal into Pearl Harbor and aim their twin torpedoes at select ships. The two-man vessels, powered by 224 batteries, rode piggyback on board five submarines across the Pacific.

On December 7 Sakamaki knew his gyrocompass was out of order but launched anyway, ten miles out. For 30 hours he struggled to steer his craft, until it snagged on reefs near Bellows Field. He was washed ashore and captured—America's first prisoner of World War II (right).

Filled with shame, he spent the war in U. S. camps, while his nine dead comrades were lionized in Japan, credited briefly with sinking the Arizona. Gradually, he put aside military values, believing "man is capable of being made anew." In an emotional moment Sakamaki—a retired president of Toyota Do Brasil S.A.—encounters his sub (above), on display in Texas.

AT THE ADMIRAL NIMITZ MUSEUM STATE HISTORICAL PARK, FREDERICKSBURG, TEXAS

ADMIRAL NIMITZ MUSEUM

leader was Lt. Fusata Iida, a "master of the air," according to his friend, Lt. (jg.) Iyozo Fujita. Like most fliers, Fujita had not strapped on a parachute because if his plane was severely damaged, he would self-bomb. Psychologically, all Japanese pilots flew out ready to die.

KANEOHE did not have any antiaircraft guns. Chief aviation ordnanceman John Finn stood in a parking lot firing a .30-caliber aircraft machine gun mounted on a rack used by instructors. Other sailors and marines aimed .45-caliber pistols, Browning automatic rifles, and even shotguns at the sky. Shrapnel gouged Finn's chest, his stomach, a hand, a foot. He kept firing.

Somebody's bullets hit at least two planes—Iida's and Fujita's. They and the rest of their group broke off the attack and headed toward a rendezvous point for their return flight. But Iida touched a hand to his mouth, the signal for fuel trouble. "I could see that gasoline was leaking from his plane," Fujita remembered. "He waved and pointed down and turned back." Fujita, through tears, saw Iida's plane dive on Kaneohe.

John Finn recalled the scene on the ground. "All our planes were burning. And then this plane comes down and disappears in the smoke. I said to myself, When he gets out of that smoke, I'm going to let him have it. I swung my gun around to the center of that smoke, and that guy came barreling out of it. I was shooting right down his propeller hub. I got off maybe eight rounds. I think he came to get me." Iida's plane roared over Finn's head and slammed into a hillside.

At Kaneohe the last attack of the day was finally over. By ten o'clock the skies over Oahu were clear. At 11:45 Marshall's message reached General Short's headquarters, but he did not see it until about 3 p.m.

Pearl Harbor turned to its dead, dying, and missing. *Where do you start?* Dorothy Young, an operating room nurse at Tripler Army Hospital at Fort Shafter, asked herself. "We gave them morphine. Put the mark on their foreheads. M for morphine," she remembered. "They were coming to us in trucks—not ambulances. Trucks. The trucks kept backing up and delivering them. Bodies, most of them. Bodies." The toll would be 2,403 Americans killed and 1,178 wounded.

On the afternoon of December 8 rescuers

using pneumatic drills broke through the double hull of the capsized *Oklahoma* and pulled out George DeLong; he was one of 32 men taken out alive.

Of approximately 400 U. S. military aircraft in Hawaii only a fourth were airworthy after the attack. The warships fared better. Much of the fleet, including its three aircraft carriers, had not been in Pearl Harbor. Repair crews immediately went to work on the torn and gutted ships. Except for the *Arizona*, *Utah*, and *Oklahoma*, every sunk or damaged ship returned to sea, some within weeks.

In the 44 months of fighting that followed, the United States Navy sank every one of the Japanese aircraft carriers, battleships, and cruisers of the Pearl Harbor strike force. Nagasaki, the city where the special torpedoes were made, was destroyed by a U. S. atom bomb on August 9, 1945. When Japan signed the surrender document on September 2,

An EXPLORER segment, "Secret Subs of Pearl Harbor," will air Sunday, December 8, at 9 p.m. eastern time on cable TV station TBS.

among the U. S. warships in Tokyo Bay was the *West Virginia*.

DECEMBER 7 AT PEARL HARBOR. They have scattered the flowers and made the speeches. The people on the *Arizona* Memorial stand in silence. For a moment some of the flowers shimmer in a patch of sea made iridescent by a veil of oil. From the *Arizona*, day after day, a drop at a time, rises a stubborn remembrance of a day of fire and valiant death. □

On a cloud-cluttered December morning, a restored U. S. training plane, an SNJ, flies over Ford Island, where the first Japanese bombs fell 50 years ago. The scene evokes the day that galvanized America and the rallying cry that sustained it throughout World War II: "Remember Pearl Harbor."

Rain Forest Canopy

The High Frontier

A new breed of scientist risks life and limb to probe the great unexplored world at the top of tropical rain forests. On a steep slope in Costa Rica, ecologist Pierre O. Berner paints rings to monitor the growth of an oak branch.

By EDWARD O. WILSON

Photographs by
MARK W. MOFFETT

THE TROPICAL RAIN FOREST I had entered was a shadowed world broken by beams and nuances of greenish sunlight. I had come home to my favorite habitat, the one before which naturalists stand in awe. I was on Barro Colorado, an island in Gatún Lake halfway along the Panama Canal. My visit rekindled a simile that had come to mind in other places and other times: Seen on foot, a rain forest is like the nave of a cathedral, a thing of reverential beauty yet with much of its splendor out of reach in the towers and illuminated clerestories high above.

There was no lack of life around me on the ground. It teemed in the patchwork of light and dark. My attention was pulled to eye level and downward by the closeness of plants and animals in the soil and undergrowth. But I remained aware of a wholly different world a hundred feet above, where brilliant sunlight drenched sprays of vegetation and Babylonian gardens, an errant wind soughed throughout the day, and legions of birds, insects, and other animals specialized for high arboreal life flew and leaped back and forth. This high layer is the powerhouse of the forest, where more than 90 percent of photosynthesis takes place and, in the fullest sense, life begins.

Given a few grains of soil, baby bromeliads spring from seeds on a leaf of the mother plant (above). Bromeliads and other epiphytes—plants that grow atop other plants—thrive in the rain forest canopy, often taking root on mats of wind-deposited soil and decaying vegetation. In Costa Rica botanist Nalini Nadkarni peels a thick mat from a branch (facing page) to study how fast the layers accumulate.

The crown foliage of most tree species grows year-round, to be consumed by animals or to die and rot. The dead material thus produced rains steadily to the ground, bearing the remnants of energy to sustain the kinds of plants and animals among which I now stood. It brings nitrogen, phosphorus, and other nutrients back to the earth, to be sucked up by tree roots and returned to the canopy to restart the cycle of life.

The rain forest canopy, an undiscovered continent as naturalist William Beebe called it, is achingly close to the earthbound observer (map, page 84). But it is almost inaccessible and has remained largely unexplored. During 35 years of visits to tropical forests, I have made repeated attempts to study insects in the canopy. I once followed a logging operation in Papua New Guinea, climbing into the upper branches almost as soon as the trees fell to capture ants, beetles, and other specimens and to take notes. I worked the margin of a forest on the South Pacific island of Espiritu Santo, where the canopy bent down to the shore. On the edge of a ravine in the Brazilian Amazon, I peered for days through binoculars into tree crowns a few yards away. I learned little from these efforts. I was forced to stay with the ground and undergrowth.

Now I walked through the forest of Barro Colorado Island to a 138-foot tower, maintained by the Smithsonian Tropical Research Institute to assist long-term studies of the canopy. Climbing to the top, I could look out over the crowns of all but the highest trees, and peer at foliage close enough to touch.

A polite distance separates tree crowns in Malaysia. Canopy "shyness" apparently results from branches rubbing together or robbing each other of sunlight, creating gaps bridged by animals that jump, swing, glide, and fly.

At my fingertips, literally, as I reached out and pulled a tree branch closer, were squadrons of ants gathered around treehoppers, thorn-shaped insects busily sucking the juices of the tender leaf shoots. The ants were not attacking these strange creatures. They were protecting them from spiders, wasps, and other enemies. In exchange, I knew, the treehoppers deposited sugar-laced excrement for the ants to eat. Such are the bonds of symbiosis that hold the rain forest community together.

Another image soon replaced the cathedral as I looked out and away: It now seemed I was floating atop a life-filled sea. All around me the bright green tree crowns of the upper story billowed like waves in a gentle breeze. Arboreal dragonflies soared and darted over the surface in search of insect prey, just as other dragonflies patrol the surfaces of ponds and lakes. Beautiful brown-and-blue charaxine butterflies swirled around one another in territorial dogfights. A pair of toucans glided into a nearby emergent tree, calling noisily. Ants scurried everywhere, hunting for food.

I could look straight down, as though peering into a crystal-clear

Like an undiscovered continent encircling the globe, tropical rain forests shelter an astonishing abundance of organisms—probably more than half the earth's plant and animal species. Heart of the forest is the canopy, the thick upper foliage where more than 90 percent of photosynthesis takes place. At canopy study sites around the world, scientists race to discover new organisms. With tropical forests being cut at a rate of 55,000 square miles a year, untold numbers of species perish before they can be identified, much less studied.

water column, all the way to the ground. Thirty feet below, hundreds of small flies danced in a midair mating swarm alongside tree crowns of the lower story. Below them giant morpho butterflies sailed by, flashing brilliant blue points of light as they opened their wings, then almost disappearing as they flicked their wings back up, the alternation sending a signal in metronomic rhythm. On the ground, far below and hard to see in the deep shade, logs and fallen tree branches lay scattered on a thin blanket of dead leaves.

Well, I made it to the treetops, I thought, and here I am, born a few years too early, a slightly creaky field biologist now cast in the role of spectator instead of participant, but happy to be that much. A new generation of scientists have begun a serious assault on the

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EDWARD O. WILSON, winner of the National Medal of Science and two Pulitzer Prizes, is the Frank B. Baird, Jr., Professor of Science and the Curator in Entomology at Harvard University. Zoologist and photographer Mark W. Moffett, a frequent contributor to the magazine, is one of Wilson's former graduate students. He is also one of a number of scientists studying the rain forest canopy with support from your Society.

mysteries of the canopy, and it will be a pleasure to travel with them vicariously. In addition to towers, they use a wide range of imaginative and daring methods to reach and study this part of the forest. Various teams of hard-muscled young men and women around the world lean booms into the upper branches, travel out in gondolas suspended from building cranes, ascend on ropes, lower supporting nets from dirigibles, nail ladders onto tree trunks, and travel along walkways suspended across the crowns of trees.*

Month by month, at an accelerating rate, their efforts have begun to disclose the remarkable and unique traits of the canopy and its inhabitants.

THEY ARE REVEALING unimagined worlds in the foliage of the rain forest, where chunk-headed snakes with catlike eyes feast on frogs and lizards; where an ant known as *Daceton armigerum*, armed with jaws like a bear trap, rotates its head vertically to snatch flies from the air; and where earthworms wriggle through foot-thick soil on tree branches—ten stories in the air. How do the worms and soil get there? That's one of the questions scientists are exploring. In the process, they are turning up thousands of new species, as yet undescribed by science. They've found a poisonous caterpillar in Peru that looks like a miniature dust mop, and in Papua New Guinea giant weevils that carry miniature gardens of mosses and lichens on their backs. So many new species are being found that it is hardly news any more.

Wincing in the face of gale-force winds, ecologist Ken Clark mans his weather station in Costa Rica's Monteverde Cloud Forest Reserve. As moist air whips in from the Atlantic Ocean, water condenses on Teflon filaments. Clark later measures nitrogen and other waterborne nutrients to determine how much the atmosphere adds to canopy soil mats and the rest of the ecosystem.

In an endless cycle, rain forest trees shed leaves that fall to the ground, thus enriching the soil tapped by the trees as they produce more leaves.

The big news is, quite simply, that life is more diverse and more plentiful than anyone had previously known. Of the roughly 1.4 million species of organisms given a scientific name to the present time and those remaining to be studied, many biologists believe the majority are to be found in tropical rain forests.

In just one 25-acre tract in Malaysia, Peter Ashton of Harvard University found 750 species of trees. In another record-breaking survey, Alwyn Gentry of the Missouri Botanical Garden identified 283 tree species in only 2.5 acres near Iquitos, Peru. By contrast, about 700 species make up the entire native tree flora of the United States and Canada.

Animal diversity is equally mind-boggling. From a single tree in Amazonia, I identified 43 ant species, approximately the same number as occur in all the British Isles. At some places in the upper Amazon basin, 1,200 kinds of butterflies occur, about 7 percent of the world's known species.

Yet even these figures pale in comparison with recent estimates of the total diversity of insects, *(Continued on page 92)*

*See "A Raft Atop the Rain Forest," by Francis Hallé, in the October 1990 NATIONAL GEOGRAPHIC.

Stairways to the roof of the forest

How to get to the top? Enterprising scientists always find a way, simple or otherwise. Nalini Nadkarni (below) uses climbing rope and stamina as she gives her son Gus a look at the view in Costa Rica. From a

tower on Panama's Barro Colorado Island (far left), the author reaches out to collect ants, a lifelong passion. Erected by the Smithsonian Institution, the 138-foot-tall structure provides access to a high but narrow study area.

Near Panama City, a construction crane (top) enables researchers in a gondola to explore a 118-foot radius anywhere from ground level to a hundred feet high. After reaching the canopy in Sri Lanka by a succession of ladders (left), scientists built a bamboo platform for pollination studies.

Some Asian tree communities stand barren for several years, then burst into fruit over a large area, an unpredictable phenomenon called "masting." When it happens, scientists need to get into the canopy fast, with equipment such as a lightweight aluminum boom used in Malaysia (second from top).

Canopy animals

Stripped of its foliage, the branch reveals residents and visitors: a snake in naked pursuit of a tree frog, birds and small mammals feasting on worms and insects. Hovering near their nest, shown hanging at center in the bottom view, paper wasps add their buzz to birdsongs and the whir of katydids—sounds drowned out by the screech of a white-faced monkey alarmed by a rival troop. Meanwhile, the canopy's silent armies, the ants, scurry to meet their mysterious imperatives.

Vascular plants

In a riot of leaves and roots, bromeliads, ferns, and other epiphytes add to the canopy's biomass. Some plants, or their relatives, are also found in temperate climates, either as natives or exotic imports: orchids, philodendrons, ericads (of the same family as blueberries and azaleas), columneas (of the African violet family), and peperomias, kin to the plant that yields black pepper.

Nonvascular plants

Among the first plants to colonize the limb are mosses, lichens, and other lower epiphytes that spread like carpets, gaining a foothold on areas with the least soil. These canopy dwellers show distinct preferences. Some species grow only on branches, some only on dead surfaces, like the stubs of broken-off branches. Others, known as epiphylls, grow only on leaves.

Soil and detritus

Gravity lays life's foundation on the topside of branches. Wind-borne dust mingles with fallen leaves, animal droppings, and plant and animal remains. This mixture, a kind of bog, is especially deep at the fork, where a bromeliad flourishes, second view from top. From the lower branch hangs a nest fashioned by paper wasps. At the end of the branches, *Azteca* ants maintain football-shaped gardens, where they literally grow plants for food.

Layers of life at the top

The profusion of life in the canopy may seem chaotic, but beneath it all lies an ordered pattern of relationships based on the struggle to survive. Plants live on other plants; animals eat other animals. And animals both exploit the plants for food and cover, and aid them by pollinating them and dispersing their seeds.

Four views of the same limb of a fig tree in Costa Rica (above) isolate major plant groupings and an array of animals, revealing the complex inner workings of canopy life.

PAINTINGS BY JOHN O. DAWSON

The bromeliad: a microhabitat

A small universe of interdependent creatures live in and around a large bromeliad, a member of the pineapple family, and the branch that supports it.

A nectar- and fruit-eating bat, *Anoura geoffroyi* **1**, homes in to feed, pollinating the bromeliad blossoms in the process. Going to and from their nest, *Myrmelachista* ants **2**, smaller than grains of rice, use a tunnel in the branch's core, where they swarm over the new, winged daughter queens **3**.

Known as a tank bromeliad for its water-collecting capacity, the plant is also home to creatures that utilize the water: tree frogs **4**, salamanders **5**, beetles **6**, flatworms **7**, flies **8**, katydids **9**, and spiders **10**.

A coin-shaped close-up shows the bromeliad's reservoir to be alive with mosquito larvae **11** and the larva **12** and pupa **13** of a wood gnat.

Orchids **14** and a stag-tongue fern **15** share the nutrients of the soil mat. Mistletoe **16**, a parasite, sinks roots into the branch itself.

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spiders, and other arthropods living in the canopy. The discovery of the superabundance has been made by enveloping tree crowns with fogs of rapidly acting biodegradable insecticides and collecting the arthropods that fall dying, in the tens of thousands, to the ground.

How many kinds of arthropods live in the canopy? In a celebrated study published in 1982, Terry L. Erwin of the Smithsonian's National Museum of Natural History arrived at a figure of 20 million for the world as a whole, using the following procedure. He first identified 1,200 species of beetles from canopies of the tree *Luehea seemannii* in Panamanian rain forest. Of these beetle species, 163 were believed to be limited to this tree species. There are about 50,000 tropical tree species worldwide, so that if *L. seemannii* is typical, the total number of canopy-dwelling tropical beetle species is 8.15 million. These beetles represent 40 percent of the tropical canopy species of all arthropods, which, therefore, come to about 20 million. The rain forest canopy contains about twice as many arthropod species as the ground, so that the total number of species—in the canopy and on the ground combined—might well be 30 million. Nigel E. Stork of the Museum of Natural History in London independently evaluated his own counts from the forests of Borneo to produce a possible range of five million to ten million tropical forest arthropods.

Why this huge variation in the estimates of rain forest diversity? A great deal depends on the degree to which insect and other arthropod species are limited to one or at most a very few kinds of trees. Because research in the canopy has been so sparse to date, this key factor remains largely unknown. If the arthropod species turn out to be very restricted in the kinds of trees on which they live, their true numbers may approach 30 million or more. On the other hand, if they are able to exist on a wide range of species, the number will prove to be closer to five million.

Whatever the exact amount of diversity in the rain forest treetops, it must run into the millions of species. The few biologists who can identify rain forest organisms are swamped with new species now pouring in from collections in the canopy and on the ground.

Yearning for sunlight, earthbound vines called llanas (below) ride piggyback to reach the canopy. One reaches out with a stem that spirals like a corkscrew. Another grabs bark with three-pronged tendrils, while a third hangs on with stout spines. But the bully of the forest, the strangler fig (facing page), isn't content to coexist. After sprouting in the canopy from seeds dropped by birds and bats, it sends roots to the ground that envelop the host tree, which dies and rots away.

MY OWN EXPERIENCE is typical. Every time I enter a previously unstudied stretch of rain forest, I find a new species of ant within a day or two, sometimes during the first hour. I search the ground and low vegetation, dig into rotting logs and stumps with a gardener's trowel, break open dead twigs and branches lying on the ground, and pull at ferns and other epiphytes growing on tree trunks and newly fallen tree limbs. On a typical day, the first 40 or 50 colonies encountered might be species already known to science, some very familiar to me, some rare and requiring later study under a microscope at higher magnification back home. Then a new species. Then another 20 colonies of established species, and one more new species, and so on in a continuing adventure for many days in a row.

One day Stefan Cover, a curatorial assistant at Harvard University's Museum of Comparative Zoology, returned from the rain forests of northeastern Costa Rica and presented me with a large ant of the genus *Pheidole* strikingly different from anything I'd seen before. I had to have more specimens! Cover drew me a map

A fog of biodegradable insecticide sprayed by Smithsonian's Terry Erwin in Peru will soon bring a rain of spiders, insects, and other invertebrates. Gathered on sheets, such collections show a superabundance of species in the canopy—far more than previously believed.

Mining a trove of invertebrates, Michael Pogue of the Smithsonian sorts specimens collected by fogging in Peru. A single Amazonian tree typically yields more than three pounds of specimens comprising 1,700 species, mostly ants and beetles. From such humble origins come medical and other scientific breakthroughs.

Woe to the novice field scientist who picks up this fluffy moth caterpillar (above). When grabbed, hidden spines break off and release an irritating venom. In the insect equivalent of a wash-and-wax job, one Daceton ant grooms another (center, right), cleaning it while possibly spreading protective antibiotic substances.

Colors send signals, say canopy scientists. The orange and black of a young unidentified grasshopper (center, left) probably mimics stinging or foul-tasting insects; its vivid blue trim may also indicate that it tastes bad.

showing the exact spot where he had found the species, near the crossing of two trails and just to the side of an adjacent fallen tree. I went there soon afterward and searched the area carefully and without success. But close by, nesting in the clay soil of one of the trails, I discovered two *more* new species of large, striking *Pheidole* ants, an unexpected gift for a biologist who prospects for ants as others dig for diamonds or gold.

These biological treasures seem endless. I am currently laboring on the classification of more than 300 new species of rain forest ants in the Harvard collection. These represent only a fraction of those already collected and awaiting study.

THE BEST PLACE TO SEE the complete profile of a tropical rain forest and to put the canopy in perspective is, I am sorry to report, where it is being cleared and destroyed. As the forest is sliced along its side and peeled back, and the intervening second growth bulldozed and burned, the trees can be seen to vary greatly in height. A nearly continuous upper canopy is the dominant feature, composed mostly of trees with flattened crowns, nearly horizontal branches, and trunks free of branches for the first 60 feet or so. The term canopy, meaning an overarching cover, is entirely appropriate. Yet rising even above this layer are a few scattered emergents, giants that tower to heights of 200 feet or more. Lower down are trees with narrower trunks and vertically elongated crowns. Some are young individuals of upper-story species struggling their way to the top. Others are mature trees of species specialized for this intermediate, twilight region. Still lower, mostly at the height of a human being or less, are saplings and herbaceous plants.

All this exuberant, multilayered growth is supported by rain, lots of it. Rain forests grow in areas with more than 80 inches of rainfall annually, which allows the growth of broad-leaved evergreen trees. The leaves are typically smooth to the point of slickness and in many species are strongly narrowed at the end. Both features, smoothness of surface and tapered form, promote the rapid runoff of water during torrential rains and help prevent the leaves and branches from breaking because of waterlogging.

Two continents of life do indeed exist as layers in the tropical rain forest. The ground is a dark factory of decomposition, where bacteria, fungi, millipedes, and termites and other wood-feeding insects degrade the fallen plant debris into nutrient molecules. These substances are quickly absorbed by the omnipresent rootlets of the trees, so that little material is present on the ground. The air is still and humid, saturated with the odors of healthy decay.

The canopy is a brilliantly lit, noisy, three-dimensional world. Wind rakes the tree crowns, evaporating moisture away at a rate comparable to that in grasslands, drying the vegetation at times to almost desert-like conditions. Relative humidity ranges from as high as 100 percent at night to less than 30 percent at midday. Sunlight bakes the vegetation, occasionally raising the temperature of the ambient air to more than 90°F, a full 10° higher than at ground level. Frequent rainstorms pound the branches and leaves, breaking away the weak ones. The rain, after filtering through the tree crowns, descends to the forest floor. It arrives as a delayed shower and rivulets that stream down trunks and elevated roots.

The drab coat of the three-toed sloth (top) is a "living bug carpet"—home to beetles, ticks, fleas, and a steady companion, a moth (above) that lays eggs in the sloth's dung. After hatching, the next generation of moths will fly, seek out sloths, and begin the cycle anew.

The exact structure of tropical rain forests varies from continent to continent, but one feature common to most is an abundance of vines. Most conspicuous are the lianas, which are thick, woody climbers. They sprout on the forest floor and then send out long shoots that grasp vegetation as the vines grow up into the crowns. Often they cross to other crowns, binding the trees together. Lianas have great tensile strength. They are composed of both hard and soft tissues, making them flexible and difficult to break or sever.

