DOUBLE MAP SUPPLEMENT: PEOPLES OF SOUTH ASIA

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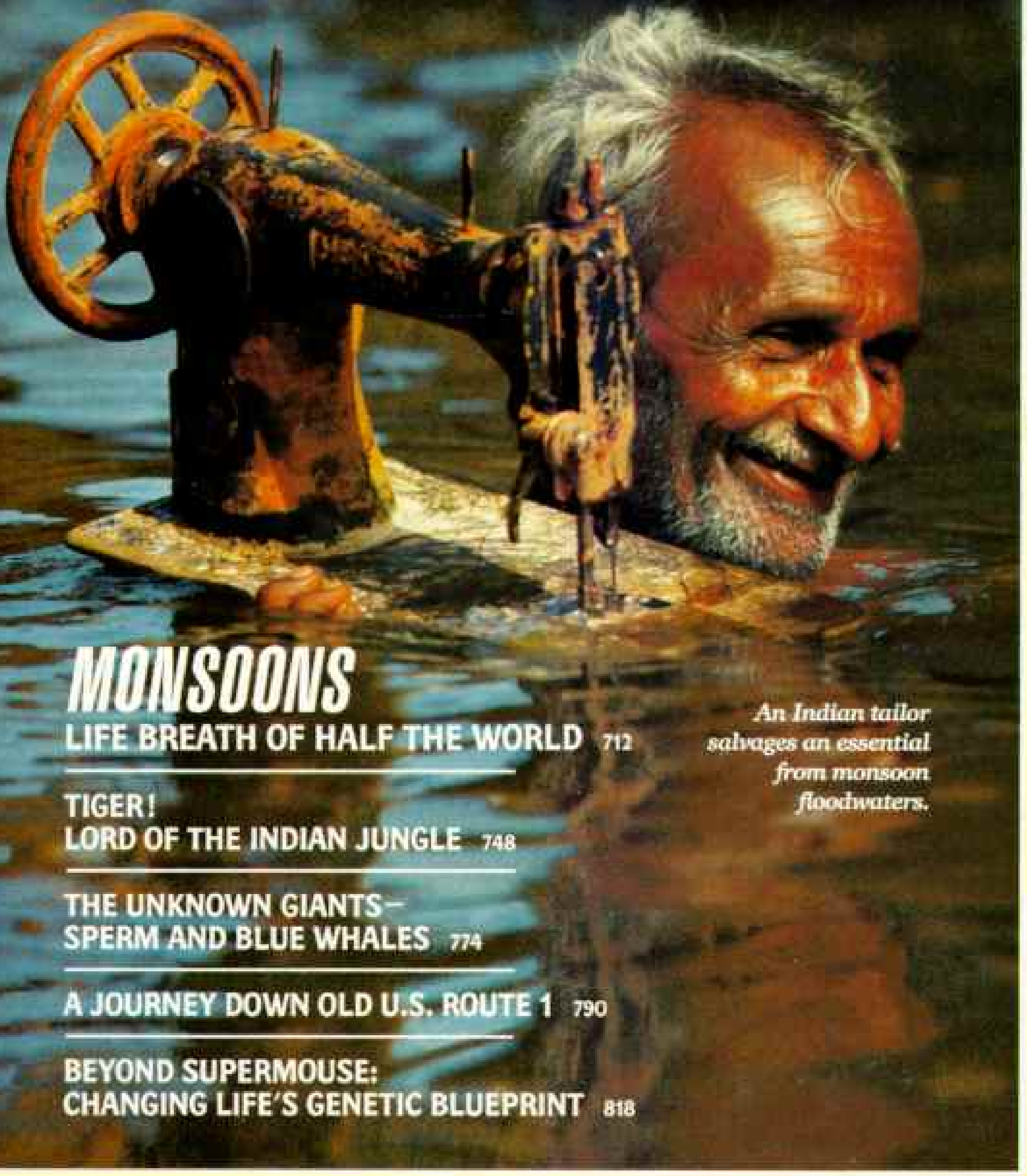

MONSOONS
LIFE BREATH OF HALF THE WORLD 712

An Indian tailor salvages an essential from monsoon floodwaters.

OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY WASHINGTON, D.C.

THE SIGN SAID we were entering the highest road in the world. We probably were, since it would lead us through 20,000-foot mountain passes. But—more important—it was taking us to a war between the two most populous nations on earth.

It was Christmas Eve 22 years ago. There was no single bright star in the east this night. They were all brilliant and unblinking. Their light passed unfiltered through the thin, dry, numbingly cold, high Himalayan atmosphere to cast a gray glow on the treeless, moonlike landscape. For the right to claim and occupy bits of this desolate, poorly surveyed mutual borderland, India and China were engaged in a brief, bitter, undeclared war.

For five weeks I had been with the Indian Army at the two major points of fighting—in Ladakh in the west and along the northeast frontier. I was learning firsthand how serious border disputes can be. The war soon ended, but the bitterness continues to this day. As the South Asia map supplement to this issue indicates, the dispute remains unresolved along both borders.

In September this year a Japanese delegation, led by three members of their Diet, or parliament, visited our offices to urge us to change our maps to show certain Russian-occupied islands north of Japan to be Japanese, not Soviet. At the end of World War II the Soviet Union simply took them and still refuses to leave—dividing families and cutting people off from their homes.

Regardless of where justice or our sympathies may lie, by color and border we indicate the country that holds and administers the land at press time. We adhere rigorously to a de facto policy regarding all the scores of border disputes in the world.

All, that is, but one of the most unusual. Since the governments in both Beijing and Taipei claim that Taiwan is Chinese, we so show it by color. But as in the Japanese islands claim, we explain in a note what cannot be told by a simple line or tint on a map.

There is no Solomonic solution that will please both parties to an international border dispute, and no brief note can explain the bitterness and bloodshed that often persist for centuries along such borders.

Wilbur E. Garrett

EDITOR

NATIONAL GEOGRAPHIC

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COVER: *An Indian tailor in Porbandar saves his antique sewing machine from a monsoon flood. Photo by Steve McCurry.*

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Life Breath of Half the World MONSOONS

Blessed and cursed, destructive and sustaining, India's summer monsoon floods a Delhi street. For half the world's people, the rain-bearing seasonal winds that sweep into Asia from tropical oceans remain life's critical uncertainty.

By PRIIT J. VESILIND
NATIONAL GEOGRAPHIC SENIOR STAFF

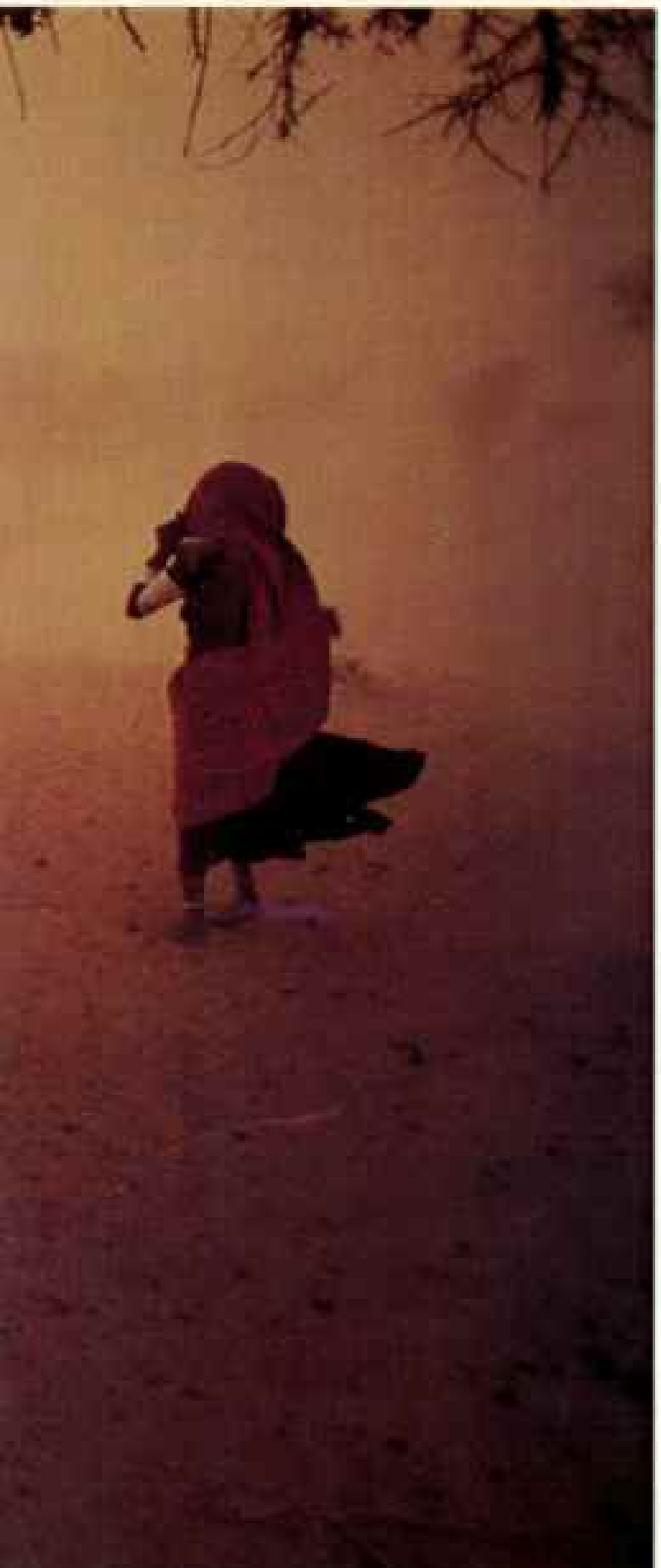
Photographs by
STEVE McCURRY

THE SEA EAGLE lifted skyward, nearly motionless in a shaft of tropical air rising from the Malabar Coast of India. It was the sixth of June 1983. In the troposphere a thin jet stream began to slip westward. The earth offered its northern half to the sun. New heat scorched the Tibetan Plateau and the deserts of Rajasthan and Arabia. It was the time of tension and expectation in