A real-life Tarzan could not have swung from tree to tree with lianas, which are attached to the ground. (And unlike biologists, he would not have been likely to endure the stinging wasps, biting ants, and spines and saw-toothed edges of the canopy vegetation. Tarzan would have stayed on the ground.)

You can categorize tropical forest plants by the way they respond to light. While lianas take root in the ground and grow upward, strangler figs do the exact opposite: They sprout in the canopy from seeds dropped by birds and bats, then send roots to the ground.

The stem climber *Monstera tenuis* of Central America, a member of the arum family so favored as houseplants, responds to light in yet another, radically different way. Immediately after sprouting from a seed on the forest floor, the *Monstera* grows toward the dark. This orientation, the exact reverse of that used by almost all other kinds of plants, leads its shoots to the deeper shadows around the base of a tree. Once on the tree trunk the *Monstera* apparently switches orientation and grows upward, toward the light.

Lured by lush vegetation, large mammals find forage in the canopy. A chimpanzee snacks on figs in Uganda's Kibale Forest Reserve. In Colombia, a spectacled bear looks for a meal of bromeliads. Largely because its forest habitat is being destroyed, the bear has been declared an endangered species.

ALTHOUGH THE TREE CROWNS and vines alone are enough to create an abounding and unique habitat, the canopy is vastly enriched by yet another dimension. Epiphytes, plants that use the trees as support but do not draw nutrients or water from their tissues, grow in luxuriant masses along the trunks and branches. They are extremely diverse worldwide, comprising 29,000 species of vascular plants in 83 families, more than 10 percent of all higher plants. In addition to orchids, which have the most species, there is a profusion of ferns, bromeliads, gesneriads, figs, arums, and members of the pepper family. There are also many nonvascular epiphytes, such as mosses and lichens.

At the Monteverde Cloud Forest Reserve of Costa Rica, Nalini Nadkarni and her fellow canopy researchers from the Marie Selby Botanical Gardens in Sarasota, Florida, have found one of the most complex assemblages of organisms on earth. There are worlds within worlds: Here and there small trees sprout from the epiphyte root masses, so that trees actually grow on the branches of other trees. Lichens and other epiphylls grow on the leaves of the smaller trees, small insects browse among the epiphylls, and protozoans and bacteria live within the insects.

The epiphytes add immensely to the productivity of the forest, filtering atmospheric nutrients and capturing solar energy that

would otherwise bounce and scatter away from the naked tree limbs. For the ecosystem as a whole, they act as supplemental foliage in the rain forest trees.

The most elaborate form of symbiosis in epiphytes, one that epitomizes the complexity of the rain forest canopy, is the ant garden. I have encountered many gardens in Brazil and Suriname at the edge of rain forests, where a bit of the canopy dips close to the ground. Spherical in shape and somewhat smaller than a soccer ball, they were made of soil and masses of vegetable fibers chewed and shaped by the ants. They bristled with small, succulent epiphytic plants that sprouted from their surfaces in all directions.

When I touched one—in fact, when I just stood with my face one or two feet away—large *Camponotus* ants swarmed out onto the surface and sprayed clouds of formic acid in my direction. The defenders seemed frantic to get to me, and I was thankful they could not fly like wasps or bees. In a lifetime of studying ants, I have never seen a species so suicidally aggressive and intimidating.

Protected and fertilized by the ants, the garden epiphytes flourish. In return, they provide their residents with food and shelter. The plants belong to at least 16 genera of philodendrons, bromeliads, figs, and cactuses. They are specialized for this strange existence, limited almost entirely to the gardens. Similarly, the most abundant ant species in the gardens appear to depend on their epiphyte partners.

How do the gardens get started? There seems to be no other way to explain it than to say that the ants plant gardens and harvest crops. They are initially attracted to fleshy appendages on seeds, called elaiosomes, that serve as food. The seeds may also smell like the ants' own larvae. After the ants have cleaned off these nutritious fragments, they drop the still intact seeds into the recesses of their nest, allowing the epiphytes to sprout and grow out through the nest walls. As the plants mature, the ants harvest food from them in the form of fruit, nectar, and elaiosomes.

The canopy serenade begins at dusk for Cathy Langtimm, sitting 70 feet up in a Costa Rican forest. Her shotgun microphone picks up the cries of tiny tree-dwelling mice, often mistaken for bird or insect sounds.

"The call is surprisingly loud, like a two-note whistle," says Langtimm, of the University of Florida. "The mice probably use sound to mark territory or locate mates. The canopy is a tangle of branches that makes it hard to attract mates by leaving pheromone trails." The calls are short—only a second or so—to evade predators.

TROPICAL RAIN FORESTS began to take form roughly 140 million years ago, near the beginning of the Cretaceous period in the age of dinosaurs. Early in that time, when most of the world's climate was tropical to subtropical, flowering plants originated and later spread as dominant elements around the world. Many of the species became partners with insects, which derived food from them while serving as pollinators and transporters of seeds. These insects, including a medley of wasps, beetles, bees, flies, butterflies, and moths, also rose to dominance. Some insect groups increased vastly in numbers and diversity simply by preying on flowering plants—feeding on them without pollinating

them or giving other services in return. Still others consumed decaying vegetation or else simply used the plants for shelter.

Biologists who struggle with the task of collecting and classifying the immense cornucopia of biological diversity ponder the important ecological question it raises: Why are there so many species? Most experts on biological diversity agree that more than half the kinds of plants and animals in the world live in rain forests, yet this ecosystem covers less than 6 percent of the land surface. Of these species, more than half either live in the canopy or, in the case of the trees and vines, create it with their upper folinge.

The mystery of why so much of life is invested in rain forests is still far from solved, but clues abound. One is the greater climatic stability of the tropical zones. The temperate zones experience wide seasonal swings in temperature each year. The tropics as a whole, and rain forest areas in particular, enjoy nearly constant temperatures and have never been glaciated. Plants and animals in colder parts of the world are for the most part adapted to survive in a variable environment, and as a result they range widely. A plant species found in New York, for example, is also likely to be found as far away as Tennessee and Michigan. A tropical species, in contrast, is more likely to have evolved to fit a narrow niche in a constant environment. Plant species in South America and elsewhere are often limited to a single valley or ridgetop. So when you add up all the tropical species, there are many more of them.

Still more diversity is piled on by physical disturbances that create gaps in the forest. When the canopy is broken open, sunlight falls more abundantly on the ground, and a new burst of vegetation springs up. The species of trees and smaller plants in this assemblage are mostly different from those in the surrounding mature forest. So are many of the insects and animals that live on these gap specialists.

Gaps are continually created at random spots throughout the forest. As a storm passes, sporadic winds are likely to break a few large tree limbs that have grown weak and vulnerable from heavy growths of epiphytes. The rain fills up the axil sheaths of the epiphytes and saturates the humus and clotted dust around their roots. Occasionally a lightning bolt strikes and kills a tree.

Elsewhere a large tree sways in a gust of wind above the rain-soaked soil. Its shallow roots cannot hold, and the entire tree keels over. Its trunk and crown shear through smaller trees to open a hundred-foot path. As the sky clears and sunlight floods the newly opened gaps, the surface temperature rises and humidity falls. The soil and leaf litter dry out and grow warmer, creating a new environment for the plant seeds resting there. In the months to follow, pioneer trees take root. They are very different from the young shade-tolerant saplings and understory plants of the deep forest. Fast growing and short-lived, they form a single canopy far below that of the major forest. Their tissue is relatively soft and vulnerable to attack by herbivores.

One of the dominant gap-dwelling groups of Central and South America, the broad-leaved trees of the genus *Cecropia*, swarm with fierce ants that live in hollowed internodes of the trunk. The ants, a species of *Azteca*, protect the trees from all predators except three-toed sloths and a few other animals specialized to feed on *Cecropia*. The slightest disturbance brings them out by the

A deft grasp—aided by five digits and an opposable large toe on each foot—serves a small opossum well as it forages in a Brazilian canopy for fruit, insects, lizards, and eggs. The vision of this nocturnal creature is enhanced by huge eyes with widely dilating pupils.

hundreds or thousands, biting with their mandibles and emitting noxious defensive secretions. Because of their much smaller size, they are less formidable than the treetop garden ants, but only slightly so. On several occasions in Costa Rica I have tried to dissect good-size *Cecropia* trees to study the inhabitants, and each time found it a harrowing experience.

In short order the little defenders were under my clothing, in my hair, running over my eyeglasses. I had to stop frequently to clean myself off, and I finally gave up. But that, of course, is the point. I was Gulliver tied down by the Lilliputians in a successful defense of their land. Although I was 80 million times heavier than each *Azteca* ant, the tribe prevailed.

When the pioneer vegetation thickens enough to shade the ground, the cycle begins to draw to a close. Conditions of light and temperature improve for mature-forest species, and their seedlings take root and grow. Within a hundred years the gap specialists are gone, and the multiple-layer high forest has returned.

The pioneer species are the sprinters; the slower growing species of the mature forest are the long-distance runners. Together they create a mosaic of vegetation types throughout the forest that is forever changing, a dazzling kaleidoscope of biological diversity. When you walk for a mile or two through mature rain forest, you cut through many of the successional phases from gap to mature stands. Life is continually enriched by the passage of storms and the fall of forest giants.

LIFE IS THUS PILED UPON LIFE in the tropical rain forests. Long periods of uninterrupted evolution have pushed diversity to extremes along several dimensions: epiphyte gardens, intense specialization, delicate symbioses, and a constant turnover of plants and animals that fill the forest gaps. But this great edifice is all a house of cards. Most of the millions of species are so highly specialized that they can be quickly driven to extinction by the disturbance of their forest homes.

Unfortunately examples of such vulnerable species are easy to find. Spix's macaw *(Cyanopsitta spixii)*, a beautiful parrot of northeastern Brazil, is on the brink of extinction due to human interference. The forests in which it can live have been largely destroyed during the past century. In addition, the Africanized honeybee, the "killer bee" accidentally introduced into Brazil in the 1950s, has occupied many of the nest sites the macaw needs to reproduce. Finally, local fancy-bird dealers, able to get $18,000 or more for each bird, have reduced the remnant population until only one individual was known to remain in the wild in late 1990.

The fragility of the rain forests extends not just to single species but also to entire local ecosystems. In the early 1980s Alwyn Gentry and Cal Dodson surveyed the plants of Centinela, an isolated mountain ridge on the Pacific side of the Andes in Ecuador. They encountered almost a hundred plant species found nowhere else in the world. A few years later, before the Centinela flora and fauna could be studied further, farmers from surrounding valleys completely cleared the ridge. The unique plant species and almost certainly a host of animal species associated with them were gone.

The tropical rain forests are being reduced in this manner almost everywhere in the world at an accelerating rate. The original cover,

A smorgasbord of fruits plucked from the canopy in Borneo (left) owes its abundance to bats, monkeys, and birds that pollinate flowers and scatter seeds. A fig tree in Singapore (far left) aids its own cause by bearing fruit on its trunk, an irresistible treat to bats.

Tied to a tree in Borneo, Tim Laman aims to loop fishing line over another branch, to haul up climbing rope for his study of strangler figs. Despite the priority given safety, dangers remain for rain forest scientists, drawn to this high frontier by forms of life yet to be discovered.

before human populations had much impact, was about six million square miles. Now it is only three million square miles, less than 6 percent of the world's land surface, roughly the same as the area of the contiguous United States. In 1979, according to surveys conducted by British scientist Norman Myers and the Food and Agriculture Organization of the United Nations, the rain forest and similar, much less extensive monsoon forest were being destroyed at the rate of 29,000 square miles a year. By 1990 the figure had almost doubled, to 55,000 square miles a year, an area larger than the state of Florida.

As the area of a habitat such as a rain forest is decreased, the number of species of plants and animals it can support also declines. The relation between these two qualities of the natural environment, area and diversity, is consistent. A reduction of the habitat to one-tenth its original area means an eventual loss of about half its species. In other words, if a forest of 10,000 square miles and a hundred resident bird species is cut back to 1,000 square miles, it will eventually lose about 50 of the bird species.

A forlorn island of trees stands in Brazil amid an area cleared for ranching, which along with slash-and-burn farming accounts for 75 percent of all rain forest destruction worldwide.

Aided only by a strap called a peconha *between his feet, Jay Malcolm shinnies up to explore a Brazilian forest "fragment" beside a clear-cut. Above him, a trap baited with bananas and peanut butter collects rodents and marsupials for a census. Researchers study fragments to determine how animal species react to such reduced habitats.*

This amount of rain forest reduction has already occurred in several of the biologically richest parts of the world, including the Philippines, parts of West Africa, and the Atlantic coast of Brazil. The current rate of deforestation worldwide translates to an eventual annual loss of species of at least half a percent a year. Even that figure is probably a considerable underestimate, because it does not take into account the near-instantaneous destruction of entire communities of endemic species such as that on Ecuador's Centinela. If the rain forests of the world hold ten million or more species, a figure many tropical biologists consider likely, the rate of extinction worldwide may well have already reached 50,000 species a year.

CAN HUMANITY AFFORD to lose so much of its natural heritage? The tragedy, as biologists see it, is that large blocks of diversity are being lost before they can be studied scientifically. The great majority of the vanishing species have never even received a scientific name.

Biologists and conservationists watch in dismay as the forests disappear, just as the extraordinarily rich two continents of life, the ground and canopy, are being effectively explored and compared for the first time. It is as though the stars began to vanish at the moment astronomers focused their telescopes.

A large part of the world's greatest biological treasure-house is being leveled for farming, ranching, and logging. The loss is compounded by the fact that if managed properly, the forests can yield a higher rate of income in perpetuity. Enough harvesting

A hundred feet high, daredevil entomologist Jack Longino pops up above the canopy in Costa Rica. He and others wonder how long such vistas will remain unbroken. At present rates of destruction, earth's rain forests could be gone by the middle of the next century, a chilling prospect.

Says a veteran botanist: "Rain forest is the very core of the biology of this planet."

techniques already exist to make this dream a reality. When timber is removed from a succession of narrow strips following the contours of the land, native trees grow back rapidly.

Other materials can be drawn from the forest with even less disturbance. A wide range of natural products were either directly extracted from or at least were discovered in rain forests and transplanted to plantations elsewhere. Their names include both the familiar and unfamiliar: rubber, copal, dammar, chicle, balata, quinine, vanilla, cocoa, coffee, Brazil nuts, avocado, rattan, and a large percentage of our most favored species of houseplants.

The fruits of only about a dozen species of temperate zone plants dominate the commercial market. At least 3,000 may be available in the tropical forests, and of these, 200 are in actual use. Some, like cherimoya, papaya, and mango, have only recently joined bananas in the northern markets.

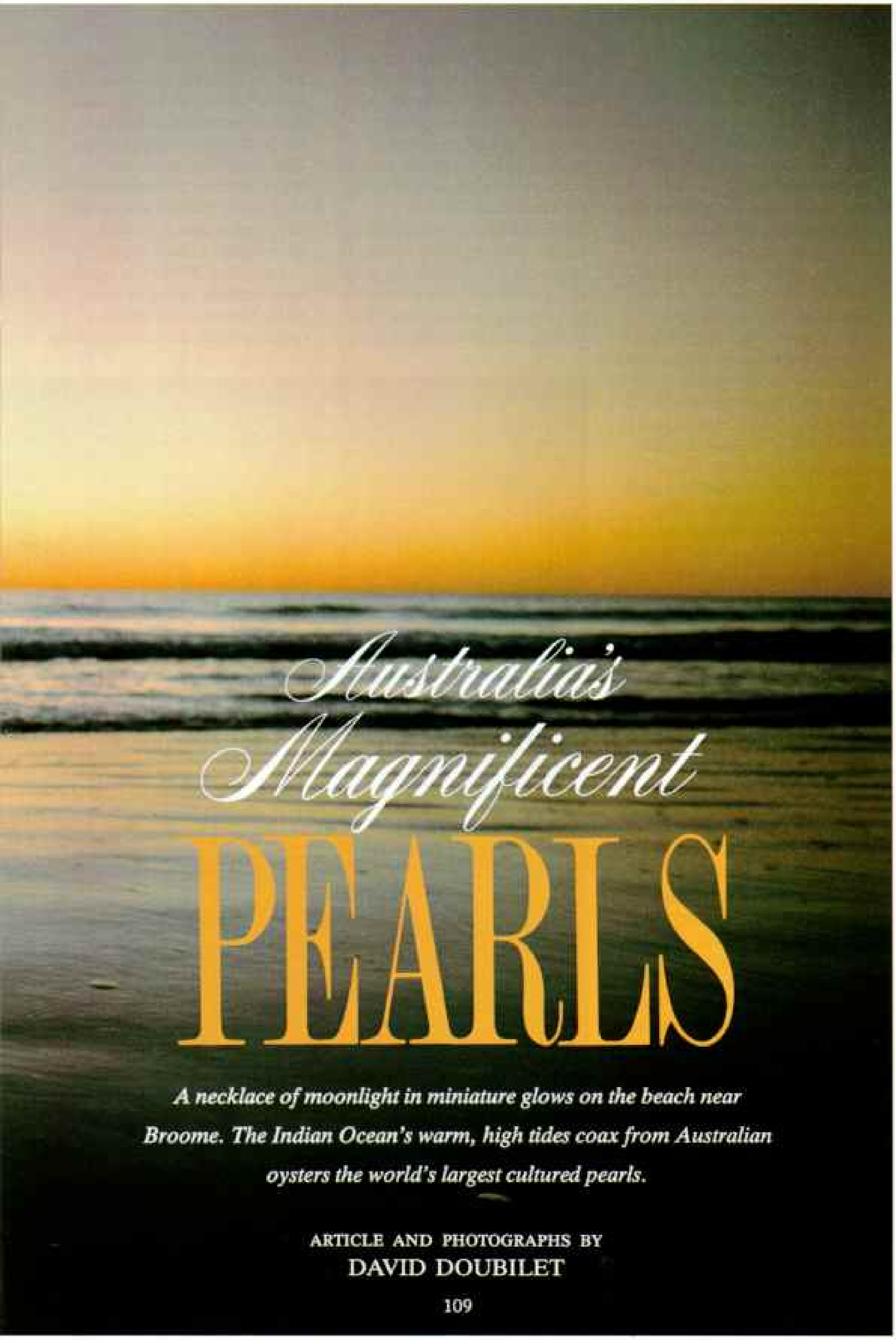
A fundamental difference exists between the two major forest types of the world, a difference that should concern economists. Whereas the commercial value of the temperate forests comes

almost entirely from timber, the potential value of tropical forests lies mostly in the large array of other products available from the diversity of their species.

An important property of the tropical rain forest products we now use is that they originate in the lower levels, from understory shrubs and smaller trees and the trunks of the larger trees. The high canopy, so little understood biologically, is almost entirely unexplored commercially. No one knows what new foods, pharmaceuticals, fibers, vegetable oils, and other materials await discovery a hundred feet above the ground.

From a beetle without a name atop an orchid in a distant threatened forest may come a cure for cancer.

But such practical concerns are not what I ordinarily think about in more somber moments as I walk the trails of Barro Colorado Island and other remnants of the tropical forests. What comes to mind is what I like to call the ultimate irony of organic evolution: that life, in the moment of achieving self-understanding through the mind of man, has doomed its most beautiful creations. □



A necklace of moonlight in miniature glows on the beach near Broome. The Indian Ocean's warm, high tides coax from Australian oysters the world's largest cultured pearls.

ARTICLE AND PHOTOGRAPHS BY
DAVID DOUBILET

A LINE of thunderheads, veined with lightning and glowing like Chinese lanterns, marched across the flat, featureless landscape. Off Eighty Mile Beach, on the northwest shoulder of Australia, the Indian Ocean bled orange from the setting sun.

Our charter boat, *Commando*, anchored for the night, rolled fitfully in the powerful outgoing tide. Veteran pearl diver Mick Bray braced against the rail and spun another horror story of the Irukandji stinger (named for an Aboriginal group), the venomous cousin of the box jellyfish that plagues pearl divers and whose sting had aborted a pearling cruise two weeks earlier.

"These two blokes never saw the Irukandji," recalled Mick, "but pretty soon they were crook—really sick. Irukandji toxin affects the nervous system. It brings terrible pain, muscle cramps, and vomiting, and then it becomes hard to breathe. I gave the boys a couple of injections, but they didn't come good, so we pulled anchor and headed for Broome."

Mick had come from his pearling boat to give us a final briefing, and to have a few beers. Next morning my diving assistant, Gary Bell, and I would join him and his crew of commercial pearl divers "fishing" for young oysters, the raw material of pearling.

A mumble of thunder, and darkness erased the land. The wind picked up, and *Commando* lurched heavily. Beneath our heaving keel, in this remote corner of the Indian Ocean, lay the richest pearl beds in the world. Here the great tropical bivalves called *Pinctada maxima*, nourished by nutrient-rich tides, produce large, lustrous pearls whose long and remarkable journey from murky sea bottom to the jewelry shops of Manhattan I had come to trace.

Pinctada maxima, known in Australia as the silver lip and in Papua New Guinea as the gold lip, is cultivated in a wide belt of warm water stretching from Burma (now called Myanmar) eastward, including Indonesia and neighboring countries. This area is the source for so-called South Sea pearls, although the South Seas of legend—the islands of Polynesia—are actually home to another species of oyster, *Pinctada margaritifera*, that creates a smaller silver-gray or black pearl.

Australian South Sea pearls have recently emerged as the Rolls-Royces of the pearling industry: rare, robust, enormous

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(10 to 20 millimeters in diameter compared with the 2- to 10-millimeter range of Japanese cultured pearls), and expensive.

Pearls are not a natural part of the living oyster but a response to an irritation. They occur when sand, or a bit of shell, or an unwelcome parasite is trapped inside the oyster's shell. The oyster either expels the intruder or surrounds it with nacre—a silvery calcium-carbonate substance that the oyster normally exudes to line its shell. After several years, and then only rarely, layers of nacre form a pearl around the irritant.

Most natural pearls found by chance in the past were flawed, lopsided or blemished. But a single perfect one could mean a fortune, and a necklace was worth a ransom.

Today most pearls are made—cultured—in an intricate collusion between man and oyster. Commercial pearl culturing began in Japan in the early 1900s when Kokichi Mikimoto patented a way of tricking small *akoya* oysters into producing pearls. The process substitutes a round bead, called a nucleus, cut from the shell of an American freshwater mussel, for the random piece of debris. A tiny piece of mantle, the oyster's fleshy lip, has to be cut from a donor oyster and inserted next to the nucleus. This bit of mantle secretes the nacre that coats the nucleus. Such "seeded" pearls are consistently rounder and more luminous, and, more importantly, they can be produced in quantity. So for many, a pearl necklace is now a reality, not just a dream.

Most cultured pearls still come from Japan, but northwest Australia has proved to be a perfect place to raise a pearl oyster. There is little industry, few people, no fertilizer runoff from agriculture—and tides as high as 33 feet.

"The big tides mix up the water, bringing a rich soup of organic particles to the oyster," Dr. Lindsay Joll of the Western Australian Marine Research Laboratories explained to me. "But the tides don't just wash in and out of the shells. The oyster feeds itself, constantly beating the water through with tiny hairs on its gills."

In 1956 Sam Male, with

Perfection shines in a handful of a pearler's best wares. Variations in color are still a mystery, but some in the industry believe that high water temperatures lend a golden cast to certain pearls.
FOLLOWING PAGES: Racks of plate-size oysters hang from floating grids at Dick Morgan's pearl farm in the Monte Bello Islands. Unpolluted waters contribute to the growth of Australia's spectacular pearls.

Australian and New York partners, formed Pearls Proprietary, Ltd., which joined with Japanese entrepreneur Tokuichi Kuribayashi to establish the nation's first pearl farm 250 miles up the coast from Broome, center of Australia's pearling world. It was called Kuri Bay, after Kuribayashi.

Sam Male's son, Kim, reflected on those times when I visited him in his office in Broome's Chinatown. "It took my father over 15 years to get enough good pearls to make a necklace," he said. "When cultured pearls came in, they seemed as plentiful as marbles."

With only a handful of farms, Australia was soon producing 60 to 70 percent of the world's large South Sea pearls. But Australian oysters are not yet *conceived* on farms, as akoyas are. Young oysters must still be found in the wild and gathered by divers on the flat sea bottom off Australia's northwest coastline.

THE TROPICAL HEAT hung in layers. *Commando* groaned through the night as seas slapped its flanks. I lay sweating, trying to sleep, visions of jellyfish dancing in my head. At dawn a luminous fog covered the sea. Sunrise was only an hour old, but tendrils of oppressive heat pushed down from a brassy sky. We had anchored in the middle of the pearling fleet of ten boats, and they were just under way.

A pearl boat serves as a divers' platform and can transport 5,000 or more live oysters in its holding tanks. Two 30-foot-long booms holding towropes extend from each side. Six tethered divers can operate simultaneously on the bottom, at depths of 20 to 60 feet, and cover a swath 60 feet across as the boat creeps along.

On Mick Bray's 72-foot catamaran, divers in Lycra-and-neoprene suits were already at work. They breathed through "hookah" gear, standard scuba-diving regulators attached to long, yellow hoses that ran to an on-board air compressor. On their backs were small, emergency air tanks.

Mick, the lead diver, shouted to us over the compressor noise: "You blokes will come with me on the next drift!" Each dive is called a drift, because the boat drifts with the tide. Today was the top of the neap tide, so there was little water movement, and the water was clear.

Mick pulled on his mask, checked his hood and gloves to see that no skin was uncovered to stingers, and took a waterproof yellow switch box off a hook: "I control the boat by signaling with this box."

As we waited, signals from Mick, somewhere in the sea below, sounded on the hot decks. . . . Two blasts of the horn: slow down; three: speed up; four: turn toward port.

On Mick's next drift, Gary and I tumbled in and clutched the towrope. We trolled in an underseascape seemingly bathed in a green fog. Dreamily we passed finger sponges, fan corals, an occasional anemone. Mick hung one-handed, like a trapeze artist.

But where were the fabled giant oysters? Mick reached down, snagged something from the silt that looked like a petrified pancake, and shoved it into the catch bag around his neck. He clipped each full bag to a line, signaled with a tug, and the bag was hauled up. We parted a shoal of silvery baitfish, and for an anxious moment a large, poisonous sea snake got entangled in my flippers.

ON THE BACK DECK the oysters were counted, cleaned of marine growth, weighed, then placed between layers of nylon netting stretched inside a window-size, rubber-coated metal frame. The panels, holding six to nine shells, were put into a saltwater tank for a quick ride to the "dump," a holding area. There the panels were attached to the sea bottom so the oysters could recover from the stress of their capture.

In two to five months the panels are hoisted back to the ship, and each oyster is opened and seeded by a technician, usually Japanese. Then the oysters are put back in panels and quickly returned to the dump for another period of convalescence. Several months later the panels are transported to a pearl farm, sometimes hundreds of miles away.

Pearl farms, spread along Australia's north coast, must be located in sheltered areas of active tides. Here the oysters are coddled like prize beef cows. The panels are hung on long lines, like underwater clotheslines, supported by buoys, and the shells are kept clean of algae, sponges, crabs, and other encrusting creatures. The tides work their nutritional magic. Intermittently the oysters are hauled up and examined by X ray to gauge their progress.

From gathering to harvesting,

"There's never been anything like them," says Nick Paspaley (above) of his marble-size gems. Australia's preeminent pearlers, Paspaley and his family control some 60 percent of the country's cultured-pearl industry. He dismisses the handiwork of Japanese oysters.

"They produce a pearl look-alike," Paspaley jokes. He holds what may be the world's largest (left), a 20.8-millimeter giant. Contrast is evident (right) in two types of cultured pearls from the Mikimoto company, the world's largest pearl dealer. The smaller Japanese akoya necklace, of very high quality, is worth $4,000; the large Australian South Sea strand, $190,000.

MICHAEL O'REILL

Calm tidal swirls off the Lacepede Islands can suddenly turn vicious. In 1935 a cyclone caught the pearling fleet here, sinking 21 luggers; more than 140 men died. Divers say

copper helmets of the lost still roll on the bottom in the surge of the sea.

pearl cultivation can take 30 months. If a pearl is good, its oyster is reseeded with a new nucleus as many as four times. As the shell grows, it can take progressively bigger nuclei and may produce its largest pearl in its twilight years. If an oyster is nonproductive, the nacre-covered inside is marketed as mother-of-pearl. Its dried meat brings as much as $350 a kilogram in Hong Kong and Shanghai, where it is prized as a delicacy. Everything is used. "The poor oyster winds up like the proverbial horse at the glue factory," fisheries scientist Lindsay Joll joked.

WHEN THE FIRST pearling camps were established on Roebuck Bay in northwest Australia in the 1860s, Broome became a rugged, mosquito-ridden boomtown—a place of dark alleyways and too many gin slings, of stolen pearls and murder. And it was nowhere; around it spread a convoluted landscape of peninsulas, archipelagos, and pungent mangrove swamps.

By 1900 more than 400 pearl boats, called luggers, worked the beds off Broome. They came not for pearls but for mother-of-pearl. The great Australian oysters supplied most of the world's shell buttons. Pearls were a sideline.

Japanese controlled the diving end of the pearl business by the 1920s. The pearling aristocracy, they strutted down the streets of Broome. But their job was so hazardous that they were said to have only five years—two to learn the trade, three to make their money. If they stayed longer, they increasingly risked their lives to sharks, fever, lung infections, and the bends.

World War II brought pearling to a halt, as the divers were interned. Japanese warplanes strafed Broome, and by 1944 the

BROOME HISTORICAL SOCIETY

Japanese (above) dominated Australia's oyster diving before World War II. Mother-of-pearl shell was the quarry; pearl culture had not yet been introduced. The work was dangerous, and Broome's Japanese graves (above right) speak to the toll of storms and the bends. Japanese returned in the 1950s with the new pearl culture. But by the 1970s new diving gear had replaced helmets, and Australian divers had replaced the Japanese. Yoshinori Maeda (right) was one of Broome's last helmeted divers.

town was all but abandoned, leaving about ten Europeans and a few intact luggers.

The war also fueled the plastic-button industry, and the demand for mother-of-pearl declined. But a few pearl boats still worked in the fifties, and some Japanese divers returned.

YOSHINORI MAEDA came to Broome in 1955, from a coastal town on the Japanese island of Shikoku. "Japan was very poor," he told me. "Not like now. I was only 22. I liked Broome. I married an Australian girl."

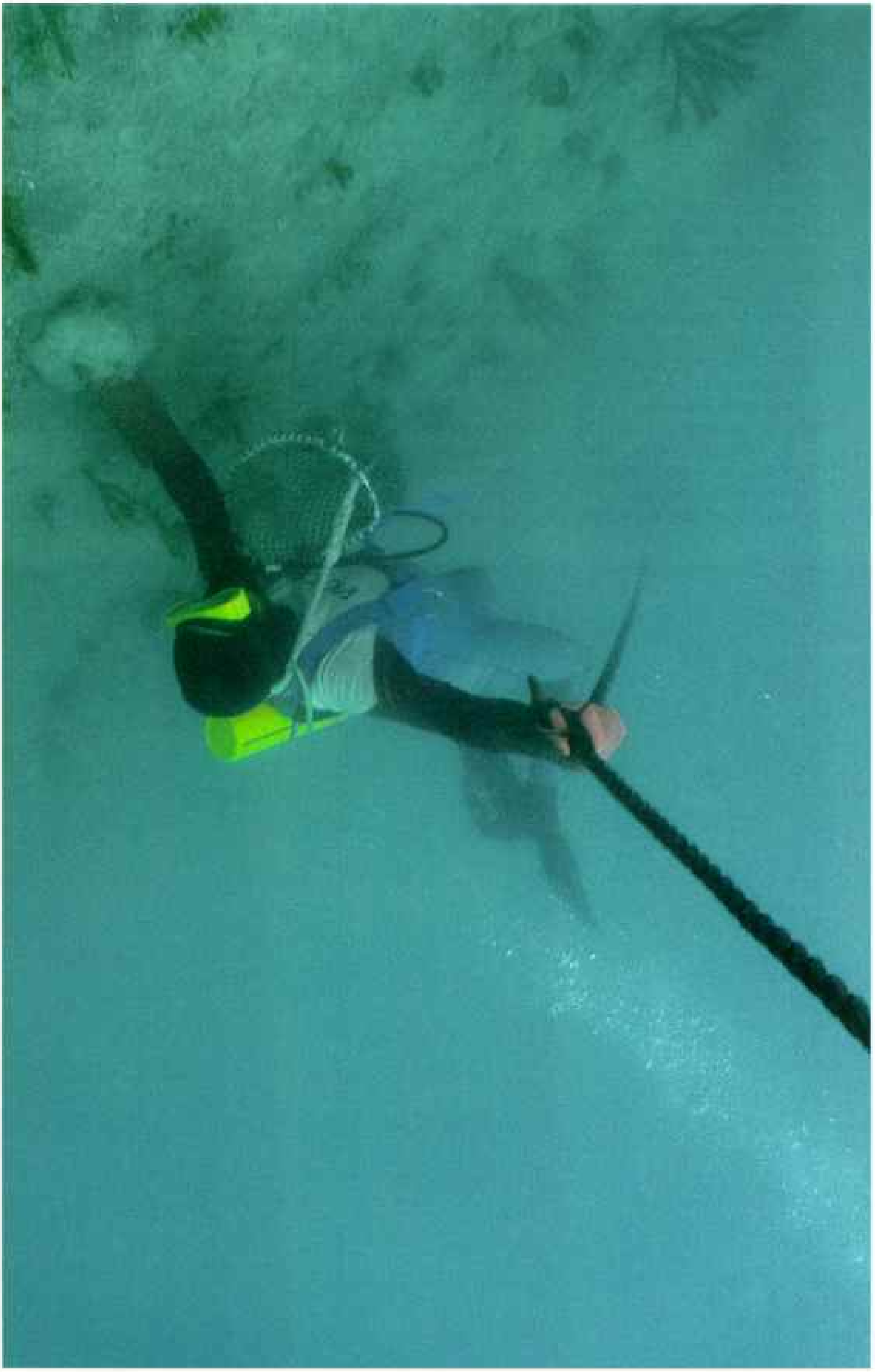
Maeda-san and I talked in his Broome kitchen, with the yellow morning sunlight streaming in. When he spoke of diving, the light seemed to shift to the pale, green light of a seabed, waxy and cadaverous. For divers invariably end up talking about the bends.

This decompression sickness is a quiet, horrifying fear. When a diver works in deep water a long time, nitrogen in the compressed air he breathes is absorbed into his bloodstream, then travels to tissues in joints, the nervous system, and other areas. If he ascends too rapidly, this nitrogen comes out of solution and forms tiny bubbles, like a rapidly opened soft drink, causing extreme pain, tissue damage, paralysis, even death. The bends can be prevented by ascending slowly, in stages.

"Once, on the last dive of the day, I came up from 130 feet," Maeda-san said. "A terrible pain gripped my stomach. I was being torn apart, sick, deadly sick. I threw up black bile. The captain told me to get back into my diving suit.

"A lot of divers were too scared or sick to get back in when they had to. They died. I tried to say no, but the captain made me. He saved my life. He wired the valve so I couldn't balloon to the surface, put me back 130 feet deep, and slowly brought me up. I was sick many times in the suit, and very scared. I was down 36 hours."

In the 1970s Japanese diving



preeminence was challenged when Australians introduced hookah gear. Wet suits and rubber masks were disdained by the Japanese until the catch rates of the Australians, former abalone divers and spearfishing champions, began to equal theirs. Today the entire fleet operates with hookahs, and there are very few Japanese divers in Australia.

ONE OF THE Australian pioneers, Allan Badger, was captain of the *Commando*, and the passenger we picked up on the way to Broome one afternoon was his friend, pearler Bruce Farley. Allan and Bruce almost single-handedly revolutionized the pearl-diving business, and as we rolled easily north in an afternoon swell, the two reminisced.

"God, I remember how sure of ourselves we were," Allan said. "Well, that first season was a disaster. The Japanese divers were fantastic. They'd let a bit of air into their suits and dance across the bottom. But their downfall was the helmet. The difference between the view

Trolling for treasure, diver Mick Bray (left) searches the ocean floor for young oysters, the first step in creating a cultured pearl. To prepare for implantation, a technician snips a piece of mantle from a donor oyster (top), then carefully slips it into an incision in the oyster's flesh. Next a seeding bead of mussel shell (center right) is tucked in beside the bit of mantle, and the animal is returned to the sea. Shells are regularly scrubbed to ward off disease, and X-rayed to monitor progress. Two years' growth may yield a pearl like this one at a Blue Seas Pearling company farm (right). Or it may yield nothing at all. "We can't command nature," says one diver. "We can only ask."

from a diving helmet and a face mask is like looking through a keyhole and a picture window."

At sunset I walked in the old Japanese cemetery of Broome. The tombstones there look like jagged, broken teeth reaching up out of the earth.

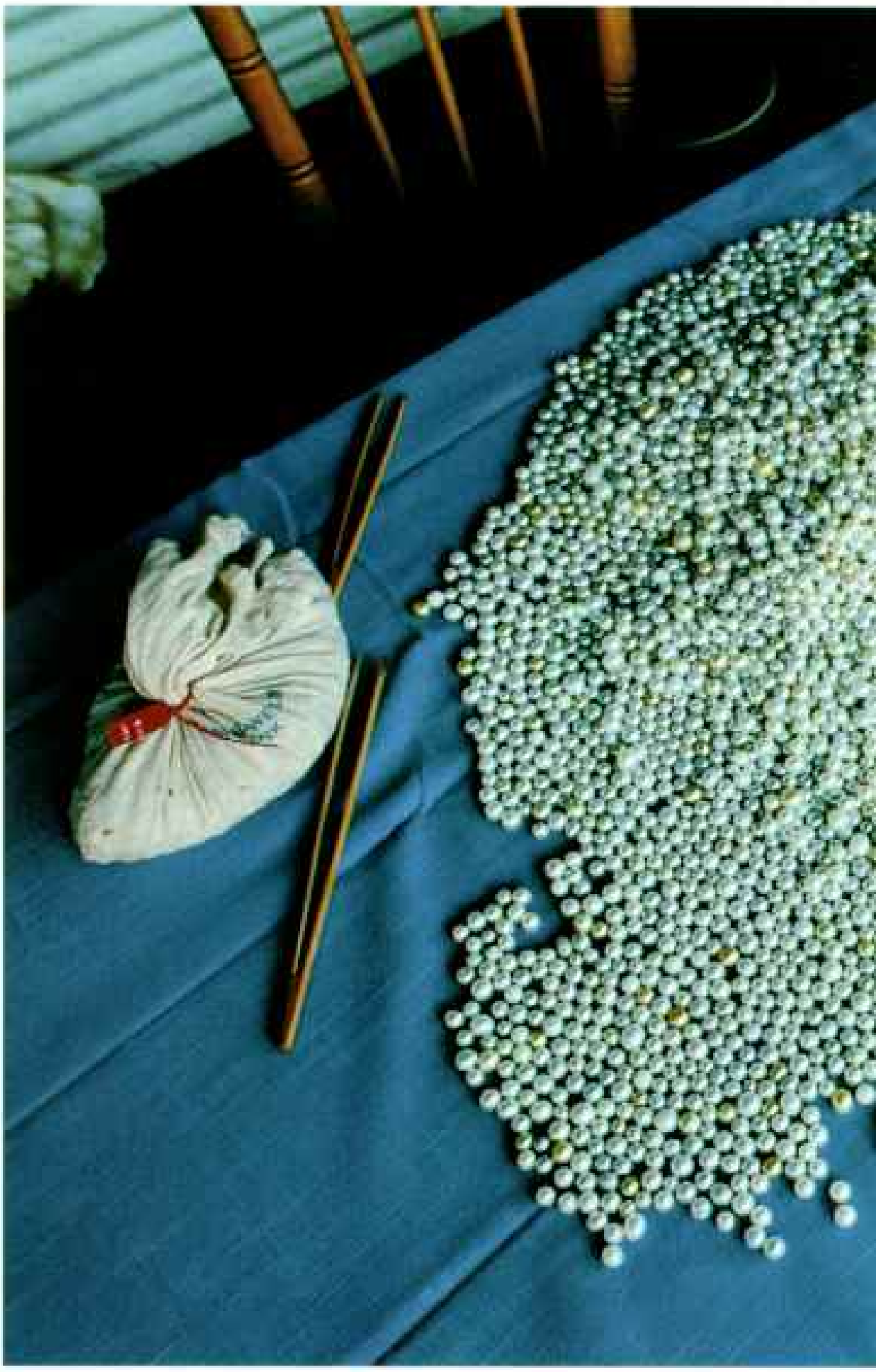
Between 1910 and 1917, 144 divers died in pursuit of the oyster, and countless others were paralyzed or crippled. They died young, but with old bodies. Cyclones too, spawned in the tropical waters of the Indian Ocean, helped fill Broome's graveyard. They came with little warning from a mild sky. In April 1908 a cyclone caught the pearl fleet off Eighty Mile Beach, and 50 men drowned.

THE JAPANESE have been inextricably linked to Australian pearling—through expertise and investments. Their seeding technique has been a closely guarded art, and Japanese technicians have been known to stop work when observers are present.

I asked Kim Male why there were so few Australian seeding technicians. "Practice," he replied. "The Japanese can practice on as many as 50,000 akoya shells before they get to be good. Fifty thousand shells in Australia is more than a year's quota for most operators. We can't afford practice."

But now the Aussies are asserting themselves more strongly in the industry, and the dominant figure is Nicholas Paspaley, a rugged and intense man of 43, born to a pearling family, who has built an empire from his headquarters in Darwin. Paspaley and his sisters, Roslynne and Marilynne, purchased Bruce Farley's Roebuck Deep Pearls company in 1986, and by 1990 they had acquired Kim Male's firm of Pearls Proprietary, Ltd., including the historic farm at Kuri Bay. Paspaley Pearling Company now controls about 60 percent of Australia's pearl business.

Pearling is a closed society, with only a dozen pearlers, licensed by the Western Australia Fisheries Department, operating on the northwest coast. Big or small, pearlers walk an economic tightrope. Any increase in production could lead to overfishing, wiping out the beds. Pearlers are not dealing with minerals but living animals. The oyster is not a pearl factory;



A black cat guards the good luck of Judy and Stephen Arrow, brother-and-sister pearlers from Broome. Such a harvest can bring more than two million dollars on the open market. Hard work and hard cash went into these tabletop riches. Despite their success, the Arrows know that pearling is always a lottery, with Australian pearls the greatest prize of all.

it will often produce a pearl full of lumps and stains or spit out an introduced nucleus and produce no pearl at all. It is as unpredictable as the sea itself.

I flew with Nick Paspaley in his amphibious flying boat from Broome to his farms east of Darwin for an inspection tour. Out along the buoy line, Nick took a ragged, encrusted oyster, pried it open, reached in and pulled out a perfect, 14-millimeter pearl, slightly golden in color.

Everyone laughed at his luck. "I swear I didn't plan it," Nick said, rolling the pearl between thumb and forefinger. "Each oyster, once it reaches the farm, has probably cost us more than a hundred dollars in labor and taxes. I hate to sacrifice one that has more growing ahead, but it's the only way I can really see how the pearls are doing."

There is also the joy of opening a secret present, the thrill of the gamble. Perfect pearls are accidents. Pearling is still more alchemy than business. Not that Nick Paspaley hasn't tried to take the alchemy out of marketing South Sea pearls. In 1989 he organized the first Australian auction at Darwin.

From auction houses the pearls move from dealer to jeweler, arriving in the world's cities as objects of great desire. In midtown Manhattan I spoke with Koichi Takahashi, a vice president of the Mikimoto company, originator of cultured pearls.

"South Sea pearls are very rare, very valuable," he told me. "Worldwide there are only 300 *kan* of these pearls harvested every year, and that includes all the black pearls from Polynesia." A kan, a Japanese unit of measure, is about eight pounds.

To those who own them, South Sea pearls exercise a powerful mystique. In Darwin, Nick Paspaley took me into his office and opened a red jewel box (page 115). Inside lay pearls, arranged as a necklace, that had never been drilled or strung.

"It's the best necklace in the world," he said matter-of-factly. "Its centerpiece is 19 millimeters, going down to 15 millimeters. But I keep changing the pearls after every harvest, every time I find a better pearl."

Nick sat back, lost in thought. Finally he said, "These pearls are products of all the years of work—ships, divers, oysters, farms, cyclones, bends, sweat. I can hold a lifetime in my hands."

And then he held up a single round pearl—luminous, perfect, seductive—the size of his thumb. It was the biggest pearl of its kind in the world.

"I had always dreamed of such a pearl," he said. "When they found it on the farm, my associate sent his code for a perfect pearl: 'There is a full moon rising.' " □

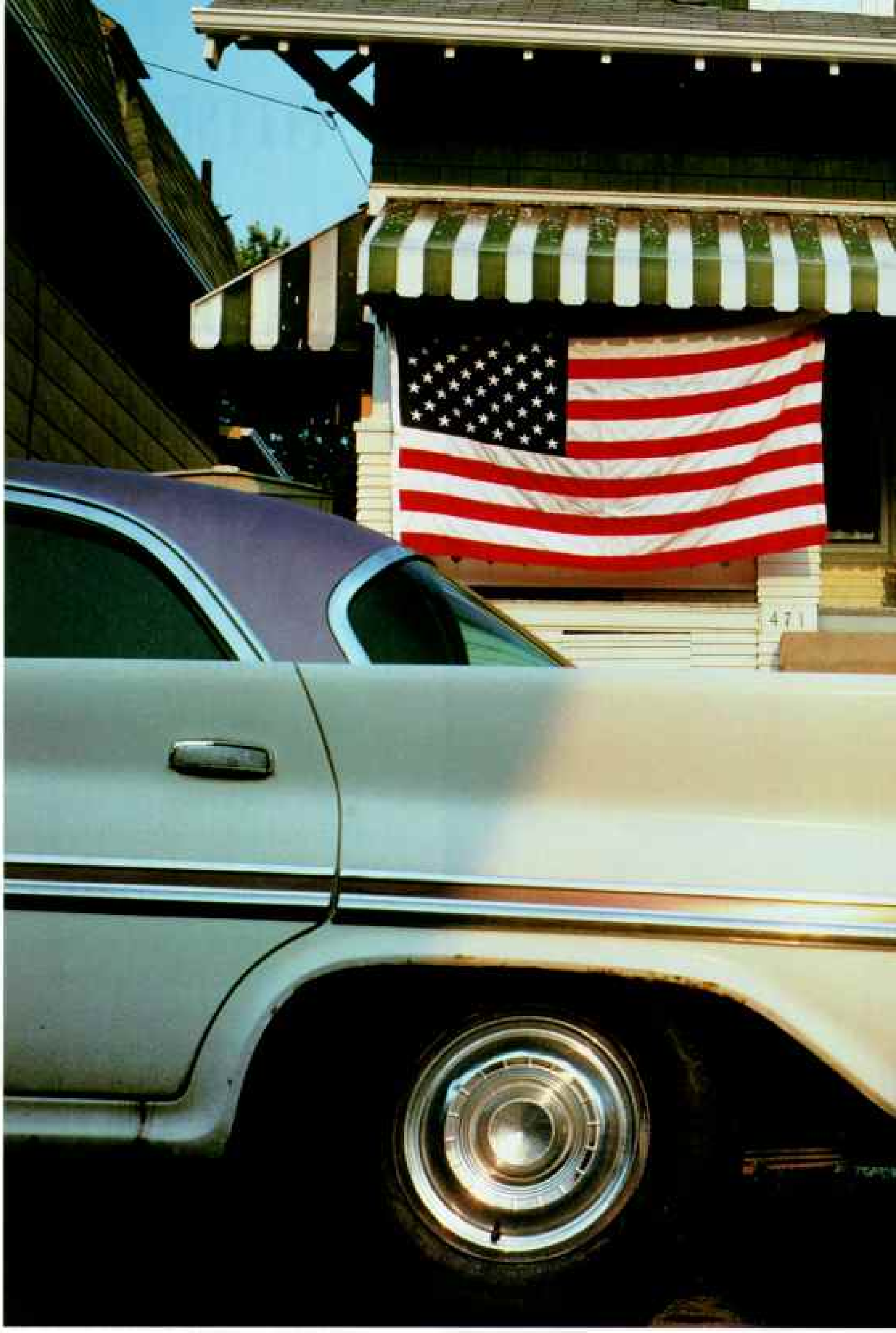
PITTSBURGH

Stronger Than Steel

By PETER MILLER
ASSISTANT EDITOR

Photographs by NATHAN BENN

Once tough enough to support 175-ton ladles of molten steel, rusted girders at the hundred-year-old Duquesne Works give way to the demolition man's acetylene torch. Steelmaking plants, source of Pittsburgh's past wealth and fame, are reduced today to skeletons, then recycled into other industries. The city now thrives, not just because it found new ways to use old resources, but also because its traditional, strong-willed people would have it no other way.