Before the monsoon, cruel winds sear the arid plains of Rajasthan as women seek

India, the time before the monsoon that Hindu astrologers call *rohini*, a time of heat and dry winds that send grit and dust clawing across the arid plains of the north. At midday the earth burns under an unrelenting sky, and at night, as Rudyard Kipling wrote, "The dry-eyed Moon in spite glares through the haze and mocks with watery light the torment of the uncomplaining trees."

The monsoon was late. That week near Ahmadnagar, in the state of Maharashtra, several women collapsed and died from heat exhaustion; after eight hours of heavy labor they had to haul drinking water from a distance of three kilometers over wild and hilly terrain, in temperatures hovering at 46°C (115°F). A dust storm lashed New Delhi with winds that reached 105 kilometers (65 miles) an hour and engulfed the city in darkness. Cloud seeders from California were hired by the city of Madras to replenish dwindling reservoirs. And on the central plateau, water was being sold at seven rupees a barrel in the city of Hyderabad. Fistfights erupted at public water taps in front of the waterworks, and office workers wearing expensive wristwatches drove frantically through the streets in their automobiles, searching for their share.



scant shelter in the lee of a tree.

The eagle soared even higher in the updraft as I picked my way along the dark rocks beside the Arabian Sea. The winds shifted with promise, deepening the resonance of the surf, muffling even the crows that cackled and lurched along the seawalls. The water grew choppy, and the black thorns of fishermen's sails scratched the horizon. Surely the time was at hand.

At the weather station at Trivandrum, capital of the state of Kerala, chief meteorologist Julius Joseph (left) thumbed impatiently through the morning's charts and graphs. "Look," he said triumphantly, pointing to a swirl of isobars, "the low-pressure trough has moved directly over us. A slight shift to the north could bring the monsoon."

But when? There was nothing left but to wait, with the rest of India, for that storied monsoon onset that inspired ancient Hindu poets to eloquence. (See **Peoples of South Asia,** a supplement to this issue.)

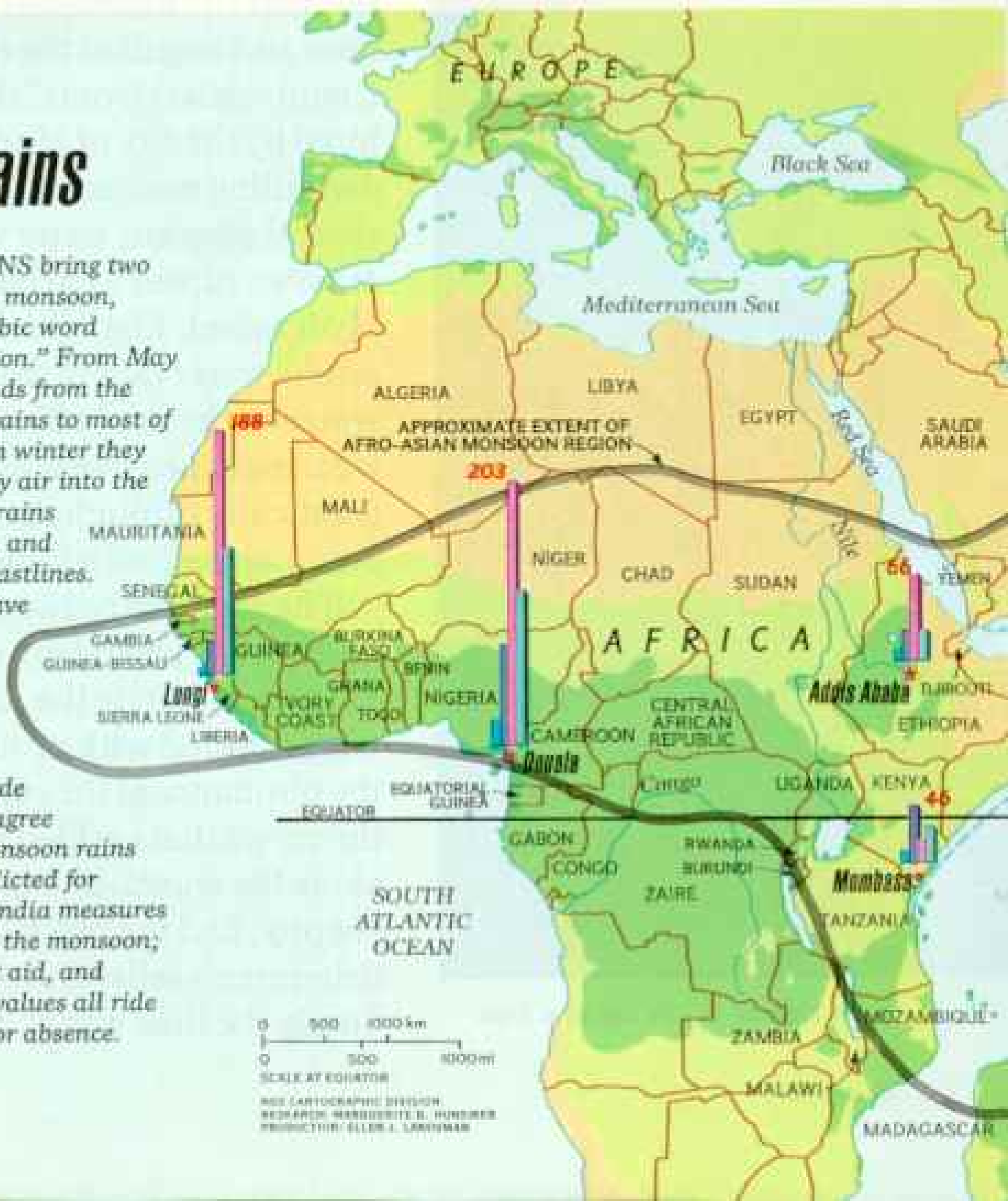
"The clouds advance like rutting elephants," wrote the fifth-century Indian poet Kalidasa, "enormous and full of rain. They come forward as kings among tumultuous armies; their flags are lightning, the thunder is their drum. . . ."

For this I had traveled four months through the breadth of the monsoon world—from Africa to north China, from

Monsoon rains

*DIFFERENT SEASONS bring two distinct winds of the monsoon, derived from the Arabic word mausim, meaning "season." From May through September, winds from the southwest bring heavy rains to most of southern Asia (**map**). In winter they reverse, spilling cool, dry air into the continent and carrying rains to Indonesia, Australia, and areas with northeast coastlines.*

Monsoon forecasts have been called the most important predictions in the world. Armed with satellite pictures and computer models, meteorologists have made great strides, but most agree that the onset of the monsoon rains can't be accurately predicted for more than a few days. India measures its economic welfare by the monsoon; flood relief, government aid, and fluctuations of market values all ride on its official presence or absence.



the tropical coast of Australia to the lofty Himalayas of Nepal—to this middling coastal city on the southwest tip of India, where the monsoon was awaited by the first of June each year.

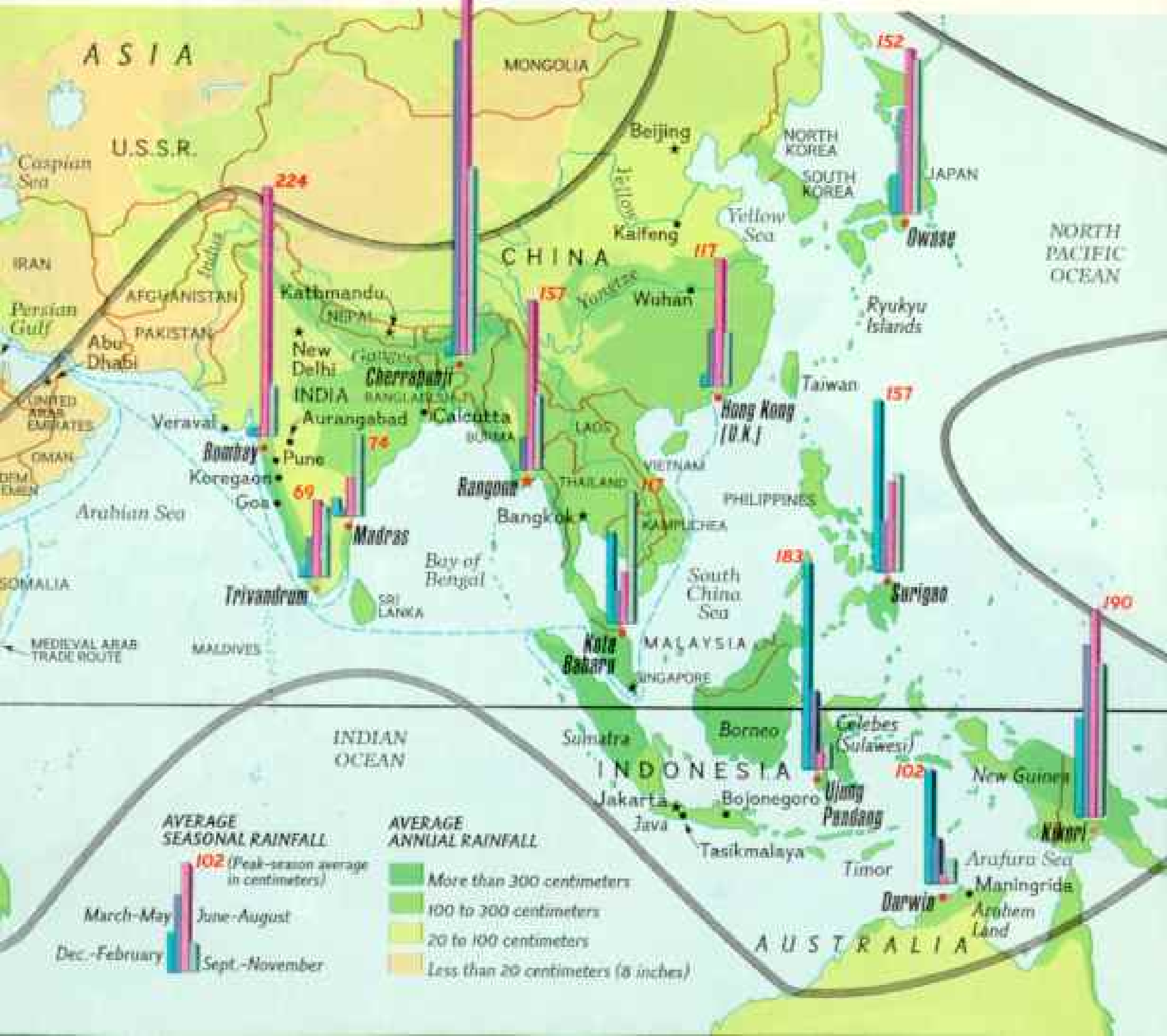
But the onset fizzled. The trough retreated south, meekly, and next morning the sea eagle turned a slow adagio in pale skies. The rain was stalled at sea, storming over the Maldive Islands.

So we waited. We waited as the sun stoked the powerful atmospheric engines of heat and water. We waited as the dusty streets of Trivandrum baked in sweat and evil smells. Wandering cattle licked their lips. Julius Joseph studied his charts.

It would come, it would come. The monsoon, after all, is the verdict of the gods. When the monsoon falters, drought and famine paralyze continents. When it swells, cyclones and floods terrorize low-lying coastlines.

But the fortunes of Asian agriculture, and thus the survival of half the world's nearly five billion people, ride on the monsoon's promise. Vital economic decisions await its whims, and politicians stake their careers on its failure or success.

In India the monsoon is predictably unpredictable. It will come, but it can arrive coyly, even gently, teasing with thundershowers. Rains can skip entire regions. It can rain for days, even weeks, until the earth is squirming with life and walls are slippery with mildew. For another week the skies may be clear, but then rain will come again, relentless, finally tedious, until memories of cracked, dry earth and fierce sun fade into wishful thinking. *(Continued on page 722)*



Solar heat fuels the monsoon engine

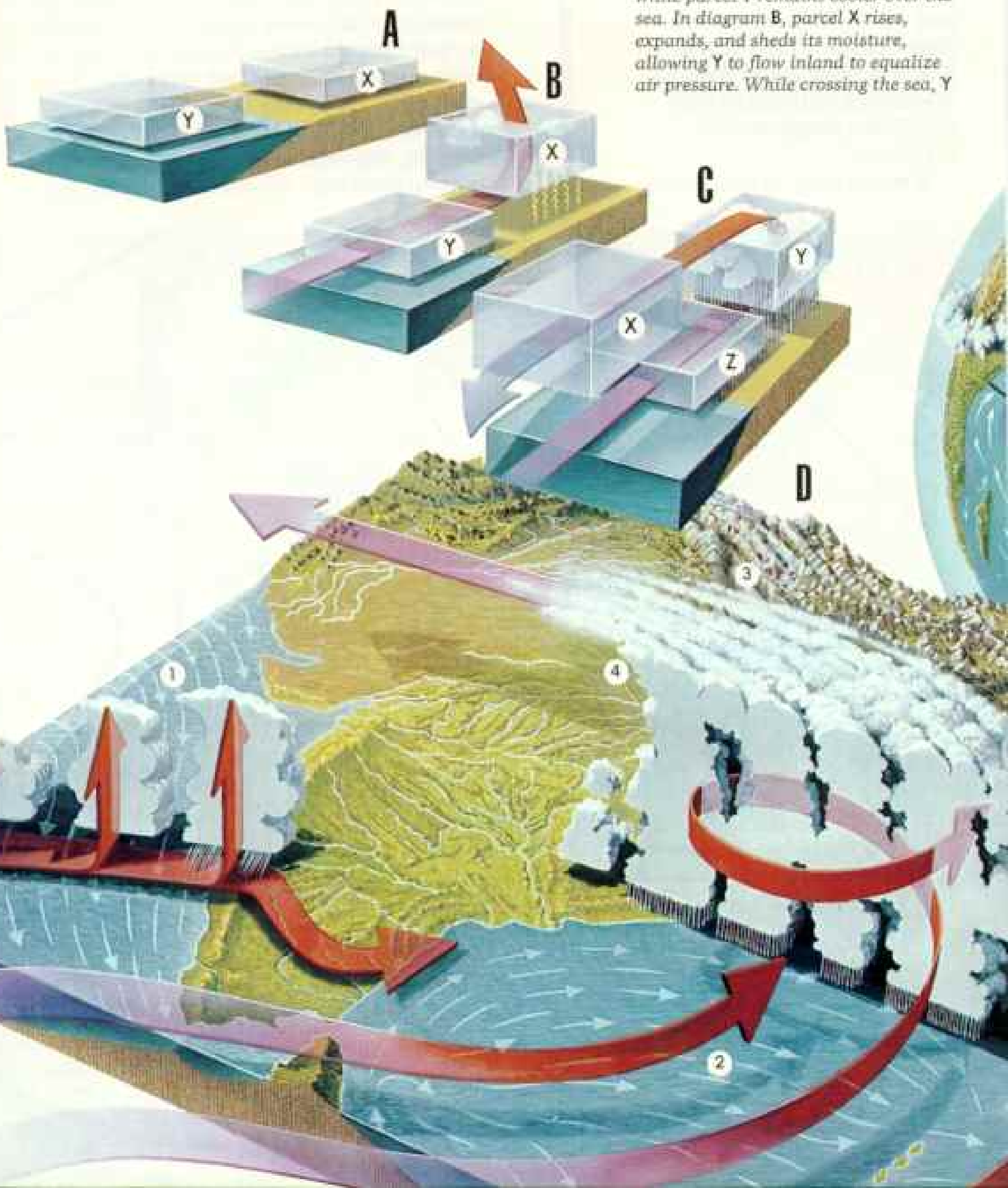
MONSOON WINDS form one of the most massive weather systems in the world, part of the global heat transfer that keeps the planet habitable. Without the monsoons to balance temperatures, latitudes exposed to the sun's direct rays would shrivel with heat, and areas of central Asia would succumb to deep, unimaginable cold.

Although the most important monsoons oscillate between India, the Far East, and Australia, and their tropical oceans, monsoon winds exist in Africa, Mexico, and perhaps even in the Arctic.

In its basic form the monsoon is a heat engine—an enormous cycle of air set in motion by temperature differences over land and sea. In summer land heats more rapidly because solar radiation does not penetrate below its surface. Water stays cooler because it mixes, but it stores heat in its upper layers for long periods of time.

Because the winds perform on a global scale, they are also directed by the tilt of the earth on its axis and by the Coriolis force resulting from the earth's spin.