Old cars and Old Glory flaunt their fins and stripes in Robert Kenney's Duquesne Heights neighborhood, one of close to 80 in Pittsburgh. Many began as enclaves of immigrants who came in the 19th century to mine coal and work in the mills.

"People don't move around much here," Kenney says. "I've been in this house 39 years. A lot of my neighbors have been here even longer. They're people you can count on, and they don't wait until the Fourth of July to wave the flag."

EARLY ONE EVENING last March, a 73-year-old Jewish grandmother heard a strange noise in the hallway outside her apartment in the Squirrel Hill neighborhood of Pittsburgh. Straightening her housecoat, she opened the door. No one there. She went to the rear stairwell, pushed open the fire door, and came face-to-face with two burglars. They were carrying a 300-pound safe.

For an instant the three stared at one another. Then the woman, rising as tall as her five feet five inches would allow, broke the silence.

"Where ya going?" she demanded.

The pair didn't wait to answer. They dropped the safe and ran.

"It was just like an Abbott and Costello movie," the woman recalled later from the front seat of her chauffeur-driven car. "Their mouths literally fell open when they saw me."

And why not? Of the 370,000 people in Pittsburgh the last one the crooks expected to meet in the stairwell was the mayor.

Sophie Masloff, crime fighter.

In her no-nonsense way, the mayor was demonstrating the tough, taking-care-of-business attitude for which Pittsburghers are famous—the same attitude with which they confronted their city's fearful economic problems during the past decade.

Shaken by the collapse of the steel industry, which had provided them with an unshakable sense of identity for more than a century, Pittsburghers hunkered down and built a new economy based on services, medicine, education, and technology. In the process, they transformed their community from one driven by quantity of production into one devoted to quality of life.

"Pittsburgh is the classic overachiever

among American cities," writes Franklin Toker of the University of Pittsburgh. "It industrialized first, it became obsolescent first, and it overcame obsolescence first."

This morning the mayor was taking me on a tour in her official car, a Ford sedan. No fancy limo for Sophie. "Pittsburgh's no place for pretensions," she said. She wanted to show me the difference between today's Pittsburgh and the smoky mill town it used to be. Our destination: the Frick Woods Nature Reserve, a 150-acre forest of sugar maple, beech, and oak less than six miles from her downtown office.

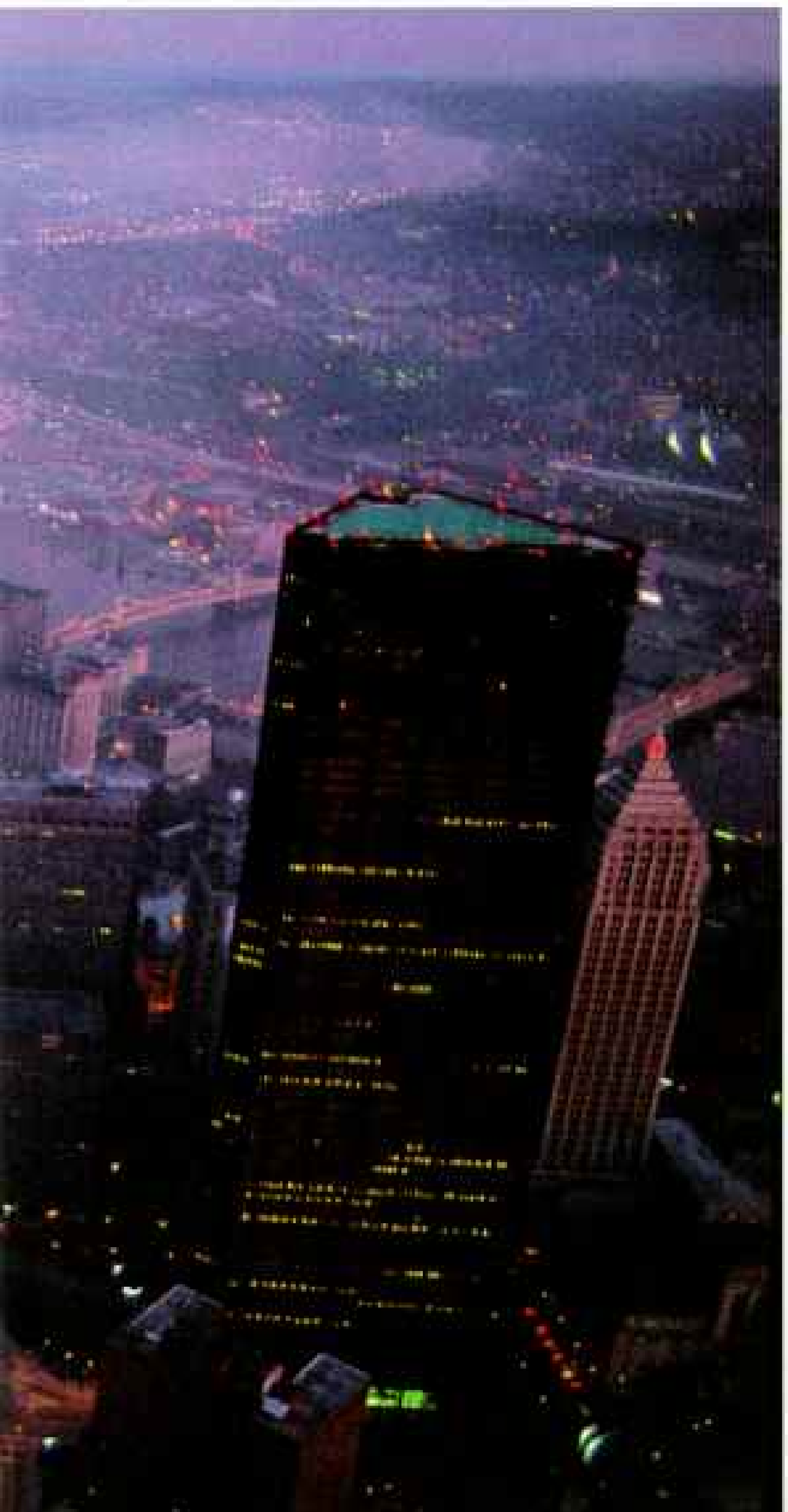
There we met Lucy Laffitte, director of the reserve, who took us for a stroll through the dappled sunlight. Because of its large parks and steep, undeveloped hillsides, Pittsburgh attracts a variety of songbirds, Laffitte told us. When I asked her what kinds, she stopped, turned her head, and named those she could hear at that moment: a cardinal, a tufted titmouse, a white-throated sparrow.

"People never picture *this* when they think of Pittsburgh," the mayor said triumphantly. "When I was growing up in this city, a blade of grass didn't stand a chance, let alone a bird."

THAT WAS THE OLD PITTSBURGH. During the first half of this century, soot from the steel mills blackened the sky. Streetlights blazed at noon. Housing for the working class was overcrowded and unhealthy. The rivers ran thick with industrial wastes.

Writing at the turn of the century, William Sydney Porter (who signed his short stories O. Henry) described Pittsburgh as the "low-downdest" hole on earth and its citizens as "ignorant, ill-bred, contemptible, boorish, degraded, insulting, sordid, vile, foul-mouth, indecent, profane, drunken, dirty, mean, depraved." The English philosopher Herbert Spencer, passing through somewhat earlier, concluded that a month in the city would justify anyone in committing suicide.

Having just spent a month in and around Pittsburgh, I can safely report that such action is no longer warranted. I found today's city a lively and attractive blend of old-fashioned ways and innovative styles, of provincial



RANDY OLSON (LEFT)

"I'm just another one of the neighbors," says Mayor Sophie Masloff, who samples pineapple at Ron Casertano's produce market. When away from her office downtown amid the towers of the Golden Triangle (left and map, pages 132-3), she mingles with constituents at picnics and church events. "I go to all the down-to-earth things," she says. "Pompous ceremony embarrasses me."

It's a beautiful day in the neighborhood when Fred Rogers plays with grandson Alexander (left); his children's TV program has called Pittsburgh home for 23 years. Worried about crime and drugs in her own Manchester neighborhood, DeShauna Ponton would rather live in safer Brighton Heights, where she and daughter Robin join a Christmas in July block party.

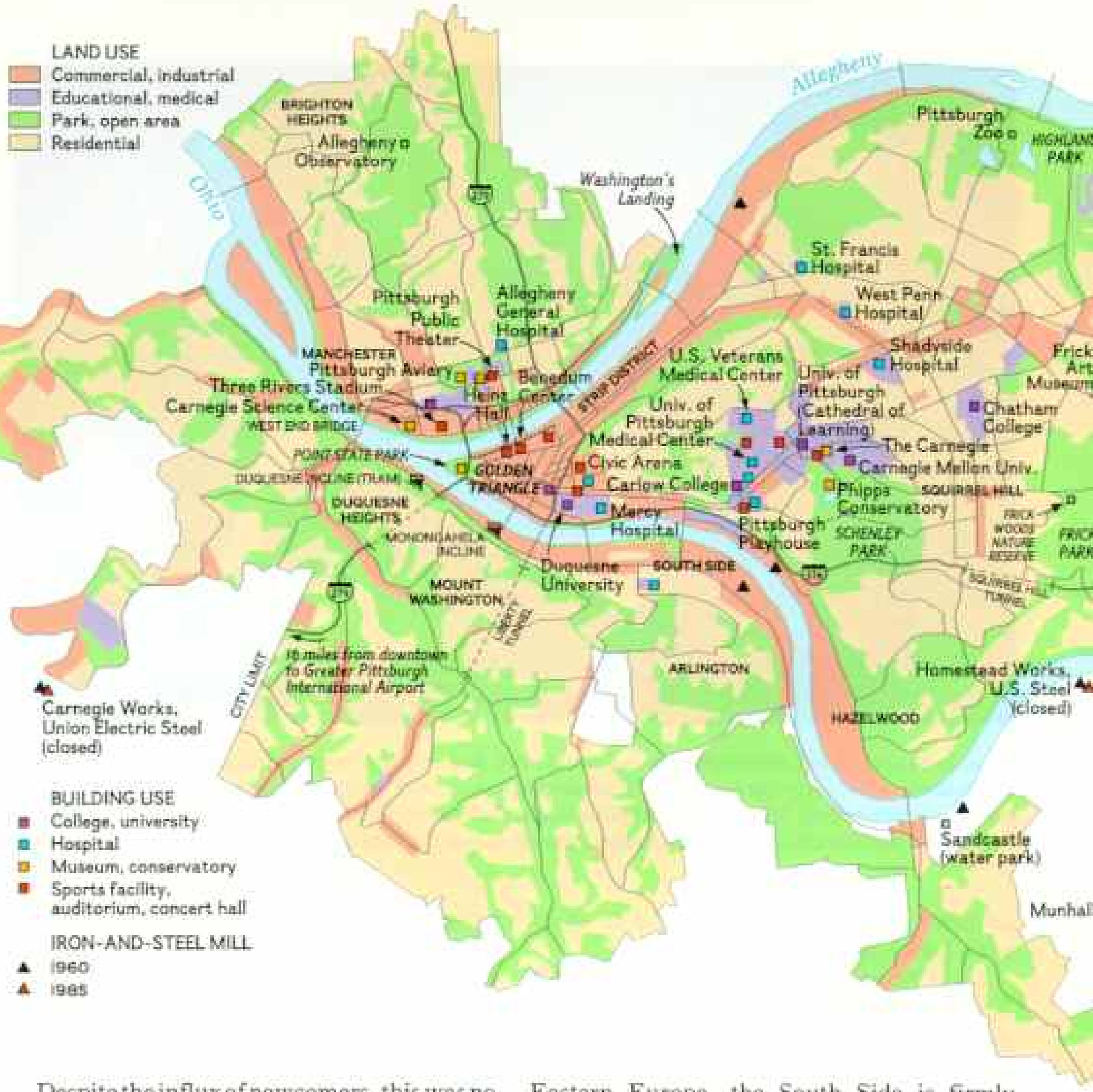
attitudes and sophisticated tastes, of small-town habits and big-city dreams.

I was delighted by the glitz of the Golden Triangle, Pittsburgh's prosperous downtown district, whose flashy towers crowd the point where the three rivers meet—the Allegheny and Monongahela joining to create the Ohio, whose waters, mingling with the Mississippi, flow past New Orleans into the Gulf of Mexico. I was tantalized by the smell of roasting coffee from the shops of the Strip District, a 20-block strip of warehouses where rich and poor rub elbows on Saturday morning to buy fresh fish, meat, poultry, and produce. I was fascinated by the rows of flat-faced houses that cling to the steep slopes in all directions. And I was mesmerized by the spectacle of the huge, decaying steel mills that rise up beside your car whenever you drive near the rivers.

"The best thing about Pittsburgh," one resident told me, "is that you can take it one piece at a time." Because of the way hills, gullies, and rivers divide the city, she said, each neighborhood has evolved as a separate community with its own ethnic flavor. You are never overwhelmed by the whole. While you're visiting one neighborhood—Polish, Italian, Jewish, German, Slavic, Arab, or African-American—the others might as well not exist.

TO GET TO KNOW at least one piece of Pittsburgh personally, I rented an apartment on the South Side, a neighborhood that, like the city it belongs to, is reinventing itself. Historically a conservative, blue-collar community, the South Side has lately attracted a smattering of artists, lawyers, architects, and other young professionals. Its commercial district, which once boasted some 85 bars, has blossomed with antique shops, art galleries, jazz joints, and French restaurants.

Bounded by the Monongahela River on one side and Mount Washington on the other, the South Side is divided by Conrail tracks into the flats and the slopes. My apartment was on the flats, a few blocks from a steel mill that closed in 1985. There was sometimes a sulfurous breath in the air, thanks to the companion coke plant upriver in Hazelwood—one of the few steel-related facilities still operating in the Pittsburgh area.



Despite the influx of newcomers, this was no yuppie neighborhood. When I stepped out my front door, I was greeted by the offices of the National Slovak Society of USA, a funeral home, and a tavern across the street. A kung fu parlor stood on the corner, opposite an auto-repair shop and a Goodwill Store. Some mornings I dropped by Pasha's Convenience Stop two doors down to get a cup of hot coffee and watch the owner's sister, Khalida Nuzhat, a native of Pakistan, try to talk customers out of their bad habits.

"Pall Mall," a man would cough, shuffling up to her counter.

"You know, you are smoking a strong brand," she would warn him.

"Yeah, I know," he would reply.

"Well, I will sell them to you, but you might want to reconsider," she would say.

A hodgepodge of ethnic groups, mostly from Eastern Europe, the South Side is firmly anchored by its churches: Polish, Ukrainian, Lithuanian, German, and Slovak. I visited St. John the Baptist Ukrainian Catholic Church one Friday morning to get a taste of the old Pittsburgh.

I was met by Msgr. Michael Poloway, who led me down to the basement. The smell of sauerkraut and fried onions rose to meet us. Dozens of *pyrohy*, a popular Slavic food, were boiling in four giant pots in the kitchen.

"Have a seat," the monsignor said, handing me an apron. "We'll teach you how to make them."

Older women, most of them chatting in Ukrainian, were crowded around a long table. In front of each was a tray of fillings: mashed potato, cottage cheese, or sauerkraut. Behind them a pair of men cranked dough through a wringer and cut it into small ovals.

PITTSBURGH

WITH PLENTY OF COAL to burn and rivers to carry goods, Pittsburgh was ripe for industry 200 years ago. But in the 1970s and early 1980s foreign competition and decreased demand for "raw" steel slowed the mills to a near halt. Today only a few remain, all outside the city. The trade-off: Pittsburgh's air is cleaner than ever, and its waters run clear.

"It's easy," said Maria Kupchak, a cheerful woman with pink cheeks. She wrapped a piece of dough over a ball of filling and pinched the edges closed. "Sometimes you gotta pinch it three times to be sure."

Monsignor Poloway, hands busily pinching dough, looked over. "St. John the Baptist has been here since 1895," he said. "We're in our fourth generation of immigrants."

After we had each filled a tray with pyrohy, he took me upstairs to show me a new stained-glass door commemorating the church's upcoming centennial. The door was paid for by selling pyrohy to the neighborhood, he said.

As we headed back through the nave, I glanced up at a mosaic. In the background was a group of Ukrainians in traditional costume. In the foreground was a group dressed in modern American clothes. And in the middle was Jesus, showing them the way.

PITTSBURGH'S FATE as an industrial center was determined from the start by its location. Founded at the confluence of strategic rivers, it began as a military outpost during the French and Indian War. British troops in 1758 seized Fort Duquesne from the French and replaced it with North America's most elaborate English fort, named Fort Pitt for statesman William Pitt—hence the city's name. Western Pennsylvania's hub of trade and transport, it flourished as a gateway for settlers moving farther west.

The fact that it sat upon a rich coal seam destined Pittsburgh to become an iron-smelting center during the 19th century. And its access by water or rail to the best iron deposits in the Lake Superior region gave the city an unbeatable edge as a site for steelmaking. Driven by Scottish-born industrial magnate and philanthropist Andrew Carnegie, by 1900 it was the nation's largest producer.

Decade after decade its monstrous mills—one stretching seven miles along the Ohio—turned out girders for skyscrapers, rails for railroads, plates for ships, heavy machinery for factories. At its peak U. S. Steel's Homestead Works alone employed 30,000 men.

But the city's luck couldn't last forever. By the early 1970s foreign competitors, making the most of the latest technology and lower labor costs, were capturing an ever greater share of a shrinking world market for steel. Slow to modernize, American companies fell behind.

When the nation's steel industry all but collapsed in the early 1980s, it would take more than 100,000 jobs from the region. Families were torn apart by the strain. Local businesses were boarded up. A way of life vanished.

"It was a strange time," said Ray Henderson of Forest Hills, who was employed at U. S. Steel's Duquesne Works for 18 years. "We saw it coming, but it was hard to accept."

After the mill finally closed in 1984, Henderson and his wife, Joyce, an EKG technician at Presbyterian-University Hospital, went through tough years. "I had to fight to keep my house. I couldn't repair my car. My daughters had to go without things I wanted to give them. But they were real troupers."

Other workers were less fortunate, he said. "We had suicides of guys from the mill. They didn't call them that, but that's what they were. Some drank themselves to death. Some drove their cars off the road. I don't know how many marriages broke up."

Almost a decade later, many former steelworkers still have problems. Of 4,000 who responded to a 1989 survey, 40 percent remain unemployed. Among those with jobs, only two-thirds work full-time, and they took pay cuts of 40 to 68 percent from their mill days.

"There's an assumption that many workers have moved on and made some sort of mythical transition to service industries or have left for the Sunbelt," said Tom Croft of the Steel Valley Authority, an economic-development organization. "But a lot are still here, working two or three jobs to survive."

It took Ray Henderson more than two years to get himself together, doing odd jobs and going back to school at night. Now an athletic-looking 50 with a salt-and-pepper beard, he owns a shop in Wilkinsburg, named Faith & Joy's Novelty for two of his granddaughters, selling gifts with African-American themes.

Mike Bilcsik of Munhall was president of United Steelworkers Local 1256 when the Duquesne Works shut down. Like his grandfather and father before him, he had devoted his working life to the mill. Last year a county agency began to dismantle the plant to make way for a light industrial park. On a cold April morning Bilcsik and I drove to Duquesne to see what was left. Our breath hung in the air as we waited for guards at the gate.

"I'll never forget the way they jeered me at this gate. They didn't believe me when I told them the mill was really shutting down," he said, remembering the faces not of corporate managers who were his adversaries but of steelworkers for whom he was struggling. It was a time of hopes and fears and self-deceptions. "They thought I was crazy."

The only workers left at Duquesne the day we visited were demolition crews. Their acetylene torches flickered within the cavernous buildings that seemed to be returning to nature. Saplings rose from inside the ruins of blast furnaces. Moss covered the catwalks. Fish swam in the sump at the water-filtration plant. And deer were said to wander at night through the hangar-like building where giant ladles had poured molten metal for so long.

To preserve the memory of what took place in such mills, Bilcsik now consults for a group called the Steel Industry Heritage Task Force. Their goal is a tourist center in Homestead

Looming over the town of Braddock (below), the Edgar Thomson Plant—Andrew Carnegie's first steel mill—still rumbles with activity. Braddock, though, wasted away when people followed the malls and subdivisions that cropped up nearby. "There's nothing left but old people," says barber Joe Szwarc (left). "One day we're going to have to level this town and start all over."

"I was scared we'd be next," says Sonny Kessler, who maneuvers steel slabs at the Irvin Plant. But the plant survived the shutdowns of the 1970s and '80s, and so did Sonny, who returned after an eight-month layoff. In nearby Homestead, those who lost jobs looked to the Rainbow Kitchen job bank (right). Some found work demolishing the same mills they once counted on for a living.

and neighboring Swissvale—with historic facilities and exhibits evoking the entire steel-making process—along the lines of the National Park Service's textile museum in Lowell, Massachusetts. Last December the group dismantled the century-old 48-inch rolling mill and steam engine at Homestead and carted them away for safekeeping.

"Twenty years from now, people in places like Duquesne won't even know there was a steel mill here," he said. "But these mills are what we are. We need to pass some of this along to succeeding generations."

EXCEPT FOR WORKERS in steel and related industries, most of Pittsburgh made a rapid recovery from the economic crisis. One reason was timing. While heavy industries in the United States were declining, service industries were on the rise. And Pittsburgh, headquarters for a dozen major corporations, was in an excellent position to benefit from that trend.