In a simplified model of a summer monsoon, below, air parcel **X** *in diagram* **A** *is heated over the land while parcel* **Y** *remains cooler over the sea. In diagram* **B**, *parcel* **X** *rises, expands, and sheds its moisture, allowing* **Y** *to flow inland to equalize air pressure. While crossing the sea,* **Y**

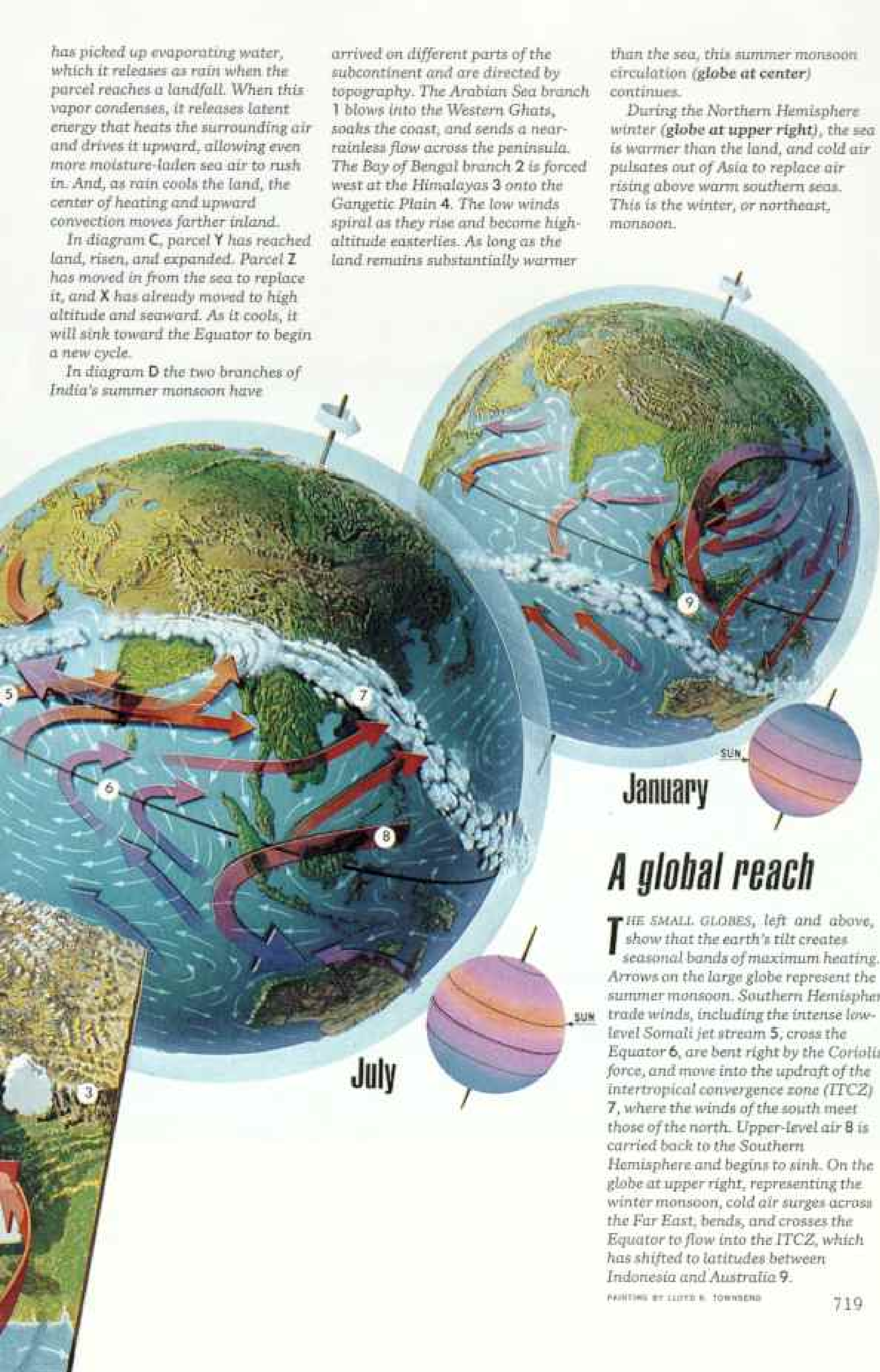


has picked up evaporating water, which it releases as rain when the parcel reaches a landfall. When this vapor condenses, it releases latent energy that heats the surrounding air and drives it upward, allowing even more moisture-laden sea air to rush in. And, as rain cools the land, the center of heating and upward convection moves farther inland.

In diagram **C**, *parcel* **Y** *has reached land, risen, and expanded. Parcel* **Z** *has moved in from the sea to replace it, and* **X** *has already moved to high altitude and seaward. As it cools, it will sink toward the Equator to begin a new cycle.*

In diagram **D** *the two branches of India's summer monsoon have arrived on different parts of the subcontinent and are directed by topography. The Arabian Sea branch* **1** *blows into the Western Ghats, soaks the coast, and sends a near-rainless flow across the peninsula. The Bay of Bengal branch* **2** *is forced west at the Himalayas* **3** *onto the Gangetic Plain* **4**. *The low winds spiral as they rise and become high-altitude easterlies. As long as the land remains substantially warmer than the sea, this summer monsoon circulation (***globe at center***) continues.*

*During the Northern Hemisphere winter (***globe at upper right***), the sea is warmer than the land, and cold air pulsates out of Asia to replace air rising above warm southern seas. This is the winter, or northeast, monsoon.*



A global reach

THE SMALL GLOBES, left and above, show that the earth's tilt creates seasonal bands of maximum heating. Arrows on the large globe represent the summer monsoon. Southern Hemisphere trade winds, including the intense low-level Somali jet stream **5**, *cross the Equator* **6**, *are bent right by the Coriolis force, and move into the updraft of the intertropical convergence zone (ITCZ)* **7**, *where the winds of the south meet those of the north. Upper-level air* **8** *is carried back to the Southern Hemisphere and begins to sink. On the globe at upper right, representing the winter monsoon, cold air surges across the Far East, bends, and crosses the Equator to flow into the ITCZ, which has shifted to latitudes between Indonesia and Australia* **9**.

PAINTING BY LLOYD K. TOWNSEND

INDIA *The glory of the rains streaming about him, a farmer in the former Portuguese colony of Goa, on India's west coast, leans into his plow pulled by water buffalo as women transplant rice seedlings that have previously been nurtured in irrigated plots. During the months of dryness, Goa farmers stockpile food, for when the rains arrive, usually in the second*

week of June, there is little time for cooking or anything but work.

In most of rural Asia monsoon means the renewal of life. It is awaited with intensity, celebrated with joy, and is firmly bound in myth, proverb, and religion. For more than half of Asia's farmers, who are still primarily dependent on a single growing season, the monsoon can mean survival itself.

JUNE 7. In Trivandrum the breeze quickened. Southern India's central weather station in Madras issued a gale warning for fishermen. Julius Joseph was expectant.

"It's a typical monsoon sky today," he said, "all kinds of clouds, at all levels—a chaotic sky. But the wind is mostly from the northeast, the wrong way."

Wind, not rainfall, defines the monsoon for meteorologists—a seasonal wind that shifts direction twice a year. Asia breathes in, then breathes out. The inhalation is the summer, or southwest, monsoon that blows from mid-May through September, bringing heavy rains from tropical oceans into the continent. The winter, or northeast, monsoon is a reverse flow beginning in October, bringing cool, dry, continental air to most of India and China and rain to Indonesia, Australia, and areas with northeast coastlines.

Monsoons are often confused with typhoons and other destructive winds. Although a rain-bearing monsoon can arrive with near-hurricane force, it is not a single aberrant storm, but the first wave of a sustained season. Where water is scarce, the monsoon is greeted with joy and relief.

THOUGH the basic physics of monsoons was described 300 years ago, no one has yet pieced together the entire mechanism or fully understood its behavior.

"Imagine a puff of cigarette smoke blown into a room," University of Maryland meteorologist Dr. J. Shukla explained to me. "A second puff will not follow the first; all will be different, totally unpredictable. We have a similar turbulence in the atmosphere."

Forecasting monsoons is often called the world's most important weather prediction, but, as Dr. Colin Ramage of the University of Hawaii told me, "The more observations we get, the more complex the monsoon gets. Some of us think we may be dealing with an intractable problem."

Other meteorologists feel they are closing in on the elusive mechanism, drawing on an immense data base compiled in the Monsoon Experiment of 1978-79 (MONEX). Twenty-three nations participated in the MONEX task force, which included more than 300 scientists, five satellites, and ships and aircraft. Data poured in from the South China Sea and, for the first time, from

Pushing replaces pedaling *when monsoon waters send the Ganges over its banks to inundate the city of Varanasi*

(Banaras) in Uttar Pradesh. Last year the city lay under water mixed with sewage, rotting grain, and floating carcasses of animals. Elsewhere in the state flash floods swept away a locomotive and three railcars.

isolated areas of the Indian Ocean, areas previously covered only by occasional ship reports. Facts are replacing guesswork as MONEX scientists collate their research. In 1984 India and China each signed high-level agreements with the United States to conduct new monsoon studies.