Though the region lost 120,000 jobs in manufacturing during the 1980s, it also gained 115,000 nonmanufacturing jobs, mostly in business services and health care. "We are

gradually becoming more like the nation as a whole," says Norman Robertson, chief economist at Mellon Bank.

There was more to it than timing, however. There was also a lot of pulling together. To encourage new businesses, particularly those in high-technology fields—computer software, biomedicine, factory automation, and advanced materials—a number of unusual collaborations were formed between businesses, government, and academia, especially Carnegie Mellon University and the University of Pittsburgh.

The Chevron Corporation in 1986 donated a former research-and-development center in Harmarville to Pitt, which included 55 buildings and millions of dollars' worth of equipment. That center is now the site of more than 160 small high-tech companies.

One of these, the Center for Hazardous Materials Research, has become a leader in training workers to handle toxic and other dangerous materials. The afternoon I stopped by, a training session was under way on the back lot, which looked like a museum of environmental horrors. There were chemical railroad cars on their sides, a tanker truck flipped over on an automobile, and a bunch of rusty drums oozing an evil-looking green fluid.

A team of five students, sweating profusely in protective suits, approached the drums. It was their second inspection of the site. During the first they'd found a dead duck (actually rubber), indicating the presence of toxic materials. Were there flammable liquids as well?

Harry Lysinger, a maintenance manager at

a government facility in Virginia, was the first student to touch the wired drum. As he lifted its side, I heard a *pop!* and white smoke billowed out from underneath.

"Kaboom!" shouted instructor Mark Ulintz. "You all fall down. You splat yourself against that truck over there. You're writhing in pain. You're dead meat!" A second team was dispatched with stretchers.

Their mistake? "They shouldn't have been so impatient," said training manager Bob Ferguson. "They should have evaluated the site further before haphazardly moving the drums. But it's better for them to make mistakes here rather than later on a work site."

Cleaning up the environment has become a big business in western Pennsylvania—500 firms in the region do such work. Considering heavy industry's historic role in the city, say those in the field, it was only natural that Pittsburgh should become a center for research into handling the problems left behind.

ONCE RIDICULED, Pittsburgh's quality of life has become a catalyst in its comeback. There are enough schools, parks, and roads to go around, in part because the city's population has shrunk by 45 percent since 1950.

Eric Hoffman, a 32-year-old researcher at the University of Pittsburgh Medical Center, moved to the area last year. The research challenge attracted him: He has grants to improve methods of diagnosing muscular dystrophy and related diseases. But the quality of life in Pittsburgh—lower cost of living, good schools, open space, friendly neighborhoods—made the move irresistible.

As seconds tick away, a liver-transplant team races to save a patient at the University of Pittsburgh Medical Center. The city is a world leader in organ transplants, cancer research, psychiatry, and genetics.

Buchanan Ingersoll, one of Pittsburgh's top three law firms, has expanded its practice to address health care and other issues. Attorney Jim Sweeny clocks billable hours to corporate clients in the United States and Europe.

"My wife and I have three children," he explained. "We always wanted a house. But there was no way we could afford one in Boston. We found a beautiful one in Squirrel Hill, four miles from the hospital. I bike to the lab through Schenley Park."

The appeal of Pittsburgh's neighborhoods is paying off in other ways. Not far from the street where Hoffman lives, yet another of the city's growth industries was setting up shop one morning. Looking only slightly out of place, several vintage automobiles, including a 1936 Plymouth, a 1941 Ford, and a 1949 Cadillac, were parked along the curb on South Linden Avenue.

Walter Matthau, the actor, was standing in a driveway, sipping a cup of coffee. Wearing a small white bib from a makeup session, he was chatting with kids on their way to school.

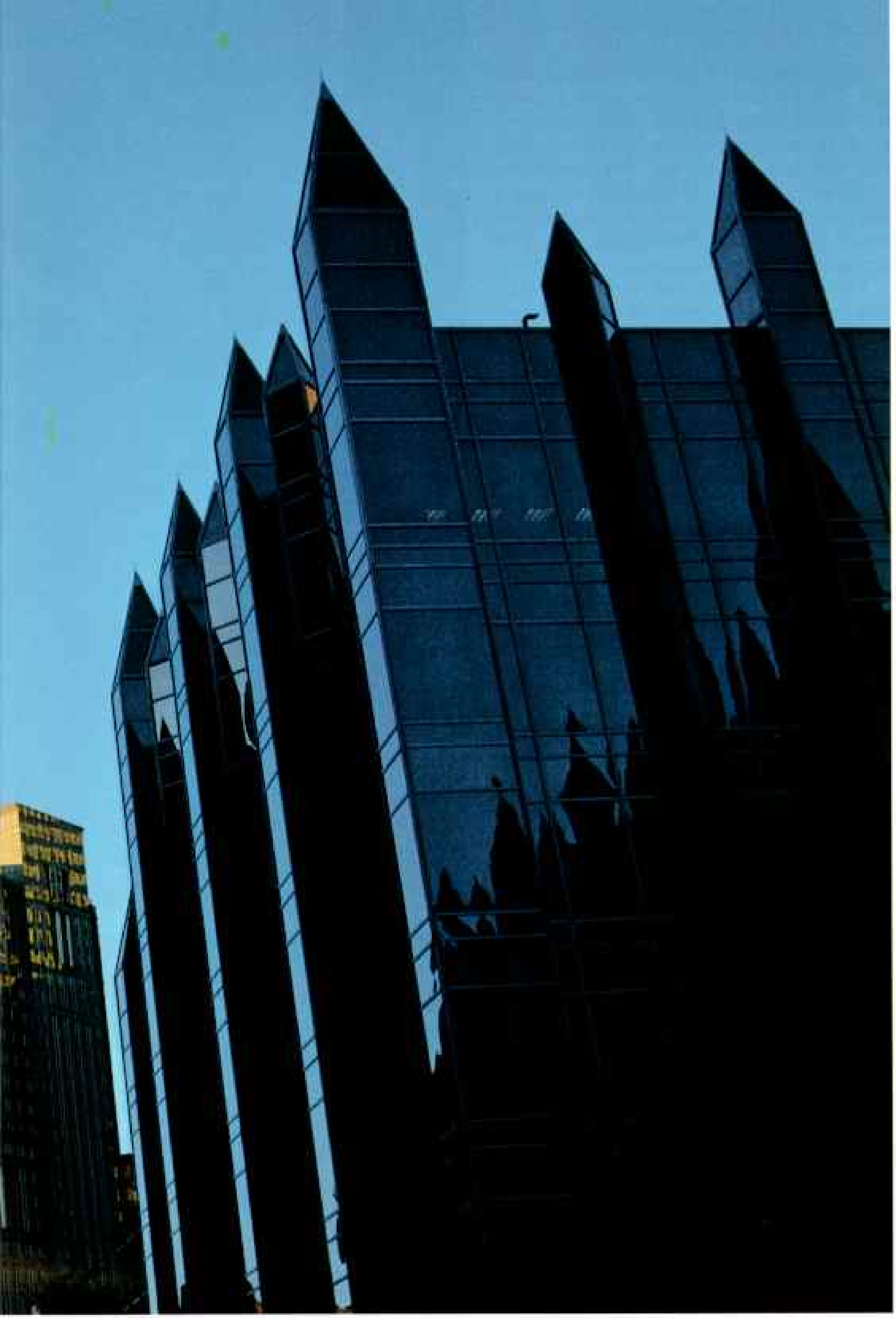
"Hey, what's going on?" he asked them.

"They're making a movie," one of the kids replied.

"Oh. Who's in it?" he said innocently.

"You are!" they shouted.

Gleaming towers and crystalline castles light the Golden Triangle, prime real estate at the confluence of the Allegheny and Monongahela Rivers. Once grimy and prone to flooding, the district was cleaned up and rebuilt during a



post-World War II civic renaissance. Reflecting the city's new corporate culture, the Gothic-inspired PPG Industries' glass ramparts, foreground, are part of a six-building complex that complemented Pittsburgh's second renaissance in the 1980s.

It was the second day of shooting for *Against Her Will: An Incident In Baltimore*, a made-for-television film. In it Pittsburgh was impersonating someplace else, a job the city does well because it has so many different-looking neighborhoods. In *The Silence of the Lambs*, a number of locations around Pittsburgh portrayed Chicago and Washington, D. C., as well as small towns in Tennessee and Ohio.

The average project puts 1.5 million dollars into the pockets of production crews, restaurants, hotels, and other local businesses, said Pittsburgh Film Office chief Robert Curran. During the past 18 months more than a dozen movies have been made in the Pittsburgh area.

From time to time a filmmaker even lets Pittsburgh play itself, as in *Flashdance* and *Dominick and Eugene*. But considering all the income the other films produce, said Curran, "we're more than happy to remain a character actor, rather than a star."

"HOLD IT, hold it, hold it!" said Tito Capobianco, general director of the Pittsburgh Opera. He was addressing three students in a new training program as they performed a scene from Giuseppe Verdi's *Rigoletto*. Tilting his head back to find the words, he scratched his neck with both hands.

"Don't just sing," he told Shelley Jameson, who was playing the part of Gilda. "Feel guilty! Why are you lying to your father?"

The students began the scene again. Once more they appeared stiff.

The teacher rose from his chair. "You are

With a tip of the hat, the Hazelwood Little League team is ready to bat the season's first ball. "My dad makes me come because he doesn't want me to play too much Nintendo," says Jason Hill, second from right. Although they wear Yankees uniforms, the team's real heroes are their own Pittsburgh Pirates (left), who warm up at Three Rivers Stadium to challenge Montreal.

young," he complained. "Why don't you approach *Rigoletto* with something new?"

This time he joined them, assuming the part of Giovanna, the disloyal maidservant who helps the Duke of Mantua slip into the young girl's house. As Gilda sang, he put his hands on her shoulders, combed her hair, and, looking over his shoulder, winked at the duke waiting in the wings. He had *become* Giovanna.

"Give me another approach!" he shouted as he returned to his chair.

The rattled but eager students were members of the first class at the Pittsburgh Opera Center at Duquesne University. They were thrilled to be associated with a company that last season had performed with the world's leading tenors—Luciano Pavarotti and Plácido Domingo.

"We're incredibly rich in the arts in this city," said Carol Brown, president of the Pittsburgh Cultural Trust, a nonprofit organization. In 1987 the trust created a new home for the city's opera and ballet companies by renovating the 60-year-old Stanley Theater and reopening it as the Benedum Center for the Performing Arts. The project is part of a

plan to turn the Penn-Liberty area, a former downtown porn zone, into a 12-block cultural district, including Heinz Hall, home of the renowned Pittsburgh Symphony Orchestra.

"Pittsburgh is like a microcosm of a big city," said Scott Mervis, an assistant editor at the *Pittsburgh Post-Gazette*. "We may not have as many things to do in terms of entertainment and the arts, but what we have is high quality."

Opera lovers in Pittsburgh come from all levels of society, I was told. The same was true, I discovered, of concert and ballet patrons, football and hockey fans, and the crowd that showed up one Friday night at the Liberty Belle Lounge on East Carson Street.

There were young couples on double dates, parents with grown children, a trio of girls wearing all black, and an older woman smoking a cigarette at the bar as if she owned the place. A hard-looking guy with gypsy black hair and a scar took the barstool next to mine. He looked as if he would be more at home on a Harley-Davidson.

The one-man show at the Liberty Belle was like nothing I'd ever seen before. Appearing in an electric blue, rhinestone-studded vest with sunglasses to match, a middle-aged singer named Frankie Capri pounded away on a keyboard or accompanied himself on an electric guitar in rock-and-roll classics like "Jailhouse Rock" and "Chantilly Lace."

His gaudy stage was piled high with flags, dolls, and puppets, and every now and then he pulled a string to make a quartet of monkeys bang tiny cymbals or make a rubber chicken dance. The audience went nuts.

A well-dressed, professional-looking woman was the first to pull a dog mask off the wall, and, to the cheers of the crowd, prance around in front of the stage. Soon nearly everyone was up doing something called the Bird Dance. They wiggled their fingers, flapped their arms, squatted with a twist.

Among the few who didn't join in was the disdainful-looking biker.

When Frankie moved on to a soulful version of "That's Amore," people started swaying and singing at their tables. From somewhere nearby I heard a strong male voice: "When the moona hits you eye like a bigga pizza pie. . . ."

It was the tough guy on the next stool.

"You know the words?" I said in surprise.

"Course," he said. "I got the record at home."

"WHEN I WAS GROWING UP on the South Side, my mother always told me, 'Don't go near the river,'" said state legislator Tom Murphy. "There were railroad tracks ten deep, the river was polluted and lined with factories. No place for a kid."

Now that has changed, Murphy added. Virtually all 35 miles of the city's riverfront—most of which had been covered with heavy industry—are available for new uses. I caught up with the legislator one rainy morning as he was walking along a trail on the South Side. It had just been opened as part of a proposed 12-mile walkway stretching from Washington's Landing on the Allegheny to West End Bridge on the Ohio to Sandcastle water park on the Monongahela. Such a trail, said Murphy, was one way the city could reclaim its rivers.

A few days later in a boathouse at Washington's Landing, Jamaine Thomas was in motion. With his red baseball cap turned around backward, the ten-year-old from Pittsburgh's Arlington neighborhood was pulling on the oars of a rowing machine as fast as he could. In the worst way, he wanted to show Michael Lambert, director of the Three Rivers Rowing Association, that he was ready to go out on the Allegheny in a real boat. But Lambert wasn't so sure.

"Arms away, body angle, keep your legs down," he told Jamaine, who had never rowed before. "Lean forward a bit more, keep your head up, then come up on the slide."

Jamaine was one of 45 kids at the boathouse that afternoon, mostly from low-income neighborhoods. They were being introduced to the sport through a program called TRY Rowing. Coaches came from the crew teams of the University of Pittsburgh, Carnegie Mellon University, and Duquesne University.

In the 19th century, Lambert told me, rowing had been a major Pittsburgh sport. Crews from shops and factories along the riverfront would challenge one another to races. By the 1870s the city boasted more than 20 rowing clubs. But after the turn of the century the rivers had grown clogged with barges, tugs, and other traffic.

The kids in the program did their rowing in a channel behind the boathouse. After some training on the machine, I joined them on the water in a one-man shell, more difficult to control than it looked. I found it was not unlike riding a bicycle. Keeping a long, slender racing

Serpentine and slippery, Sandcastle water park meanders across a railway yard that once sprawled along the Monongahela. It is the first of such renewal projects erected on old riverfronts. Light industrial parks are replacing worn-out mills as Pittsburgh puts on a new face.

shell afloat requires you to execute a precise series of physical movements and somehow, at the same time, to relax. I had trouble doing both.

Lori Gassner and Annie Schleicher, two members of the Pitt crew, were coaching a group of boys in a "four," a 44-foot racing shell with four rowers and a coxswain. Lori was steering the motorboat following the boys. Annie had a red megaphone.

"Watch your timing, Christian. Row with your eyes shut!" she shouted.

The boys scowled but kept trying to do their best, oars wandering in all directions.

As they glided under the old railroad bridge where the channel joins the river, I was struck by the image of them struggling together. They were acting out the spirit of collaboration that had worked so well for this city.

By pulling together when it counted, the people of Pittsburgh had survived the collapse of their largest industry, protected the small-town atmosphere of their neighborhoods, and managed to keep alive an awareness of the natural beauty of their steep hills, narrow hollows, and swift-flowing rivers.

The question now, as one Pittsburgher put it, is whether the new post-industrial city, with its high-tech labs and white-collar style, can provide its residents with an identity as compelling as the old steel-town image. Will the new Pittsburgh have room in it for the quirky, old-fashioned qualities that inspired such loyalty in the old one?

Watching the boys rowing down the channel with the towers of the Golden Triangle blazing in the late afternoon light—looking every bit like Pittsburgh's version of Oz—I couldn't help believing that all things were possible. □

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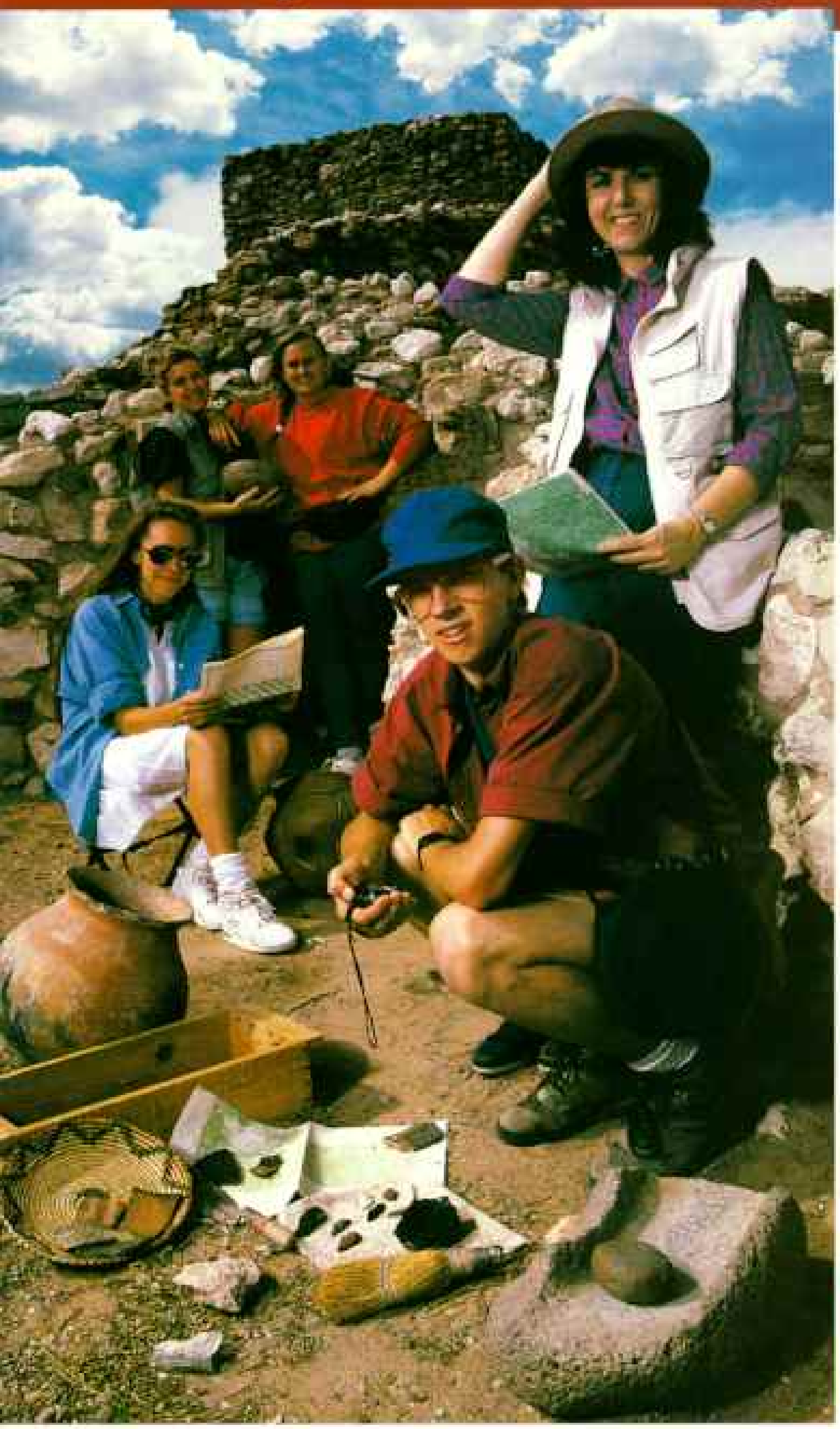

Sherry Baca, a math teacher at Prescott High School in Prescott, Arizona, believes that the study of math shouldn't be confined to just the classroom. Which explains why these students are busy exploring the site of an archaeological dig in their native state.

The genesis of this inventive approach to teaching math skills came from a video Sherry showed to her class. "The students were fascinated by a program on archaeology and the Anasazi Indians," explains Sherry, "and that gave me an idea."

The "idea" is a teaching unit developed by Sherry to show how math is applied in archaeology. In the process, the students learn how archaeologists map out digs using variations of the cartesian coordinate system. They develop their own graphing and cataloging system. They even investigate the dating of artifacts. This learning experience climaxes with a field trip to the Anasazi ruins in Northern Arizona where the students see firsthand how scientists apply the very math skills they are learning.

Like all of her teaching innovations, Sherry created this one with one purpose in mind: "I just want my students to enjoy and love math as much as I do."

Undoubtedly, Sherry has succeeded. That's why State Farm is honored to present her with our Good Neighbor Award. We are also delighted to make a contribution of $5,000 to Prescott High School in her name.

Sherry Baca. She's shown her students how the quest for knowledge can take them to some interesting places indeed.

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THE PRESIDENT'S REPORT ON THE

Education Foundation

Dear Members:

There's no substitute for firsthand experience. That's what teachers rediscovered this summer at advanced training programs sponsored by the Society. Whether they were exploring computer keyboards or hiking trails, we were proud to help these educators, who promise to become the future leaders of the campaign for geography education.

Gilbert M. Grosvenor
President and Chairman

BOTH BY ZIGGY BRIMBERG

HOW MANY drops of water will fit on a penny? Such a question may seem strange for a geography teacher. But it was all part of an experiment in predictions for Laurie Molina of Tallahassee, Florida (above, at left). Now for the rest: learning how to use a telecommunications program called NGS Kids Network, developed by the Society, to share results with others across the country (top). The most common answer: about 20 drops.

Laurie was one of 32 teachers at our first Educational Technology Leadership Institute, in Atlanta. Co-sponsored and generously supported by IBM Educational Systems, the institute introduced educators to the latest classroom technologies. Upon graduation they were given equipment from IBM, laser-disc players from Pioneer, and software from 16 companies. In return they will train some 2,000 of their colleagues.

"I'll never teach the same way again," said Rick Farney of Evansville, Tennessee. "I can't wait to hear my kids ooh and ah."

WHEN JIM GOODMAN, head of the Oklahoma Alliance for Geographic Education, stopped by the sheep ranch of Mae Yazzie John near St. Michaels, Arizona, in June, he was accompanied by 20 teachers ready to share in the daily chores of a Navajo family. They were on a field trip—one of 49 across the country sponsored by state geographic alliances—to study Anglo, Hispanic, and Indian cultures of the Southwest, as well as its geology and geography. The teachers also got some practical experience: As three held down a reluctant sheep in a dusty corral, a fourth sheared the squirming animal with hand clippers. Said Linda Beckham of Tulsa: "Nothing compares to field experience like this."

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Geographica

KENJI KAWANO

Navajo Code Talkers Meet a Japanese Friend

They are an unlikely combination: a Japanese photographer and a group of World War II Navajo "code talkers." The result of their encounter is a book that highlights the secret role of the several hundred Navajo Marines who served in the Pacific, translating and transmitting radio messages in the Navajo language. Frustrated Japanese military men admitted after the war that they could not break the "code."

Kenji Kawano, 42, had never heard of the Navajo when he arrived in Los Angeles from Japan in 1973. Traveling the next year, he happened upon Window Rock, Arizona, where the open, blue sky of the Navajo Reservation—"so different from Tokyo"—captivated him.

Hitchhiking one day, he met Carl Gorman, then a leader of the Navajo Code Talkers Association, to which many of the surviving Navajo Marines belong. Gorman told him about his wartime experiences, the two men became friends, and Kawano stayed to photograph the veterans. His photographs, like that of William Dean Wilson (above), recently were published in a book, *Warriors: Navajo Code Talkers*.

"I'm a former 'enemy,' but they had nothing against me," he muses. "The Navajo don't care about what happened in the past, and I don't either. What happened at Pearl Harbor and at Hiroshima, that's between government and government, not between individuals."

When Iguana Social Life Turns Perilous

Venezuela's green iguanas get along well with one another most of the time, so well that 30 to 40 will spend the night in a single tree. But come mating season, things turn ugly, often with dire consequences.

Gordon Rodda, a University of Arizona biologist who spent 19 months studying iguanas on the Venezuelan plains, found that large, older males—dominant in iguana society—chase away their smaller, younger competitors during the six-week mating season that begins late in November. The smaller iguanas "try to hang around and sneak a copulation," Rodda says, but most of the time they are forced out of their home trees and into trouble.

When iguanas inhabit trees along a road—usually a single line of trees—the evicted males are "forced to cross the road to find a new place to live, something they otherwise wouldn't do," Rodda says. And that puts them squarely in the path of speeding cars.

The unusually heavy male road kill along with predators on the ground causes Venezuela's green iguana population to be "skewed toward females," Rodda says.

HERBERT LANKS, BRUCE COLEMAN INC.

National Geographic, December 1991

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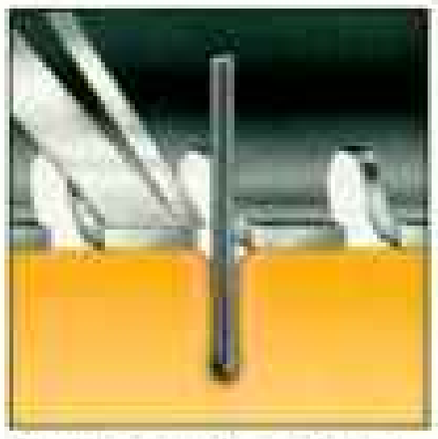

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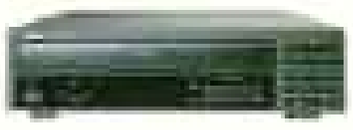

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STEVEN RUMPHREY

A Singing Champion for Louisiana's Isleños

Irvan Perez's boyhood on Delacroix Island south of New Orleans was so isolated that he spoke no English, only Spanish, until he began school. Now, six decades later, he struggles to keep alive the songs and Isleño dialect of his people, descendants of the 2,000 Canary Islanders who settled in the Mississippi Delta from 1777 to 1784.

Perez, one of 16 National Endowment for the Arts heritage fellows for 1991 (GEOGRAPHIC, January 1991), is a singer of *decimas*, ten-stanza narratives, some of which date back to 15th-century Spain.

In the past 50 years, electricity and roads have come to the delta. Many Isleños, longtime fishermen and trappers, have taken other jobs. But Irvan Perez is still seeking songs in the style he learned from his father and uncle. "I go from house to house; I pick up a piece here, a piece there, and before I know it, I've got most of a decima," he says.

Antarctica and North America: Long Lost Kin?

Imagine a world in which Antarctica sits near the Equator, attached to North America. That is exactly what two geologists have done in formulating a new theory on continental placement.

According to Eldridge Moores of the University of California, Davis, and Ian Dalziel of the University of Texas at Austin, the two landmasses may have linked up more than a billion years ago, joining other regions much later to form a Precambrian supercontinent (left, shown in its then inverted position).

"For a long time people thought Siberia was what had broken away from North America," says Moores, "but we put the pieces together differently."

Their research revealed that an ancient metamorphic rock formation known as the Grenville Belt, which starts in Quebec and runs into Texas, closely resembles rocks found on the margins of East Antarctica—possibly a continuation of that same belt.

When the two continents broke apart, roughly 600 million years ago, it opened a basin that would later become the Pacific Ocean. At that time, scattered fragments had not yet coalesced into the giant landmass we know as Eurasia.

Using Lasers to Build an 11th-century Viking

Meet Eymund (below), a Viking fisherman who lived—and died—near England's city of York.

No, he hasn't returned to life. His likeness is the result of traditional archaeology plus the use of lasers to create three-dimensional computer images (GEOGRAPHIC, June 1989).

Eymund's skeleton was one of some 130 found in 1986 by the York Archaeological Trust. Its Jorvik Viking Centre features a re-created street scene of the time Vikings ruled the city. The trust wanted the figures to look more like Vikings and less like 20th-century Britons, so they turned to techniques used by a London hospital to show patients how they'll look after facial surgery.

A sculptor based the model on a computer image created from an excavated skull. One problem: Eymund is so lifelike that he looks out of place in the exhibit. Others of his ilk will soon be created.

SIMON J. HILL, YORK ARCHAEOLOGICAL TRUST

If it had less legroo
and cost thousands mo

Logic would seem to dictate that when you pay thousands of dollars more for a car, you should get a lot more car. Apparently, in the case of the Cadillac Sedan DeVille versus the Chrysler Fifth Avenue, logic does not apply. Both cars provide ample room for six, air-conditioning, automatic transmission, automatic load leveling, stereo sound system, fully reclining seats, all as standard equipment. Both offer safety and performance. A driver's air bag is standard on the Chrysler Fifth

*Standard equipment levels vary. Legroom comparison to Cadillac Brougham.
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m, a lesser warranty, re, it could be a Cadillac.

Avenue, as is a powerful fuel-injected, 3.3-liter V-6. Anti-lock brakes are also available. Here, however, is where logic totally falls apart. The restyled Chrysler Fifth Avenue costs thousands less, yet it has more legroom than the largest Cadillac.* And it offers a better warranty: bumper-to-bumper protection for 5 years or 50,000 miles! So if you're looking for a great luxury car, defy logic. Pay less, get more.

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Geographica

SHAWN E. HENRY, USNA; NGS ARCHIVES (RIGHT)

Reunion Celebrates Sub's Historic Voyage

Around the world in 85 days? What's so remarkable about that? True, it did take Ferdinand Magellan's crew three years (1519-1522) to accomplish the first circumnavigation.

How about being the first to circle the globe underwater, nonstop, in a nuclear submarine?

Thirty-one years ago, as the U.S.S. *Triton* prepared for her epic voyage, the U. S. Navy called reserve Comdr. Joseph Baylor Roberts to active duty. The seasoned NATIONAL GEOGRAPHIC photographer was assigned to record life aboard the sub as it followed in Magellan's wake.

Joe Roberts was 58 at the time, definitely the oldest on board. So, when the *Triton*'s captain, Edward L. Beach, author of the November 1960 GEOGRAPHIC article describing the feat, heard about a reunion of shipmates to meet in Groton, Connecticut, this past August, he little dreamed that Joe would be there to join them.

But join them he did, still toting a camera around his neck at a vigorous 89. "I'm glad they didn't smear oil on my hair and shave a groove in it this time," Joe said, recalling his Neptune's initiation rite when he crossed the Equator underwater for the first time.

Suggestions for GEOGRAPHICA may be submitted to Boris Weintraub, NATIONAL GEOGRAPHIC magazine, Box 37357, Washington, D. C. 20038, and should include the sender's address and telephone number.

Observer Poised for Mapping Flight to Mars

It may be the most difficult map-making job ever undertaken. Next September, if schedules hold, NASA's Mars Observer spacecraft will begin an 11-month journey that will place it into orbit around Mars. Then, for one Mars year (687 earth days) beginning in December 1993, it will send back detailed data about the red planet's geology, atmosphere, and climate, which includes the seasonal advance and retreat of polar ice caps. This global portrait will include high-resolution images of scientifically important areas.

Mars Observer will be NASA's first mission to that planet since the two Viking landings in 1976 (GEOGRAPHIC, January 1977). "This is a geological and climatological mapping of the entire planet," says William Piotrowski, Mars Observer program manager. "Viking gave us detailed information about two points, but we don't know if the rest of the planet is like that. It's as if we had landed just in the Gobi or Sahara deserts on earth."

Mars Observer will send back data that can be used to help plan future robotic or manned landings on Mars. But, says Piotrowski, manned landings are a long way off; the main job for the $10-million-dollar spacecraft is to gather scientific information.

JET PROPULSION LABORATORY

A Hyena Mystery: Do They Kill Their Twins?

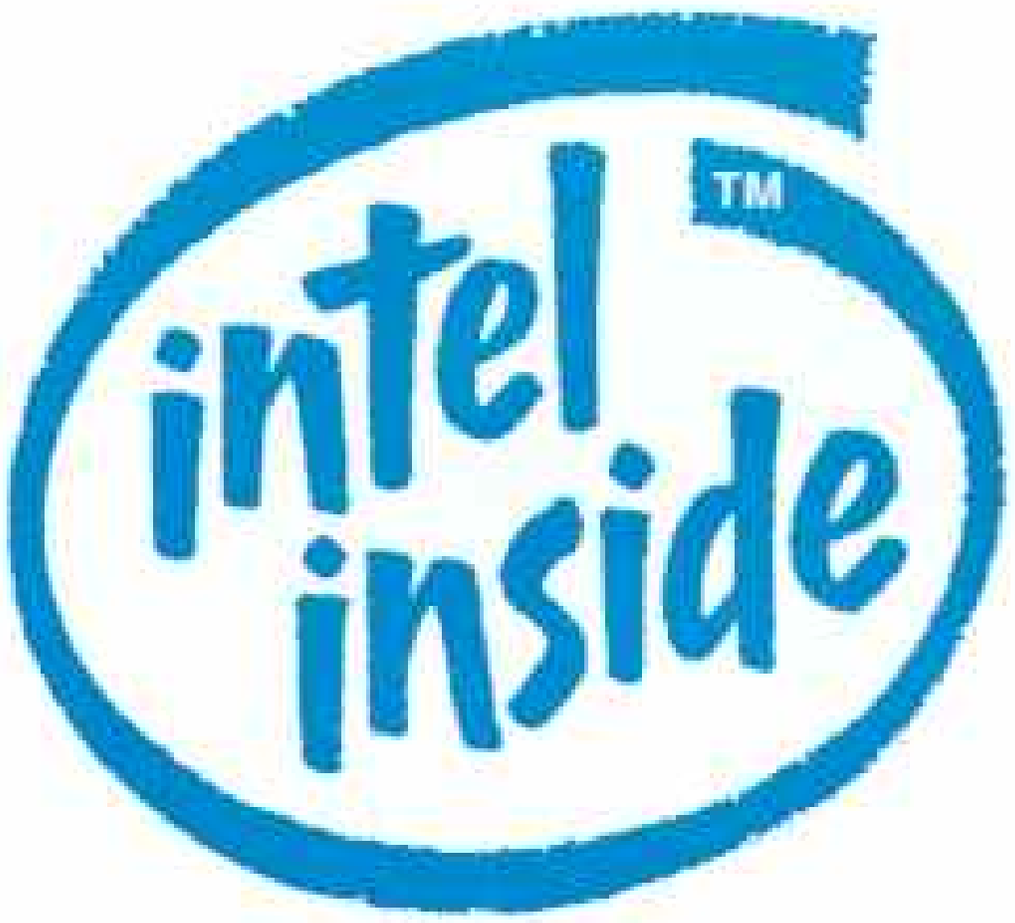
A fierce presence in sub-Saharan Africa, spotted hyenas are the most common large land predators. Aggressiveness starts early: They are born, often in litters of two, with fully developed canine teeth and a willingness to use them.

A University of California research group says that firstborn hyenas attack later arrivals of the same sex and prevent them from leaving their birth den to nurse, thus causing their death. If true, it is the first known case of habitual "siblicide" in wild mammals.

Zoologist Laurence Frank, who studied spotted hyenas in Kenya with support from the National Geographic Society, was puzzled to find so many singleton infants and mixed-sex pairs. When he located a rare same-sex pair, one newborn had bite marks and was emaciated while the other was "fat, happy, and vigorous." In a captive colony the group set up in California, he saw firstborns attack their twins. No hyenas died in captivity because all the infants were able to reach their mothers to nurse.

How to spot the

very best PCs.



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Forum

A Comeback for Nuclear Power?

The excellent article (August 1991) showed that although nuclear power has been stalemated by controversy, it is reckless to assume we can abandon this valuable energy source. As a recent study of the greenhouse problem by the National Academy of Sciences pointed out, conservation and new forms of solar energy are unable to replace fossil fuels as the major electricity source for this country. We need nuclear power to generate a substantial portion and to offer insurance against climate warming.

LYNN E. WEAVER, PRESIDENT
Florida Institute of Technology
Melbourne, Florida

Only a few sentences about nuclear waste in a 30-page article in no way reflect the magnitude of that aspect of the nuclear power debate. After four decades of splitting atoms, there is still no technology to neutralize the radiation hazard this garbage poses to generations yet unborn. If we don't know what to do with it, how can we justify creating such incredibly dangerous waste?

PAT NOWICKI
South Windsor, Connecticut

About 75 percent of Americans agree that nuclear energy "should" be part of our energy future. I think the power of the antinuclear groups to manipulate the regulatory and court systems has put electric utilities off ordering new nuclear power plants. Bills moving through Congress are expected to make the licensing process more rational.

THEODORE M. BESMANN
Oak Ridge National Laboratory
Oak Ridge, Tennessee

I was surprised that no mention was made of another nuclear power program, similar to the French one, that uses standardized reactors and superior manufacturing, training, and operating procedures. Over a hundred nuclear reactors power the superquiet submarines, gigantic aircraft carriers, and guided-missile cruisers of our United States Navy. It is one of the world's oldest nuclear power programs.

TODD F. BREED
Seabrook, Texas

During a cold spell in February 1989, 7,000 new energy-efficient homes and 237,000 weatherized older homes cut 200 megawatts of electrical demand in our area, preventing power shortages and expensive power purchases. With extra insulation, air-leakage control, and better windows, new homes built to model conservation standards used half the energy of houses built to minimum government specifications.

Under the guidance of the Northwest Power and Conservation Council, Idaho, Montana, Oregon, and Washington are weatherizing more existing homes, building energy-efficient new homes and commercial buildings, and retooling industries to save thousands of megawatts of generating capacity. All of this is cheaper than building nuclear or coal plants.

KEN W. EKLUND
Department of Water Resources
Boise, Idaho

More nuclear power is the wrong answer to the wrong question. The question that needs to be posed for "Our Electric Future" is "When are we going to start conserving power?" not "How are we going to generate more power?" A more responsible approach toward our energy use would make conservation a priority and ensure that the construction of new plants would be a distant last resort.

NICHOLAS KURZON
Cambridge, Massachusetts

The Persian Gulf: After the Storm

No one who views these photographs could hold to the outmoded belief that war is acceptable as a means of resolving conflict. The environment was not the only casualty. Harvard public health experts estimate that an additional 175,000 Iraqi children will die within the year of cholera, typhoid, and malnutrition. Our military victory is a moral tragedy.

ANN MARIE JUDSON
Lemoyne, Pennsylvania

One man, Saddam Hussein, was responsible for this jab in our collective eye. His name was mentioned only twice in the article. As long as madmen like this exist, wars will be fought to stop them.

RICHARD T. COYNE, JR.
Leesburg, Florida

I was angered by the slant of reporting, which characterized the Iraqis as "wanton" and "so barbaric as to defy understanding," while virtually ignoring the devastation to the earth and human life caused by more than 85,000 tons of allied bombs. To ignore the deaths of thousands of Iraqis while lamenting the deaths of Kuwaiti zoo animals is unconscionable.

BRENDA FUNK
Lawrence, Kansas

You omitted an ominous consequence of the war: higher carbon dioxide levels and an amplified

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Whether discovered on Valentine's Day or any other day, a diamond remains the ultimate symbol of love.

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greenhouse effect. A recent report by the British Parliamentary Office of Science and Technology says the CO_2 emissions over Kuwait could reach 227 million tons over the next two years, corresponding to a 4 percent rise in global CO_2, a major greenhouse gas.

NATHANIEL MEAD
Blounts Creek, North Carolina

An article to be published in the GEOGRAPHIC early next year will give an update on the environmental situation in the Persian Gulf.

National Park Service

"The Best Idea America Ever Had" is quickly becoming the biggest headache America ever had. Park Service employees may be dedicated, but, as stated, they are unable to properly maintain the parks in their care. Yet in 1991 alone the Park Service has an appropriation of 103.6 million dollars for federal land acquisition. If the service cannot take care of what it owns, why is it purchasing more? When the government purchases land, the local tax base needed to sustain schools and services is destroyed.

BARBARA LABARBARA
Sacramento, California

We taxpayers take for granted all the services available in our national parks. On a trip to Manassas Civil War battlefield my cousin and I decided to retrace our grandpa's adventure when he was a 16-year-old private in the 82nd Ohio Infantry. A kind park ranger was able to place us within a hundred yards of where our grandpa's ankle met with some Confederate fire.

RANDY MAST
North Royalton, Ohio

Regarding your map of National Park Service sites: On June 24 the U. S. House of Representatives voted to remove George Armstrong Custer's name from the Montana battle site and rename it Little Bighorn Battlefield National Monument. This will be a fitting, long-overdue memorial to the Native Americans who also fought and died in the attempt to preserve a way of life.

MONICA ALEXANDER
Pittsfield, Massachusetts

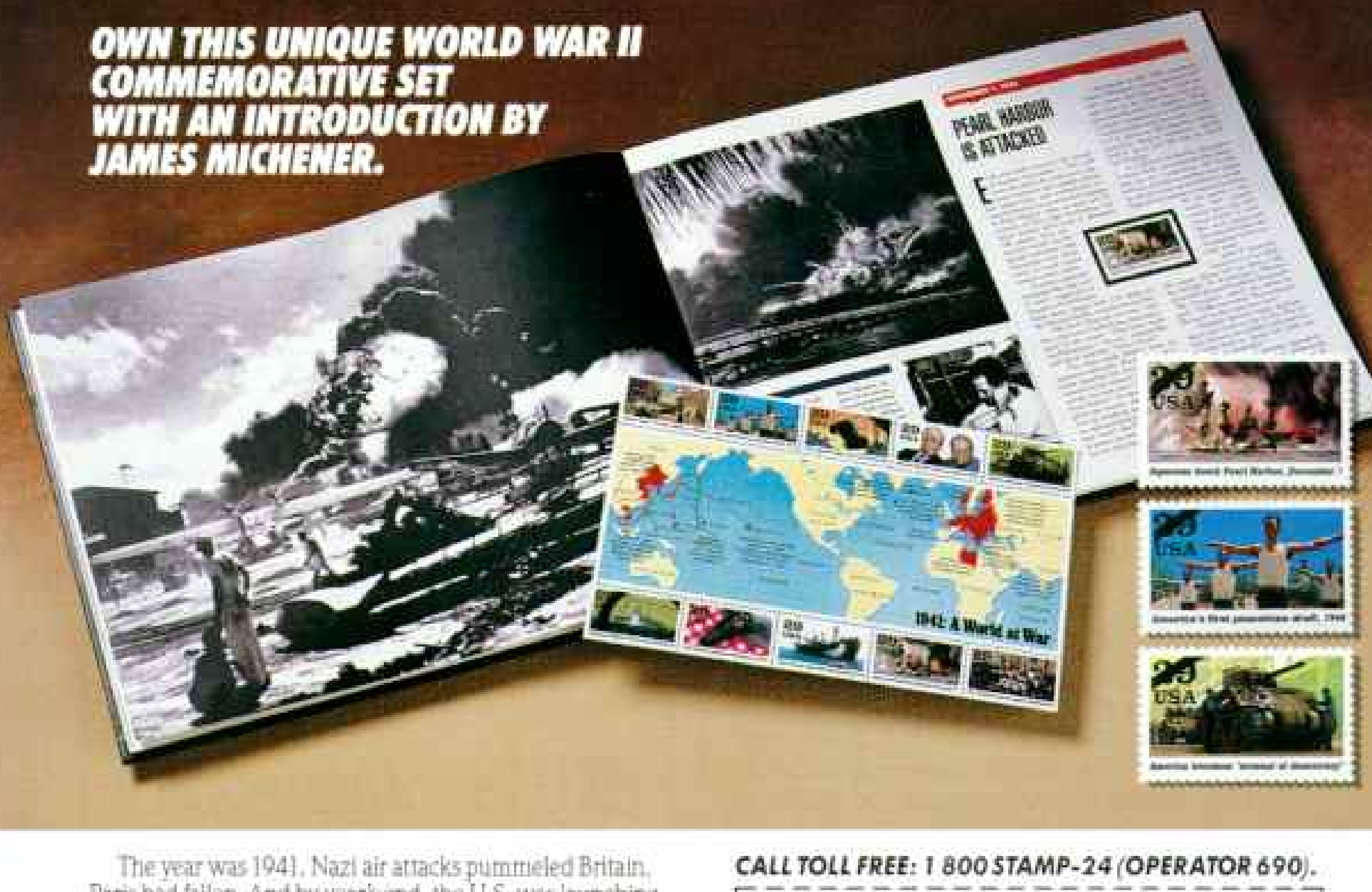
Cuba

As a Cuban and a geographer who in 1980 escaped in a boat, I praise your article, except for a few comments. The total lack of freedom is what is moving us to risk and lose our lives. It is not the economical or political limitation, as Peter White stated. Castro will never accept the option of a referendum, free elections, or a plebiscite, because he will lose against democracy. He knows that, and he remembers Nicaragua's example very well.

MOISES GOLOBOVICH
Miami, Florida

50 YEARS AFTER WWII, THE MEMORIES ARE AS POWERFUL AS THE EVENTS.

OWN THIS UNIQUE WORLD WAR II COMMEMORATIVE SET WITH AN INTRODUCTION BY JAMES MICHENER.



The year was 1941. Nazi air attacks pummeled Britain. Paris had fallen. And by year's end, the U.S. was launching the most powerful fighting force in history.

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Peter White seems to have picked up on many of the shortages that the Cuban people endure. Inexplicably, he missed the most obvious: the shortages of liberty, information, and free choice.

LORENZO PÉREZ
Miami, Florida

After serving as a Peace Corps volunteer in the Dominican Republic, I have often compared the different paths of the two Caribbean neighbors. The democratic and market-oriented Dominican Republic does not come close to matching Cuba's high marks in literacy, life expectancy, and infant mortality. Free election and market-oriented policies in the Dominican Republic have not kept that nation from experiencing population flight as desperate Dominicans continue to cross the treacherous Mona Passage to Puerto Rico.

JOHN M. STEVENS
Tucson, Arizona

White could also have mentioned the fine buildings constructed for the Pan Am Games, some of the world's best beaches, and the warm hospitality of the people.

DANIEL J. MCVICAR
Antigonish, Nova Scotia

L'Enfant's Washington

The reproduction of L'Enfant's 200-year-old map is indeed ingenious and amazing. I think the article would have been more complete if a portrait of the genius engineer L'Enfant had also been included.

OSWALDO A. CASUPANG
Jersey City, New Jersey

The silhouette on page 122 is the only known likeness of L'Enfant.

Another copy of the original L'Enfant map was made in 1887 by the U. S. Coast and Geodetic Survey. My grandfather, B. A. Colonna, as assistant in charge of topography, was responsible for this tracing. The draftsmen had to use sunlight, mirrors, and magnifying glasses as the original had been mounted on cloth and varnished and was almost indistinguishable. Copies of this tracing are still sold by the National Ocean Service.

ELLEN BRITTON
Princess Anne, Maryland

The citizens of Belo Horizonte, Brazil, believe L'Enfant laid out their beautiful city. Why wasn't this mentioned?

R. B. MEARS
Oakmont, Pennsylvania

Brazil's third largest city, Belo Horizonte was modeled after L'Enfant's plan of Washington, but a century later.

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Forum

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And it's why we plow GM four-wheel-drive systems through tons of mud to stress them to the limit. It's one reason why GMC Trucks and Chevy Trucks have delivered higher resale value than any truck over the past 12 years.

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Even as you read these words, someone, somewhere on this planet, will be venturing into the unknown.