"The exciting thing is that we're getting answers at all," says Australian meteorologist Dr. Peter Webster, now at Pennsylvania State University. "In five years we've started to understand how it all hangs together."

have sailed from the Persian Gulf, borne on the monsoons. They raked India for spices, gems, and teak, and scoured the East African coast for frankincense, mangrove, ivory, and slaves. The legendary Arab sailor Sindbad was said to have reached China on the shifting winds.* "Monsoon" derives from the Arabic word for season, *mausim*.

Back in mid-May I had been to the African port of Mombasa to see the remnants of the ancient traffic. A modern facility handles Kenya's containerized shipping there,

Rupees from heaven, *rain enriches the state of Orissa on the east coast of India as cumulus clouds shed their moisture over the swollen Mahanadi River (**left**). Across the plains of northern India and Bangladesh, entire villages are often stranded on high ground when such great rivers overflow with monsoon waters. But the floods cover the fields with rich silt washed down from mountains and ensure the success of the summer growing season.*

*In Goa, diked rice fields are parched and brown in May (**right**), and resourceful farmers flood some of them with seawater to raise fish and to use as evaporation pans for salt.*

When the rains are late, Christian Goans carry loads of rocks up steep mountain slopes in penance and sometimes lower a statue of St. Anthony, to whom they pray for rain, into a well.

*But with the arrival of the monsoon the same fields are transformed into emerald green by August (**far right**).*

JUNE 8. That evening in Trivandrum lightning danced soundlessly on the clouds that lined the southern horizon. From the seawall I scanned for pied-crested cuckoos from Africa, said to fly before the winds. But there were only the crows and the nasal drone of the muezzin's call to prayer, drifting from a Muslim village across the water.

Islam itself rode the winds to the Malabar Coast. Through recorded time Arab dhows

but wooden dhows still anchor in Old Town, a steamy, intimate warren that sizzles in chocolate, pungent curries, and fried cassava. Masai tribesmen elbow through the alleyways with sleek Hindu merchants, dark sailors from Abu Dhabi, and caramel-colored maidens whose lustrous eyes dance over veils of Muslim silk.

*Tim Severin followed "In the Wake of Sindbad," in the July 1982 GEOGRAPHIC.

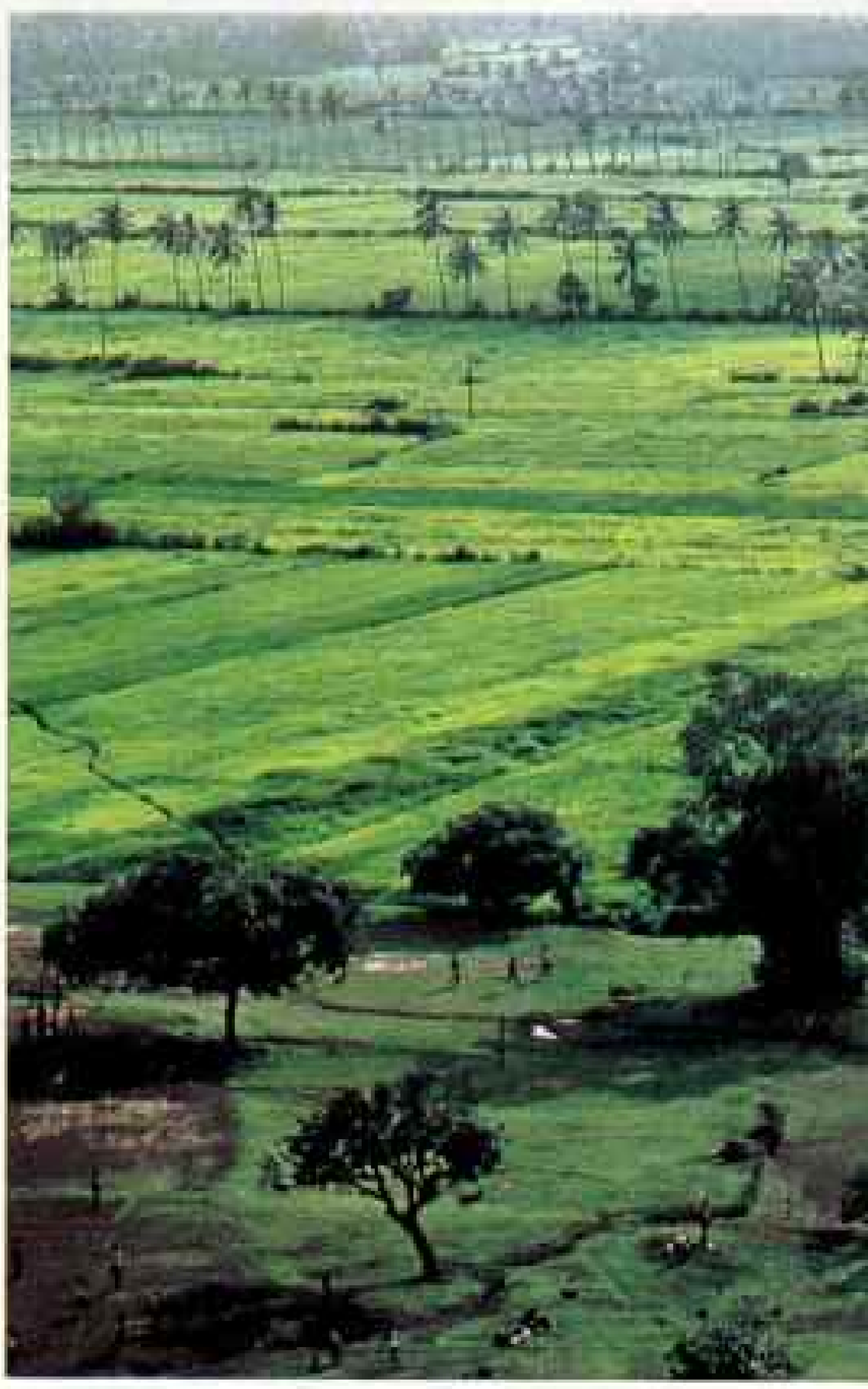
The *Sarina al Aziz* from India had been unloading koko wood, kingfish, and shark fins from Somalia when I arrived, and Mombasa's longshoremen heaved bales of coffee onto the *Taysir* from Dubai, bound for the Red Sea. Like their predecessors, the dhows rarely risk the full force of the southwest monsoon, but head north just ahead of it. Supplementary diesel engines help through rough weather.

"Now there are only a few days left," declared port dhow master Mr. Mnabe, a broad-shouldered African given to repeating himself in a loud voice. "Only a few days left. If the dhows do not sail now, they cannot go."

The Kenyan twilight had shone like a pearl, but by next afternoon the southerly winds had strengthened and coalesced; dark clouds pumped across the eastern skies. The Somali jet stream, a major component of the southwest monsoon, had set in.

This powerful, low-level stream of air begins as trade winds in the southern Indian Ocean. Bent right by the Coriolis force, caused by the spin of the earth, the air mass veers off the Kenya Highlands as it crosses the Equator, gathering momentum northeast along the African coast. The seas shift with the wind until a virtual river within the ocean, the Somali Current, rolls 150 kilometers wide toward Arabia.

South of the West African hump in the South Atlantic, and all across the Indian



Ocean, other winds pull north as the continents heat. By the end of May the southwest monsoon has usually begun; moist air is pulsating into West Africa, the Indonesian islands, and continental Asia.

In the Far East the monsoon starts earlier than in India and is just as important. The "plum rains," or *meiyu*, of China drench the southern coast around mid-May. In Japan the *baiu* brings rain into the Ryukyus. But

Swinging in celebration, *village girls sing the ancient melodies of Teej, the festival marking the return of the monsoon and the promise of prosperity. In India's poetry, winter sun brings misery; dark clouds symbolize happiness. Heavy rains are said to murmur the longing of lovers, and a beautiful woman has hair black as monsoon clouds and eyes that flash like lightning. Cries of the peacock* (**right**) *symbolize monsoon-season sensuality.*

on its way north the summer monsoon causes serious floods, loss of life, and extensive damage to China while at the same time nourishing the crops that feed a billion people.

The powerful monsoon rains hammer Burma and the mountains of Thailand, Laos, and Vietnam. They flood the streets of Bangkok, a slowly sinking behemoth where hasty progress has filled in many of the ancient *klongs* that drain the city.

In India the summer monsoon develops in two branches. In the western branch, vortices powerful enough to disable aircraft can form over the Arabian Sea. A deep, humid air mass churns into Sri Lanka and India's Malabar Coast, battering the Western Ghats with prolonged, nourishing rain, which spills into the central plateau. It buffets the coast in waves, moving north, traditionally reaching Bombay by June 10.

In the Bay of Bengal branch, violent

thundershowers, the *kal Baisakhis*, wrack Bangladesh and the Indian states of West Bengal and Assam. Tropical depressions push north from the bay, are deflected west by the southern flanks of the Himalayas, and storm across the scorching Gangetic Plain. Cherrapunji, a perennially soggy village on the south slopes of the Khasi Hills, is overwhelmed with one of the highest average yearly rainfalls on earth, 1,142 centimeters (450 inches).

The two branches usually merge over central India by the second week of July. By the end of September the monsoon has played out against the Himalayas.

JUNE 9. At midnight a stifling silence descended. Air conditioners hiccuped to a halt as electric-power rationing reached home consumers in Trivandrum. All power to heavy industrial users had already been severed. Now, movie houses were restricted to one showing a day, neon display lights were outlawed, and stores were compelled to close by sundown.

Kerala was down to six days of power, its major hydroelectric reservoirs drained to an all-time low. Only the arrival of a healthy monsoon could prevent a total power outage in the state.

Julius Joseph, scientist and adviser, hung up the telephone at the weather station. "That was Mr. Pillai, Kerala's minister of electricity," he said. "He fears a total power breakdown. But I gave him some hope. The monsoon will come any day now."

Across India reservoirs dwindled into puddles as the rains hovered offshore. About half of the nation's electricity is generated by hydropower, and thus by the monsoons. Government officials confessed to newspapers in anxiety that late rains would impede food production, aggravate inflation, and increase prices—and all this in a preelection year. Prime Minister Indira Gandhi, touring in Europe, asked for monsoon forecasts to be added to her daily political briefings.

The state of Karnataka found itself with 900 extra elephants that had migrated from the parched forests of Tamil Nadu, in India's southeast. Summer rain would barely ease the drought in Tamil Nadu, for the state lies in the shadow zone of the southwesterly winds and depends heavily on the winter monsoon for its water.

During that season of the northeast wind, from October to March, the rest of the country stays relatively mild and dry. Surges of winter-monsoon cold from Siberia are shunted off by the high-rising Tibetan Plateau and funneled into eastern Asia.

ALL OF EASTERN ASIA bears the brunt of the winter monsoon. In the middle latitudes, freezing temperatures and bitter wind, not rain, pulse out of Siberia. Frigid, dry air pushes south. Cold cyclones rear over the Gobi desert, gusting in suffocating dust storms called *karaburan*. The winds stream southeastward, growing water heavy and warm over the sea. They curve southwest, bent by the Coriolis force, and probe toward the tropics.

"In the days of the emperors the frozen bodies were stacked like cordwood on the streets of Beijing, waiting to be picked up each morning." I had heard this from Zhao Zhen of the Academy of Meteorological Sciences in Beijing, where I attended a seminar between American and Chinese monsoon experts.

The science is deeply rooted in China. We were each given a collection of weather data, for example, that spanned 500 years. Deep as well is the Chinese love of learning. A wave of newly published books had hit Beijing as part of the liberalization of cultural life, and on the broad boulevards people gathered like moths to sit under streetlamps after dark, simply to read.

By the time surges of monsoonal cold hit the tropics, they have lost most of their chill, but winds can reach 35 to 45 knots, whipping the South China Sea into a frenzy, setting up rainstorms that drench the coasts of Southeast Asia, Borneo, or the Philippines.

NEPAL

Rejoicing in the renewal of life that the monsoon brings, women gather at the Baghmati River in Kathmandu for a ceremonial bath. They honor Parvati, wife of the Hindu god Siva, who dwells among the peaks and sends the streams cascading to the plains.

For the heavily commercial city-state of Singapore, the condition of the South China Sea affects shipping schedules and work on the forest of offshore oil rigs. "During the strong winter monsoons even fishermen can't go out," Singapore meteorologist Dr. Lim Hock had told me. "Waves up to four meters high sweep the beaches on the east coasts of Malaysia, causing much damage."

Racing toward the Equator, the northerly winds are heated and sucked upward over Indonesia. Rain squalls roll up mountain slopes. Great columns of soaked, heated clouds rise and tower over the islands and northern Australia. Sumatra, Borneo, and most of the northern islands get ample rains from both monsoons, but a marked dry season sears eastern Indonesia in winter. In 1983 the islands of Timor, Sulawesi, and Bali suffered severe drought.

JUNE 10. The summer rains had reached Burma and Malaysia, but only a drizzle trickled over thirsting Trivandrum.

"Most peculiar," said Julius Joseph. "Rarely does this much delay occur."

To save fragile mountains *from the erosion inevitable with monsoon downpours, a village boy near Kathmandu (**left**) plants pine seedlings on slopes denuded for firewood and by overgrazing. Nearby, monsoon-triggered landslides have turned a mountainside (**below**) into washed-out gullies—an instant desert. Nepalese farmers, forced by rising population to look higher and higher for firewood, fields, and grazing grounds, have stripped nearly a third of Nepal's forests in the past 30 years. Now, with outside help, Nepal has mobilized villagers to help themselves; local committees protect forests and maintain more than 600 tree nurseries. Although the destruction has been stemmed, more than a million hectares (2.5 million acres) must be reforested by the year 2000 to meet fuelwood needs alone.*

Since June 1982 the operative word for world weather had been "crazy." Blamed was a tongue of warmer-than-usual sea surface in the eastern Pacific that South Americans call El Niño, The Child, since it occurs around Christmas every four years or so.*

El Niño tossed world weather patterns into turmoil. It deflated the 1982-83 monsoon in drought-struck Australia, stifling the November rains that usually pound the northern coast. Only in early March did the thunderheads straggle into Darwin, capital of the Northern Territory.

Darwin was pure tropics in April. The afternoon heat and humidity were staggering, and only mad dogs and American journalists went "out in the mid-day sun. . . ."

In its normal cycle the territory is a land of either-or. The monsoon heralds the Wet, with a capital W, as distinct from the Dry. And the Wet thunders into Darwin with enthusiasm; in 1974 the city was virtually destroyed by a tropical cyclone, or hurricane.

*Assistant Editor Thomas Y. Canby told of the devastation wrought by El Niño on five continents in the February 1984 NATIONAL GEOGRAPHIC.

At the height of the Wet, wild tropical grasses grow eye-high, and the gullies are choked with vegetation. When the rains stop, the land turns tinder dry. Searing winds sweep north from the outback; bushfires crackle across a territory the size of Oregon, out of control by August.

"The more water, the more vegetation—the more vegetation, the more fires," was the neat but chilling synopsis of Mike Rowell, chief officer of the Northern Territory's Bush Fires Council in Darwin.

"The vastness of it all," he had sighed. "We have more country, more fuel on undeveloped land, and fewer people who know how to handle it than any other monsoon region of Australia. The old-timers understand how to live with fire. Our big problem now is the growth of Darwin—and newcomers not always aware of the problems of fire. The result is a highly dangerous situation at least four months of the year."

What to wear to a monsoon *poses no dilemma to boys leading water buffalo on a rocky road near Kathmandu. A banana-leaf slicker is one inexpensive option (***above***). Another: Woven straw umbrellas (***facing page***) held on by tumplines that fit around the forehead, leaving hands free for work.*

BY THE ANCIENT CALENDAR of the Aboriginals it was still *gudjewg*, monsoon time. It was the time when grass seeds are knocked to the ground by the rains, and a lizard—*biguw bagainmen*—calls from the trees. Perhaps the Aboriginals still understood.

I had left for the Aboriginal settlement of Maningrida, on the coast of Arnhem Land, in a small twin-engine plane as the tardy monsoon pushed inland from the Arafura Sea. Rains riveted off the windshield, and powerful updrafts sucked the aircraft up and down like a piston. Below lay a vaguely sinister wilderness, a fecund soup of green mud, with rivers bloated like sated pythons.

Maningrida, an isolated administrative center of about 700, supports 24 or so outstations of Aboriginals. When the rains turn rivers into lakes, road traffic is severed and many outstations are marooned. Despite their four-wheel-drive trucks and shotguns, the Aboriginals still rely on traditional hunting methods and foods such as crocodile eggs. The crocodile is a totem animal to the central Arnhem community.

"There's a feeling of self-dependence here," said David Bond, a white Australian who is manager of the Bawinanga Corporation, the local economic body. "People want to live out in the bush and have their place in the sun. But they're Australians. They want to be part of the nation too."

Ngalyod, the rainbow snake, is the creator spirit, Arnhem Land's symbol of the northeast monsoon. It brings the rains and life; it stands as the rainbow after the storm. But man himself, for a grudge or a sense of revenge, also can summon natural forces.