The equipment they will have chosen to accompany their adventure will have been selected with the utmost care; their reliance on it will be total.

Yet the chances are that one of the most vital things they take along will be on their wrist.

A Rolex Oyster timepiece.

The Oyster case has been created to provide absolute protection from the elements. Increasing water pressure will only serve to improve the efficiency of the seal between crystal and case, and the winding crown screws down to close as securely as a submarine hatch.

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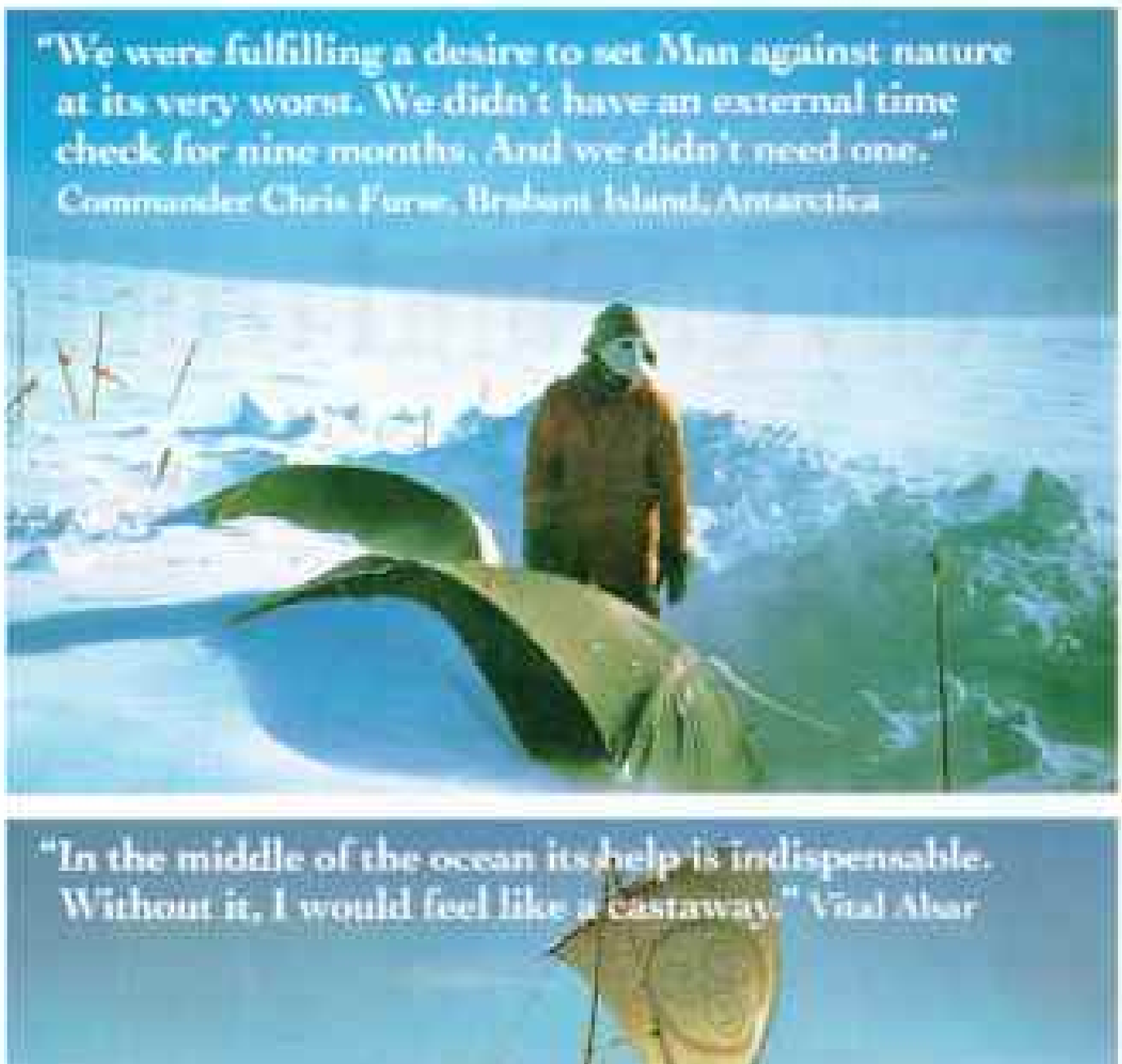
Somewhere underwater – it could be deep beneath the North Sea oil rigs or exploring a shipwreck entombed below the Arctic ice – divers will be relying on their Rolex to tell how many precious minutes of dive time remain in their tanks.

Yet it is not only underwater where survival can depend upon a Rolex.

Somewhere in the world – in dense jungle, or the baking desert, or polar wasteland – an explorer could even now be navigating by dead reckoning. For this task, an utterly reliable timepiece is essential.

The sheer ability of a Rolex Oyster



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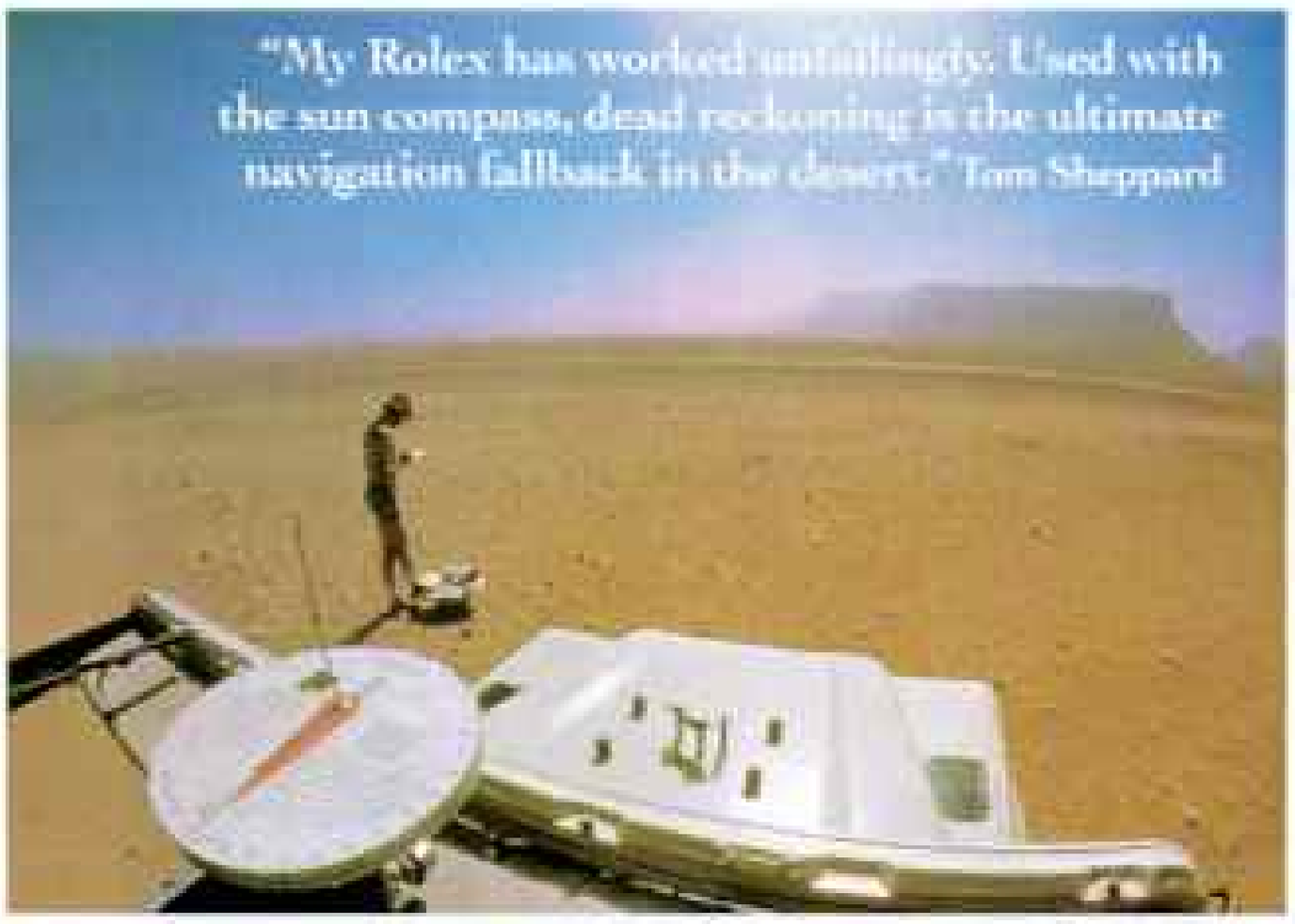

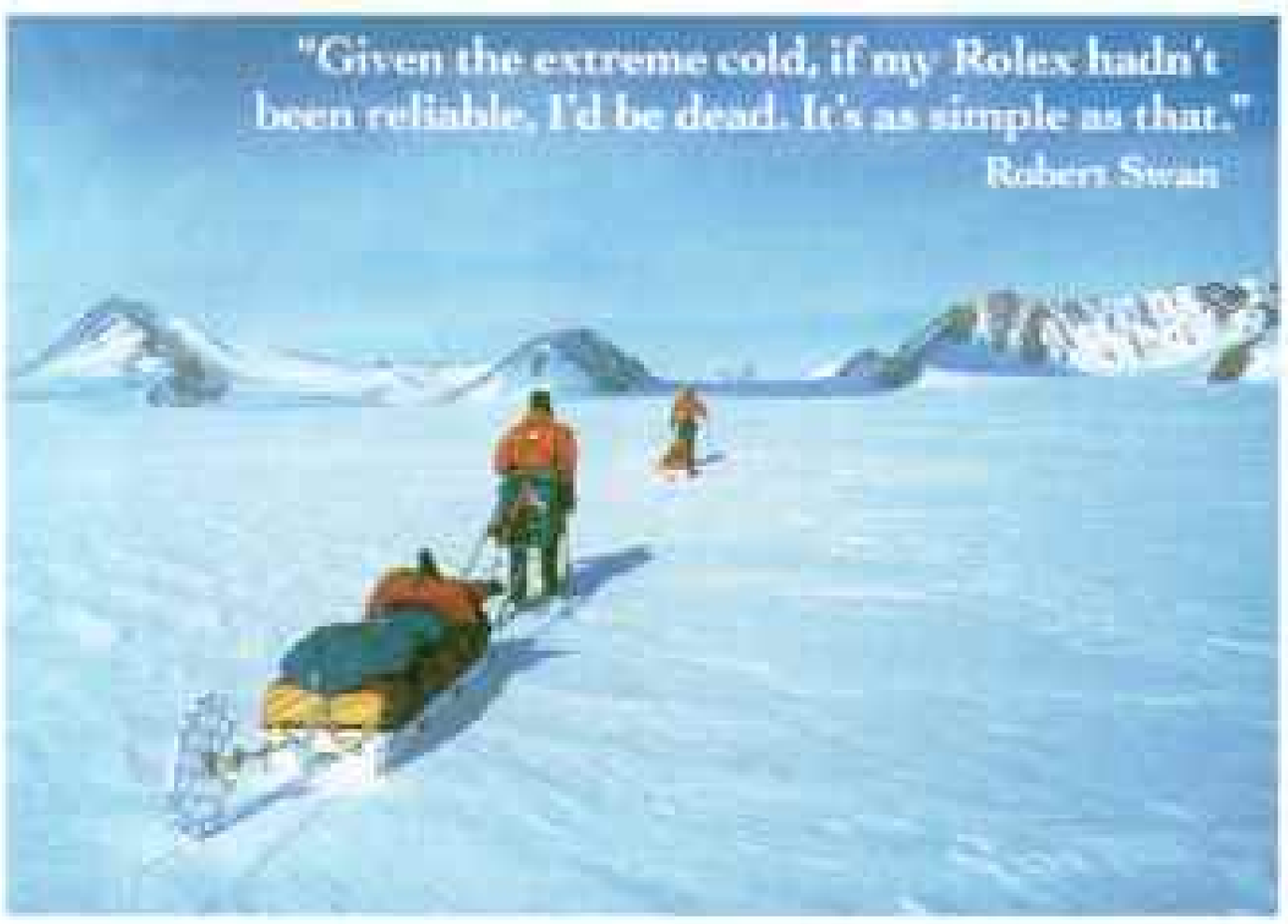

than tell you the time.

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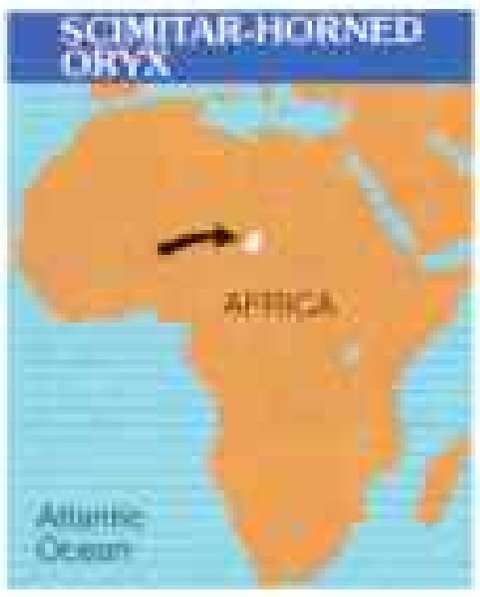

Scimitar-horned Oryx

Scimitar-horned Oryx
Genus: *Oryx*
Species: *dammah*
Adult size: *Shoulder height, 100-125 cm*
Adult weight: *100-200 kg*
Habitat: *Arid grasslands in Chad*
Surviving number: *Less than 200*
Photographed by Alain Dragesco

A lone scimitar-horned oryx appears on the horizon, like a specter in an inhospitable land. Just 30 years ago, thousands roamed the vast sub-Saharan grasslands, but relentless hunting, drought and lack of protection have driven the oryx to near extinction. Ancient petroglyphs found in the mountains of the Sahara may one day be our only reminder of this majestic antelope. To save endangered species, it is essential to protect their habitats and understand the vital role of each species within the earth's ecosystems. Color images, with their unique ability to reach people, can help promote a greater awareness and understanding of the scimitar-horned oryx and our entire wildlife heritage.

NATURE

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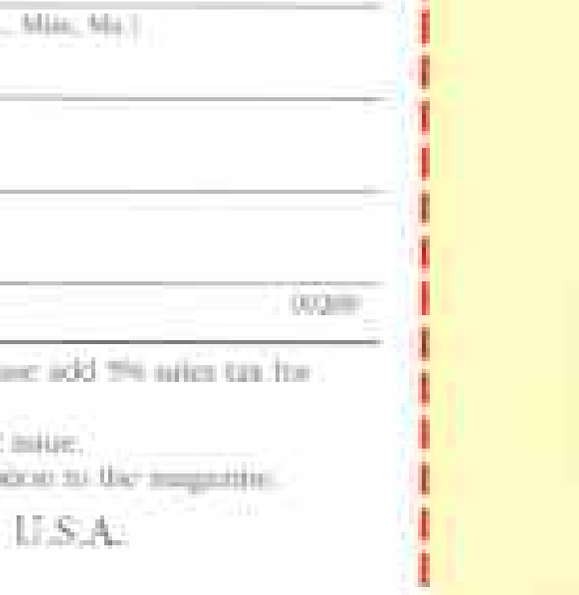

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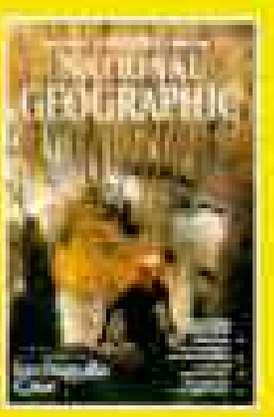
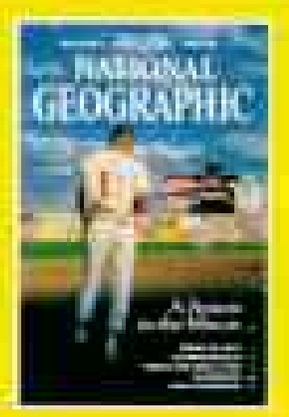


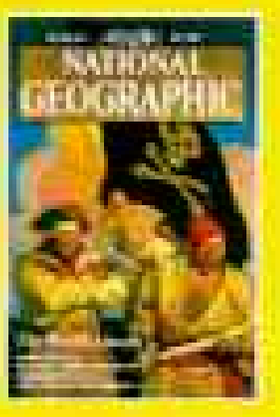
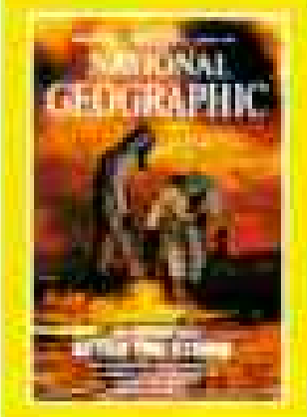
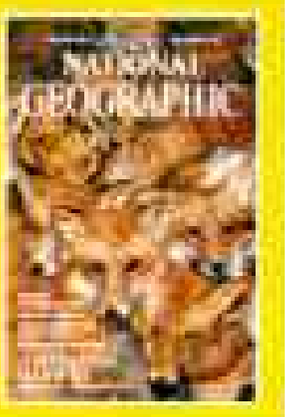


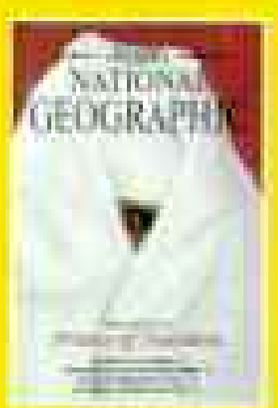

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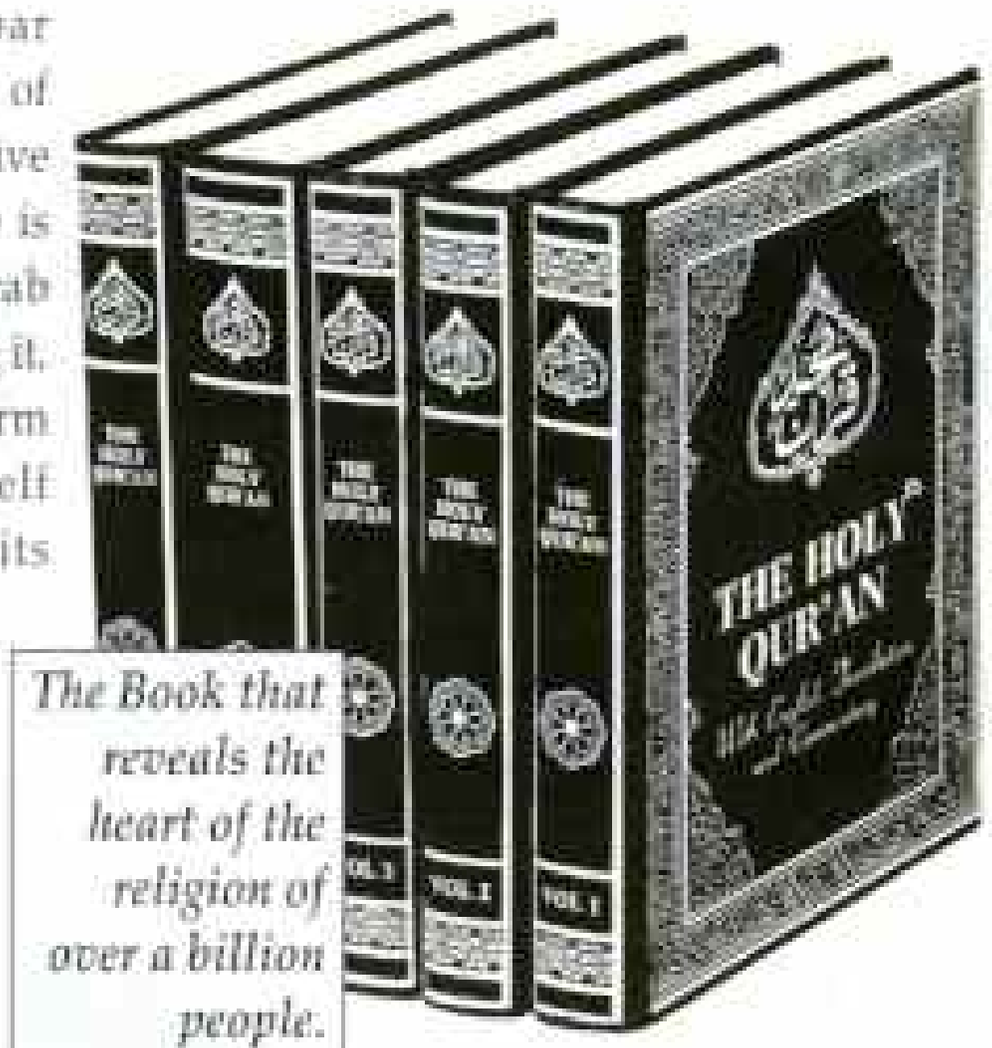

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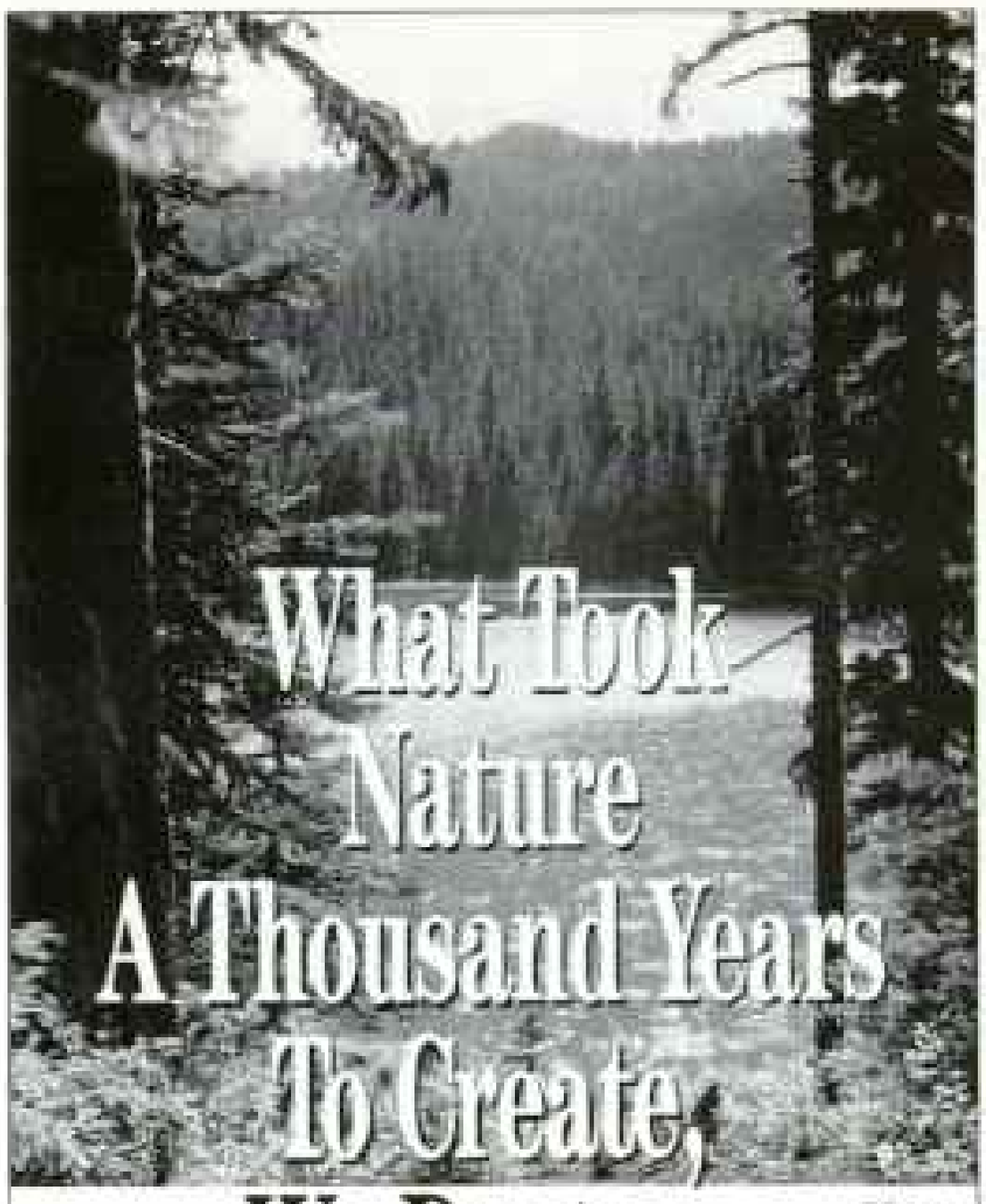

We Destroy In A Single Day

This ancient forest was standing tall long before the voyage of Columbus. Majestic trees like these could be found across the continent. Now they are reduced almost exclusively to small scattered pockets on public lands in a few states in the Pacific Northwest. Once cut, they can never be replaced. Never.