Jimmy Burinyila, an Aboriginal and curator of the local museum, told me how rain is made: "The water snake, yellowbelly, that one is lightning. Now the file snake . . . the file snake you find in fresh water. It

AUSTRALIA

*Masters of survival techniques for northern Australia's monsoon, Aboriginals like George Milpurru and family still strip the stringybark eucalyptus (**top left**). With help from the family dog (**above**) they treat the bark with fire to fashion a hunting canoe for the crocodile-infested Arafura Swamp. In his new craft (**above right**) Milpurru poles after tucker, or bush food, such as fish, goose, or file snake, a creature whose hiss can bring the monsoon clouds, according to Arnhem Land beliefs. Later, in the midst of a downpour (**right**), he carries embers from a neighbor's fire to cook dinner.*

Many Aboriginals, frustrated with the "whitefellow" world, have settled into the bush to regain traditional values. During the rainy season from November to April, when they may be marooned on high ground as rivers swell into lakes, they rely on old hunting methods.

can float, and go *tshhhhhhh!* And make the rain. Now a man can make the sound of the snake, and that brings the rain. He will stay home and sleep, and it will start pouring and pouring."

I had asked Luke Taylor, an Australian anthropologist who does research in Maningrida, about the lack of rains this year.

"The people have had a two-month-long ceremony in the bush," he answered. "They were singing the rain away, keeping it from coming, until they were finished. Others were calling from all over the territory by radio, asking them to stop.

"The meteorologists blame pressure troughs, but we know the real story here. It rained for two bloody weeks after the people broke up the ceremony and went home."

JUNE 11. Indians, beseeching gods and meteorologists alike, still waited. Julius Joseph spent his morning comforting politicians and press at Trivandrum. Heavy cumulonimbus clouds had gathered, but the wind still gusted from the northwest. "Two or three more days," he augured.

The state of Kerala, normally water rich, shriveled. The last monsoon and seasonal rains had failed. Tea fields had turned brown; coffee had missed the crucial "blossom showers." Rubber tapping had been suspended. Rice farmers stared bleakly at the packed earth, awaiting the time to plow.

With the new high-yielding rice strains of the green revolution, farmers who irrigate can grow two, even three crops a year. But half of India's arable land depends solely on monsoon rains and a single growing season. For farmers the coming of the monsoon is still life's critical uncertainty.

In the best of years rice farming is a gamble. Will pre-monsoon showers soften the soil in time? When should seedlings be transplanted? If too soon, they will wither; if too late, the crop will die when the rains stop.

But with a growing complex of irrigation schemes, bore wells, and storage tanks, India has become self-sufficient in food for the first time.

In the west Indian state of Maharashtra, farmers have long been tethered to the monsoon stake. In May 1983, however, humble acceptance was not in fashion. In the village of Karjat 500 women marched in protest and staged a hunger strike against the government's water management policies. Niggling rains had cut harvests to subsistence levels, and, with the monsoon unknown weeks away, even drinking water prospects were grim.

I HAD JOURNEYED through Karjat soon after, on the road from Bombay to Pune, and to the city of Aurangabad. The road knifed through the bluffs of the Western Ghats, where cripples and sadhus, holy men, perched to gather alms from wealthy travelers. Past Pune lay a flat, torrid landscape of thornbushes and mud huts. Villagers sat in the stifling heat as if stunned, and a dry wind sucked moisture from the dying pipal trees that lined the roadside.

Near the village of Koregaon I stopped on a bridge to watch as women hauled water from a well sunk into a broad, snake-dry riverbed. An old farmer in dirty linen approached, stuck out his chest, and saluted stiffly, in the British manner. "I'm a military man," said Dattu Madhu Glonhane.

He wanted to explain the plight of his village. "God doesn't like this place," he said. "There was a solar eclipse and a lunar eclipse here. We don't have enough water for irrigation, just for drinking. But the earth is good. If it rains this year, there will be lots of crops."

"What if the rains don't come?"

"People are going to start looting," he said. "Others are going to starve. If there is no water, it doesn't matter if you have a job or not. So we're living on hope. Even the birds die of thirst. But birds have wings—they can fly away. We are stuck here."

He dismissed a group of amused village boys with pomp. "I'm a military man," he said, saluting again, and was gone.

At the hotel in Aurangabad a pitiful golf putting green had faded to dirt and singed straw. Drinking water the color of antifreeze sat on the table at lunch. "It's been filtered three times," said the waiter defensively.

That afternoon I wandered the narrow streets of this timeless city of the Mogul Empire. Aurangzeb had ruled here, giving it his name. But its ornate stone carvings, city walls, and mosques were finally abandoned to the enduring peasantry. Aurangabad lay limp in its thirst. Women flogged

laundry by the overworked stream. Street pigs snuffled in doorways where weary merchants in red turbans lounged on sacks of grain. And the eternal bullocks plodded under the eternal whip—their humps like tumors, their faces lean, ascetic, and hopelessly vacant.

A wind hit suddenly in whirls of hot grit and stinging dust. The sky blackened, and goats cowered against walls. Traffic moved on in a sepia haze. The high leaves tossed dryly. There was no smell of rain, no promise. And then the dust storm passed, and the dark clouds were gone again.

But pre-monsoon rains had filled the Bhima River near Pune when I returned on my way back to Bombay. Traces of green stippled the fields, and mud puddles sank into the caramel-colored earth. On the roadside, villagers cremated one of their own, a shrouded body on a metal-frame funeral pyre. The shape of the frame mimicked the form of their mud homes, and also the haystacks that nurtured their cattle—the three symbolizing a cycle of birth, struggle, and death. The smoke rose into clear skies from the pyre, seeding unseen clouds.

JUNE 12. I was awakened at night by the bold, dry scrape of cockroaches the size of a thumb, scudding across the nightstand.

"We are all praying for rain," said the chambermaid thoughtfully, as she sprayed in the corners next day.

The city grew impatient. Trivandrum's public schools, scheduled to open June 1, remained shut. Not enough water for drinking and sanitation, officials explained.

The monsoon can be poetic in the countryside but hard news for urban India. In Bombay, drinking water was little in evidence as I walked through the center of India's wealthiest metropolis. I remember a six-year-old boy, scrubbing aluminum pans on the sidewalk, who stood for a moment to catch his breath. Then he walked to a carton of empty soda bottles behind a kiosk and raised each to his lips to salvage the dregs.

And I remember the water vendor who pulled a barrel on a wooden cart through a slum district in the city center shouting, "Water, only one rupee!" A thin, shirtless man implored him for a drink. The two argued. The vendor twirled a black mustache like a melodrama villain and waited for the rupee. The thin man licked his lips. The vendor, indifferent, moved on.

"How much do you make a day?" I asked the vendor, hurrying after him.

"Forty pails, forty rupees."

"That's a lot of money," I said, having been told that the average Indian field laborer earns about 15 rupees a day. "How can you charge so much?"

CHINA

Wearing masks, mother and son protect themselves against bitter cold winds in Kaifeng in the Yellow River Valley. Here surges of intense cold, not rain, characterize the winter monsoon. Dust storms are common in northern China as repeated waves of winter-monsoon cold pass on their way south.

The vendor did not answer; he simply pointed to the cloudless, intimidating sky.

But in the first sustained downpour, life in Bombay sloshes to a halt. Muddy water fills the taps. Many old buildings collapse. Garbage and cattle dung clog drains, turning streets into stinking canals that invite cholera and dysentery. The low-lying slums that surround Bombay like a grimy quilt are swept away. Train service, lifeline of the city, is severed. Where the tracks cross the neighborhood of Parel, I had met with residents who routinely evacuate their families into a nearby factory building when the water invades.

"We know we need the monsoon, but it's a problem for us," P. G. Bhujbal, a local resident, explained. He pointed to a stream of sewage that trickled from an adjacent apartment building, where chickens pecked at grains of floating garbage.

"We are the lowest point in the area," he said. "The gutter water mixes with the rain water and comes into the houses. We put the tables on top of the beds and sit on the tables. The water is chest high sometimes."

"So many years have passed and always the same thing," said William D' Souza, another resident. "But nobody is doing anything for us. The government? They come, they see, they go."

Yet Bombay waits eagerly for the rains, if only through cultural mandate. Children in underwear rush into the streets to rejoice in mud puddles, and prayers of thanks fill the temples. Only when the reservoirs are full does the rain's soggy monotony wear thin.

IN THE CITY of Madras, where the northeast monsoon is the culprit, reservoirs had stood nearly empty that May. The beleaguered Madras Metropolitan Water Supply and Sewerage Board had sunk 132 new deep-bore wells. They had initiated a scheme to divert water to the city from the Krishna River, some 400 kilometers away. They had imported water by steam-cleaned railroad tank cars, imposed a tight rationing system, and dispatched fleets of drinking-water trucks daily to plumbing-poor neighborhoods.

Still, Madras suffered. Trees and grass had withered in the parks. Mere walking was a trial through the cloying heat, exhaust

INDONESIA

Fighting off despair, a farmer in Java ***(above)*** *struggles to save rice fields from flood-borne volcanic debris spewed from nearby Mount Galunggung and carried down by monsoon waters. Such eruptions have wreaked havoc since 1982. Another family* ***(left)*** *stands in a home also devastated by water and volcanic ash. Although thousands have fled into refugee camps, many are spiritually tied to their ancestral lands and refuse to give up and leave.*

fumes, and the constant whine of beggars. A sign scrawled on a concrete wall offered, "Repent! Jesus will give you rain."