During the next few months, the White House and the Congress will be deciding on the fate of most of the remaining old-growth forests in the U.S. Now is the time for Americans to speak out against the senseless destruction of one of our most priceless natural resources. If the cutting does not stop, in a few years, most of the remaining ancient forests will have vanished forever.

Our ancient forests provide clean air, fresh water, and natural habitat for many rare wildlife species. Can human-kind afford to ignore these vital interests?

The Wilderness Society believes that the short-term gains of the timber industry should not supersede the long-term interests of the American people. Please join our dedicated team of ecologists, economists, and foresters in waging this crucial battle. For more information, or to send a tax-deductible contribution to our Ancient Forest Protection Campaign, write to The Wilderness Society today.

The Wilderness Society 900 17th Street, N.W., Washington, D.C. 20006
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While no one can erase the horrible pain Ginger felt, we can make sure this abuse never happens to another defenseless animal. Please, won't you send a donation to further our work? This year we hope to place close to 2,000 animals like Ginger in good homes, but we need your help for all the other orphans who wait at our shelter—hoping and longing for someone to take them home.

For a gift of $100 or more, you will receive a "Certificate of Kindness." It is 8"x10", is suitable for framing, and has the "Prayer for Animals" by Dr. Albert Schweitzer. A $100 gift will provide veterinary care and a week's stay at our shelter for one needy dog or cat. It will buy a week's supply of food for our orphans. THANK YOU.

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□ $10 □ $20 □ $25 □ $50
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Earth Almanac

Freeloading Caterpillars Masquerade as Ants

There is an air about the caterpillars of some European large blue butterflies that certain ants find irresistible. A deceptive chemical odor apparently convinces the ants that the caterpillars are long lost kin. The ants take them home, and the adopted caterpillars then make a meal of the ants' own young.

Tumbling from plants into the foraging area of their main hosts, *Myrmica* ants, the caterpillars secrete the same recognition chemicals as ant larvae, according to Jeremy Thomas of Britain's Institute of Terrestrial Ecology. The ants soon

J. A. THOMAS

discover the caterpillars and haul them back to their nest.

Once inside, the party starts. One primitive caterpillar species simply devours the ant larvae. But a second, more advanced type rears up like an ant grub to be fed by workers (above). Large blue butterflies, all endangered by habitat loss, can use such an advantage.

New Airport Versus Blue Coral—Fatal Impact?

Perhaps the world's largest and finest colonies of blue coral grace Pacific shallows off Japan's Ryukyu Islands. Named for its naturally blue skeleton, the coral (top) continues to weather a storm of controversy over an airport that could ruin the reef.

HELIOPORA COERULEA; TOMIO KOBAYASHI&AWA

To boost tourism, the government announced plans in 1979 for a new airport on Ishigaki Island big enough for jumbo jets. But runway fill would have buried part of Shiraho Lagoon, along with its giant stands of blue coral. Shiraho villagers opposed the scheme and were soon joined by the International Union for Conservation of Nature and Natural Resources, Friends of the Earth, and other groups.

In 1989 officials moved the proposed airport site—but only 2.5 miles north. Now other alternatives are being explored, including building the airport wholly on land. "Runoff and sedimentation would still destroy the reef," coral biologist Katherine Muzik says. "Blue coral is only one of more than 130 species here. The diversity is what makes this healthy reef so important."

Eagle-eyed Snowy Owls Help Clear Runways

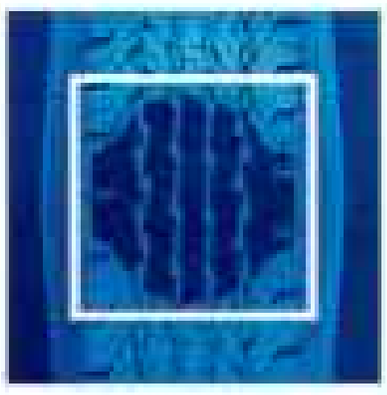
Flocks of birds are unwelcome airport visitors that can be sucked into a jet engine and cause a catastrophe. At Boston's Logan International Airport natural security agents—snowy owls—help police the runways. Their presence as feared predators reroutes potentially dangerous flocks of snow buntings or starlings.

From summer homes on Arctic tundra, the owls migrate south during fall. A goodly number stay at Logan until April. "I think the 1,800 acres of mowed grass make the owls think, 'Gee, this looks like home,'" says Norman Smith of the Massachusetts Audubon Society. He adds that 23 snowy owls once staked out the airport at the same time.

NORMAN SMITH

National Geographic, December 1991

WE'VE GONE TO THE ENDS OF THE EARTH TO HELP YOU SURVIVE A TRIP TO THE MARKET.



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Goodyear Wrangler radials are a tough, steel-belted family of durable radials that really get around. On highway. And off.

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GOODYEAR

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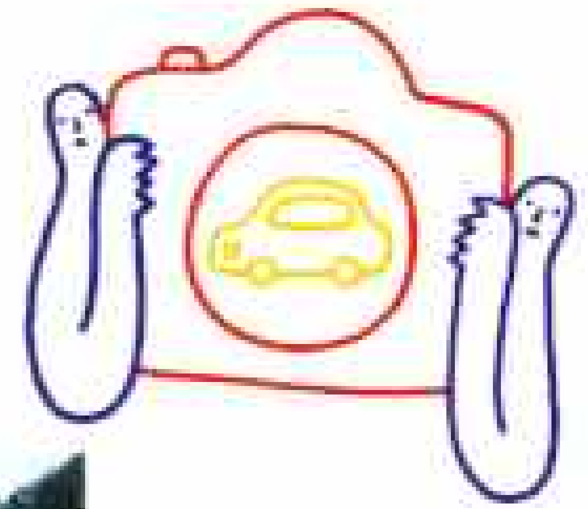
Announcing the Winners of the Mazda Photo Contest '92

Presenting what happens when those inspired behind the wheel get behind a camera.

Judging from the entries we received, there are a lot of inspired Mazda drivers that have become skillful Mazda photographers. Congratulations to the 15 first prize winners and the 45 second prize winners. And a hearty thanks to all those who made this photo contest such an inspiring experience for all of us.



First Prize Winners


Ashley de Fraser *(Australia)*


Dr. Peter Randell *(Australia)*


Tony McDonough and Annaliese Frank *(Australia)*


Adolf Blum *(Austria)*


Erik Mathiesen *(Denmark)*


Henning Sorensen *(Denmark)*


Pourcelle Marc *(France)*


Reinitraut Semmler *(Germany)*


Nuno Filipe Serrano *(Portugal)*


Damrong Juntawonsup *(Thailand)*


Santi Panggaibul *(Thailand)*


Joe Livermois *(USA)*


Nick Galante *(USA)*


Sonny Robinson *(USA)*


Stephen S. Weygandt *(USA)*

Second Prize Winners

Bob Bell *(Australia)*
Sue Pingel *(Australia)*
Hecher Hubert *(Austria)*
Jens Ellensohn *(Austria)*
Johann Frank *(Austria)*
König Jürgen *(Austria)*
Michael Schachenhuber *(Austria)*
Rath Elfriede *(Austria)*
Resch Helmut *(Austria)*
Rafael Yip *(Canada)*
Bain Ackerman *(Canada)*
Bob Smith *(Canada)*
William Zierhofer *(Canada)*
Germán A. Jiménez Castro *(Colombia)*
Bo Nielsen *(Denmark)*
Carsten Meldom Madsen *(Denmark)*
Jørgen Lund Truelsen *(Denmark)*
Vagn Sangill *(Denmark)*
Dingo *(France)*
Guery Marie-Christine *(France)*
Merlet Marcel *(France)*
Burkhard Hillert *(Germany)*
Krause Kerstin *(Germany)*
Ling Mo-sze, Monica *(Hong Kong)*
Clifford Hutchinson *(Ireland)*
John J. Honny *(Ireland)*
Anthony Borg *(Malta)*
Gino Galea *(Malta)*
Khin Than Shwe *(Myanmar)*
Mg Mg Hla Tint *(Myanmar)*
Tin Moe Hlaing *(Myanmar)*
John King *(New Zealand)*
Peter Bonner *(New Zealand)*
Rocky Roe *(Papua New Guinea)*
Jitapron Kitpermpool *(Thailand)*
Nopawon Tripob *(Thailand)*
Pakdi Atisingha *(Thailand)*
Tepchai Arreabhandha *(Thailand)*
Weerapan Chaikere *(Thailand)*
Süleyman Iskender *(Turkey)*
Cliff Fraliner *(USA)*
Jeffrey D. Cummer *(USA)*
Jon Steinbring *(USA)*
Seidl Helmut *(USA)*
B S Oulton *(Zimbabwe)*

Let's focus on '93.

Next year, we'll be looking for further photographic inspiration. Anyone can enter. So set up your camera, focus on a Mazda and shoot.

mazda

Earth Almanac

KEVIN FLEMING

DARRELL WONG, ALLSTOCK

Landmark Everglades Pact Targets Farm Runoff

Drained for development, canalized and straightjacketed to suit human needs, Florida's Everglades have been abused for decades (NATIONAL GEOGRAPHIC, July 1990). But a complex agreement involving state and federal governments will improve habitat for creatures like egrets (above right) by providing a natural filtration system to clean up pollution from farm runoff.

South of Lake Okeechobee in the 450,000-acre Everglades Agricultural Area, phosphorus is the issue. The Everglades' rich muck soil is naturally high in phosphorus. When the marsh is drained to grow crops like sugarcane (above) and vegetables, the soil oxidizes, adding phosphorus to runoff that enters remaining marshland. Environmentalists say the nutrients cause cattails and other plants to crowd out native saw grass.

"There have always been isolated patches of cattails. But when the natural balance is disturbed, they can dominate thousands of acres," says Tom MacVicar, South Florida Water Management District deputy executive director. An ambitious, costly plan to reduce phosphorus by 80 percent calls for the state to convert 35,000 acres of farmland back to marsh. This buffer zone would absorb phosphorus before it reaches state-owned water conservation areas just north of Everglades National Park. Farm groups challenging the agreement deny that runoff harms the Everglades.

Cubans Pump Pedals to Save at the Pump

"*¡Atención! Ciclos en la Vía*—Caution! Cycles on the Road." All over Cuba the signs are going up. From an energy standpoint, Fidel Castro's revolution is going in circles.

Only a few of Havana's two million residents used bicycles last fall, when Castro announced a new austerity program, partly triggered by the Soviet Union's decision to slash oil deliveries by nearly a third. Gasoline was rationed to about 15 gallons a month for each car owner.

Enter the nonconsuming, nonpolluting bicycle. The government has bought about 700,000 from China—heavy models with no gears—and another 100,000 from the U.S.S.R. Workers pay more than half the average monthly salary, yet sales have been phenomenal. Cuban factories are gearing up to turn out 500,000 bikes a year. Next summer a million ciclos may be wheeling around Havana—compared with an estimated 150,000 private cars in the entire country.

KEN REGAN, CAMERA FIVE

National Geographic, December 1991

Your one-year-old's
not be all they're going
she has a handle on this
she's really, really,
cabinet

She's also fairly adept at unscrewing tops and opening lids. In other words, there's no end to children's curiosity or their resourcefulness. And, in turn, the dangers they can create for themselves.

This is especially true when it comes to household chemicals. Which is why we'd like you to take a few simple precautions to keep your child away from them.

1. Store all potentially harmful substances-bleaches, detergents, spot removers, pesticides - out of the reach of your children. In fact, simply taking hazardous materials out of sight could eliminate up to 75% of all poisoning in small children.

2. Childproof those cabinets within their reach with safety latches. You can find them in most hardware stores for about a dollar.

3. Don't take potentially harmful substances out of their original containers. That label is, after all, your quickest and clearest source of information about the nature of the product and the safest ways to use it.

4. And while we're on the subject, why not take the time to read all the chemical labels in your home.

5. If you have questions concerning any of these chemicals, our Chemical Referral Center at 1-800-262-8200 will put you in touch with people who can best answer them.

language skills may to be, and she's not sure walking thing yet, but good at opening doors.

6. So you'll always be prepared, look in your local telephone directory and note the number of the nearest Poison Control Center.

All this may seem deceptively simple. And it is. So why not take a few moments and make your home safer?

We'd also like you to know what the chemical industry is doing to produce, transport and handle chemicals more safely. Just call 1-800-624-4321 and we'll send you our Responsible Care® brochure.

The Chemical Manufacturers Association.

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1

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To keep you in touch with your family and the world, we'll give you a factory-engineered cellular phone at no extra charge.†† And while you may never need roadside service, we'll make sure it's available to you with a special 4 year/40,000 mile plan.††† It provides 24-hour toll-free assistance and more at no extra charge. Even if you're locked out or you've just run out of gas.

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Plymouth Voyager LX

Dodge Caravan ES

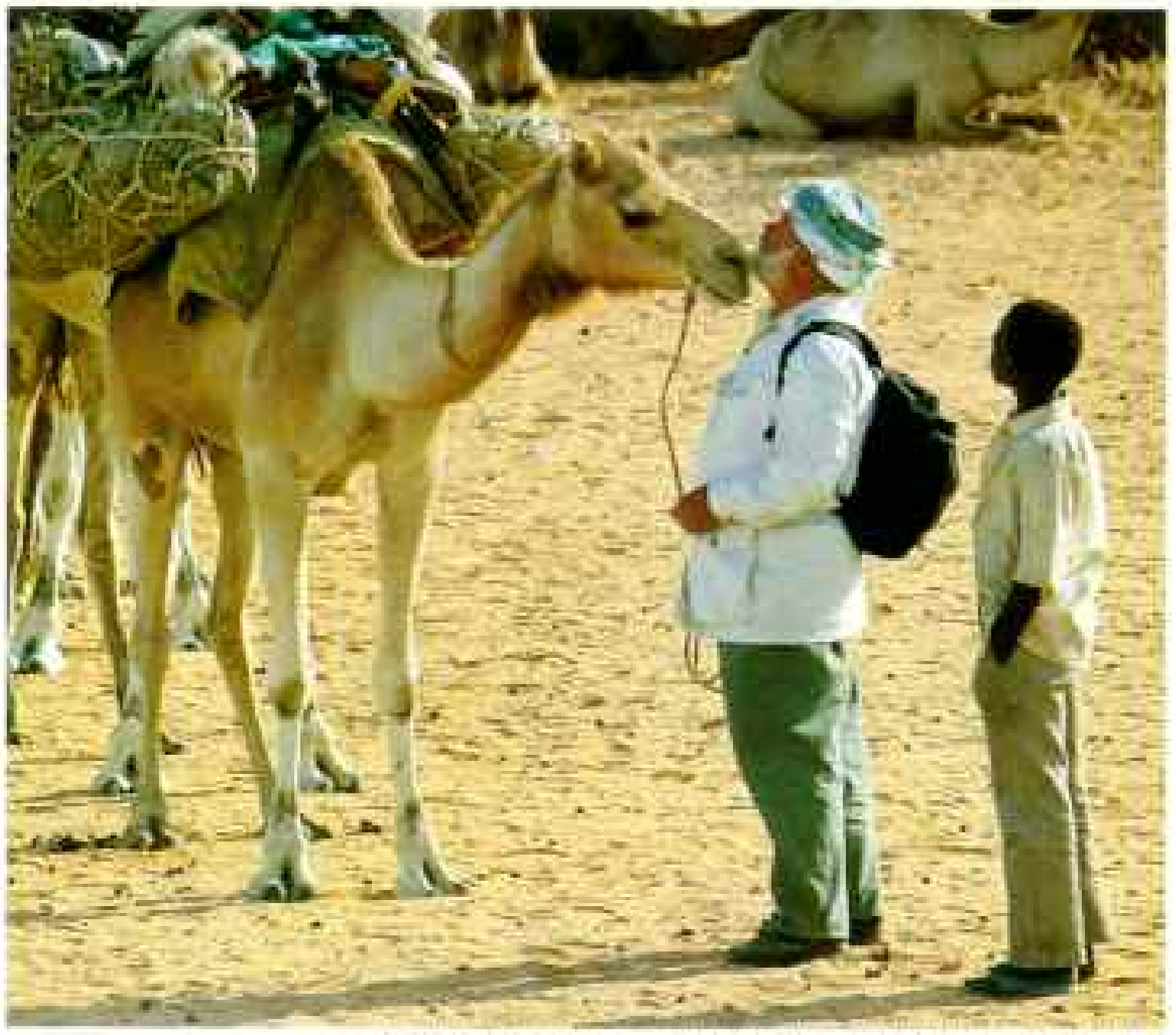
On Assignment

"I'm sure if Ibn Battuta were around today, he'd be working for NATIONAL GEOGRAPHIC," says senior writer TOM ABERCROMBIE. And who better to track the medieval traveler's tireless exploits than two of our most traveled staff members—Tom (right), turbaned and nuzzling a camel in the Sahara, and photographer JIM STANFIELD, clowning at a remote road sign near Timbuktu in Mali.

The two have nearly 60 years of combined GEOGRAPHIC experience (Tom with 35, Jim with 24), but this was their first assignment together. Their paths originally crossed, however, in the 1950s in Wisconsin, where Abercrombie worked with Jim's father and uncle on the photo staff of the *Milwaukee Journal*. "I grew up with Tom's name around the house," says Jim, who followed him to the *Journal*, then to the NATIONAL GEOGRAPHIC. "Tom has been the one person on our staff I've always wanted to work with."

Tom has specialized in the Middle East, learning Arabic and converting to Islam. In an odd footnote to that full career, he once happened across a half dozen of his photographs reproduced in a new medium—the currency of Yemen.

Jim's drive to take pictures of places that people don't know much about and his talent for breathing life into bygone civilizations were powerful spurs in the Ibn Battuta coverage. Little-known beyond the Islamic world, the 14th-century Moroccan's tale was worth telling, Jim says, as "a way of educating people so they realize there was someone other than Marco Polo."



PHOTOGRAPHS BY JAMES L. STANFIELD (ABOVE) AND THOMAS J. ABERCROMBIE

ROBERT LUSCOMBE

"Shooting Pittsburgh was like coming full circle," says NATHAN BENN, setting his camera aside after 18 years as a contract photographer for the GEOGRAPHIC. "When I was growing up, W. Eugene Smith, who did a pivotal photo essay on the city in the 1950s, was my hero. It's only right that this is my last assignment, at least for the foreseeable future."

In a heat-resistant suit (far right), one of many guises a photographer must put on, Nathan documents a day in a steel plant: "My work has been a passport to enter the lives and cultures of others."

Nathan has co-founded a company to combine electronic media with archiving, distributing, and licensing still images. "Curiosity has been my main motivation," he says, "and this new venture is an extension of it."

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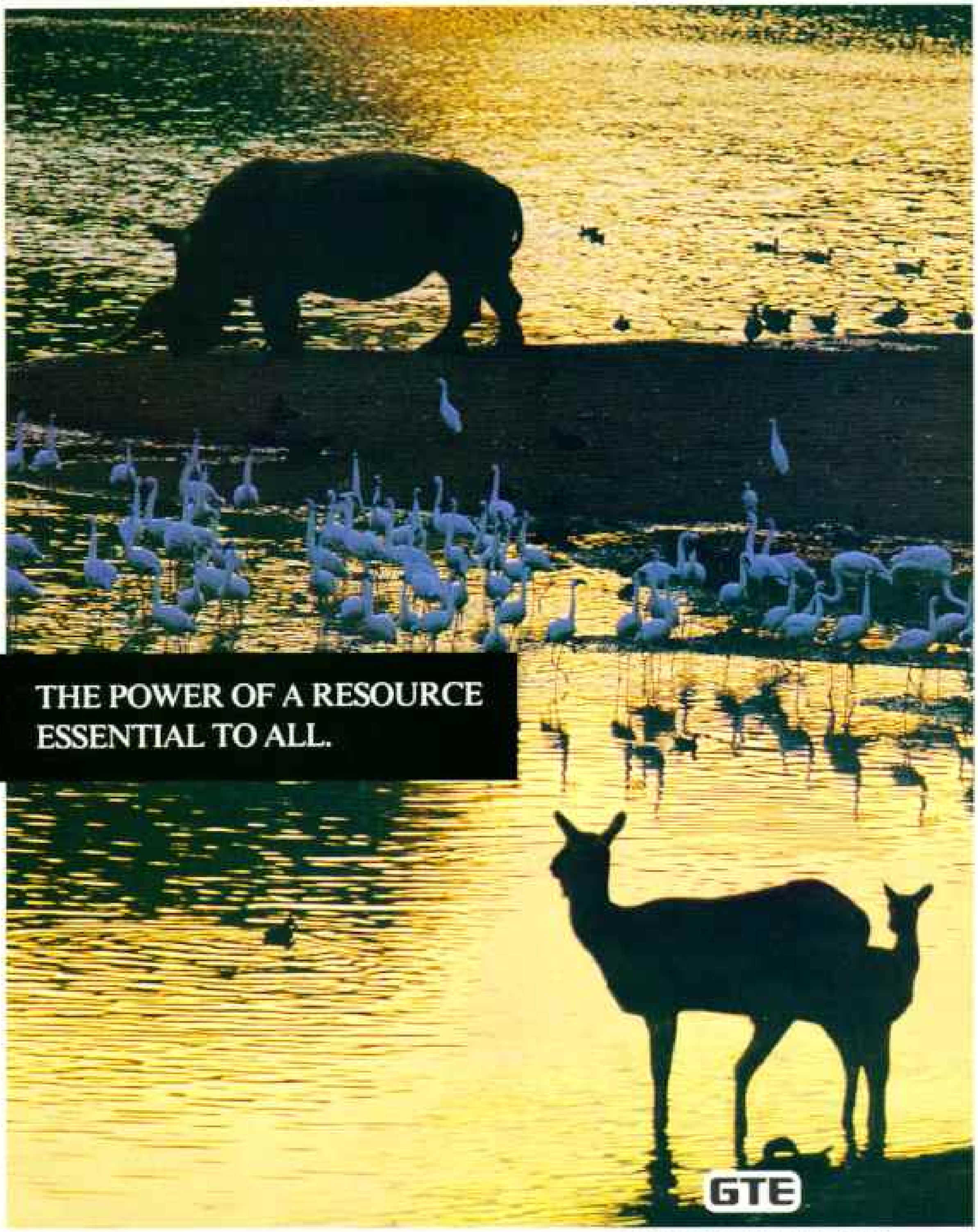

THE POWER IS ON