In a poor neighborhood a line of determined women had already formed at dusk at their water-rationing station; their aluminum and brass pots were strung like a necklace on the sidewalk.

"They sleep here in order to keep their place in line," a local resident informed me. "It goes on all night."

AT THE OFFICE of the water board, managing director Dewan Mohammed outlined the dilemma: "We have to hold on till October," he said. "All our rivers are dry. You can walk from Madras to Kanniyakumari [on the southern tip of India] without getting your feet wet. There are no snow-clad mountains for us, no perennial rivers. Tamil Nadu is a dry state, dependent totally on the rains.

"This is the third year that the monsoon has faltered; it's a hardship. But it will not fail; the rains will come. They have to come."

The previous October, when the winter rains were expected, violinist Kunnakkudi Vaidyanathan had waded into the Red Hills Reservoir and rendered a 70-minute-long raga as an invocation to the gods. Self-styled "miracle man" Thomas Jacob, a bank clerk from Kerala, had sent out telepathic rain-making waves. But only a puja, a Hindu prayer ceremony in which a thousand women in red robes sat with a thousand candles and chanted heavenward, had succeeded in bringing brief showers.

At Kapaleeswarar Hindu temple, where the dried-up temple pool had been turned into a cricket field by street urchins, I watched members of the red-robed sect as they chanted: *"Om, shakti, Parashakti! Om, shakti, Parashakti!"* beseeching their goddess of supreme strength. The gathering joined a growing procession, the men bearing an altar that smoked with purifying camphor and offerings. Musicians struck up a reedy tune, temple bells tinkled, and the procession clanked and chanted down the Madras streets, past wandering cattle, children being lathered at public water taps, and the ubiquitous movie billboards where macho men postured with weapons beside chubby-thighed maidens in distress.

If prayers alone could bring rain, Madras might be sated. But in India even prayer is a matter of form. Said T.V.A. Seshan, a religious philosopher and an editor at the newspaper *Hindu*, "It has to be incanted in a certain way, with a certain inflection, pronunciation, and pitch. The priests can do it. I can't do it."

He chanted unsuccessfully for me in a gravelly voice.

"When a number of persons chant in a particular way," he said, "it creates a certain sound vibration that affects the atmosphere and is capable of seeding the clouds. The priests don't know the scientific aspects of it—they only know the sound has to be in this fashion, in this way."

The wind had picked up that evening, blowing the wrong way from the odorous tidal backwater by the century-old Madras Boat Club. Distant lightning flashed like a pale eye winking. The wind touched the neem trees and whispered through the wicker chairs as Madras waited.

JUNE 13. The coast at Trivandrum was lost in haze and drizzle; the air smelled of iodine. The sky was cast in chalk. I sat in the coffee shop and sulked at the crows. In the previous 83 years only four monsoons had arrived here this late.

Yet rains were reported over other parts of Kerala. The city of Cochin, to the north, had showers at night. On the beach the foam was tinged with evidence—yellow-brown silt loosened by rains in upland watersheds.

Some erosion is natural, but too much of India's topsoil has been lost to the sea. Exposed earth, particularly in the mountains, has little chance to hang together in the sustained downpours of the monsoon. And vegetation has been indiscriminately stripped to dangerous levels—sometimes for profit, often for survival.

The loss of forests has become a major concern and a potent political issue throughout monsoonal Asia. The problem is near critical in Nepal, where nearly a third of the forests have been destroyed in the past 30 years. The Himalayas, the spine of Nepal, are still in full geologic thrust, rising half a centimeter a year with the concomitant grind of earthquakes and crumbling rocks. But Nepalese farmers have accelerated the

natural process, carving foothills into fields, angling their terraces higher and higher, hacking too many trees into firewood, and leaving goats and cattle to nibble at whatever is left.

These high, fragile mountains are the southwest monsoon's natural barrier in the Indian subcontinent, and the winds empty against the newly shorn slopes with a fierce finality. Each year more frequent and more powerful landslides sweep the hills. Terraces, fields, livestock, people, and entire villages have been lost, and many families face each monsoon with growing fear. Thousands have already left for the increasingly overcrowded Nepalese lowlands.

The landslides add enormous loads to the silt flushed into the snow-fed Himalayan streams and suffocate the great rivers to the south, sending them into spate with heavy rains and turning the northern plains into vast lakes. A tenth of the world's population lives here, trapped between seasons of blistering heat and crippling floods that leave crops sodden, homes splintered, and whole communities stranded.

JUNE 14. A lone fisherman, his dark body taut like wires and pulleys, worked his catamaran through the surf to the beach at Trivandrum. He unlashed a net bag of silvery *chala,* a sardine-like local fish, as

The show goes on *for a family in Bojonegoro, Java, although the monsoon-swollen Solo River has carpeted their living room for two weeks. The water is little more than annoying unless it shorts out the electrical system—a hazardous possibility. A candle burns on the coffee table.*

Rain, rain, go away. *For two chilled Javanese girls huddled under a rice basket, the monsoon has lost its magic. With the rains, Mount Galunggung's debris has*

turned their city of Tasikmalaya into a nightmarish landscape of gray ash, giving Indonesia another reason to shift people from overcrowded Java to other islands.

buyers gathered around. His name was Abel Johnson. Such a man should know.

"The monsoon is God's way of providing fish," he said. "When the sea is rough, the water near the shore will be very cold. Fish like cold water, they will come very close, and we will have good tuna, shark, and prawns. And the vastness of the sea will not matter to us."

"But will it come today?" I pressed.

Abel squinted into the horizon where I could see nothing. "It is very hot," he said. "Also the wind is from the west. There was a change in the waves this morning."

Later I heard thunder, and the air was quite still. There was no wind, I realized, for the first time in eight days. And then, at 2:30 p.m., a squall line of gray edged from the southwest. It deepened into a solid wall of clouds that seemed to push the wind before it. The seas leapt into whitecaps, and heavy waves assaulted the shoreline.

Fishermen scrambled to lash their boats to the wooden frames that lined the beach. Palm trees thrashed like gladiators. Darkness covered the earth, and the monsoon, in a churning mass of "rutting elephants," rode majestically into the Malabar Coast.

THE *GRAND LOTTERY* had begun. The rains picked their way at random—blessing, denying, destroying. They fell, as an Indian proverb says, on one horn of the buffalo but not the other.

The initial burst merely doused Kerala but overwhelmed the state of Gujarat. A vicious cyclonic storm, with winds reaching 115 kilometers an hour, tore roofs off houses in the port of Veraval, and the merchant ship *Har Gange,* en route from Dubai, was reported missing. Overflowing dams left 150 villages stranded in the Junagadh district. Military helicopters were dispatched to drop food and supplies to hundreds perched on rooftops. More than 500 people perished.

Almost overnight, grass appeared and leafless trees sprouted in green. Centipedes and slugs and earthworms gloried in the rich mud. Sowing began for the kharif—the autumn crop—on June 17.

By June 21 hundreds of structures—offices, homes, shanties—had collapsed in Bombay. Floods had made shambles of

Rice-paddy pudding *of monsoon mud cushions an Indonesian boy as he tumbles harmlessly from a slippery*

terrace wall near Ujung Pandang on the island of Sulawesi. His brother, driving oxen, smooths the field with a flat board. Later they will transplant seedlings they have nurtured in patches of irrigated soil while waiting for the rains.

Almost afloat in her front yard, *nearly adrift in a sea of tiny leaves, a Javanese girl in the town of Bojonegoro knows firsthand the ravages of monsoon waters. Yet the blessings of the monsoon more than outweigh the blasts, as those who depend on its life-giving waters acknowledge.*

train schedules, and thousands of telephones were cut off as water seeped into buried cables.

By July 6 many of India's major rivers were in spate, leaving countless victims. The highway between Bombay and Goa was blocked by landslides, and three people were killed by lightning. Exhausted Aurangabad finally got its rains by July 10.

ON JULY 20 THE MONSOON was revitalized by a powerful cyclone over the Arabian Sea. The rains reached New Delhi on schedule, making up for lost time, and nourished arid Punjab and the deserts of Rajasthan four days early. Late rain washed over Trivandrum, and Balakrishna Pillai, minister for electricity, upped the movie-house quota to two showings a day.

Bangladesh rejoiced in the annual flooding of its delta, and Burmese mountain tribes hunkered under palm-frond roofs against the deluge. In Thailand Bangkok sank deeper into the mud. In China the Yangtze spilled into the countryside, inundating 70,000 houses and 300 factories in the city of Wuhan. A million Chinese mobilized to fight the waters. Ten thousand marooned peasants were rescued by a boat-and-bridge brigade of the People's Liberation Army.

In Nepal 30 villagers were killed in a wrenching landslide on August 1, in the Baglung district near Pokhara.

On August 11 the Indian government cited a comfortable inventory in the national grain pool, putting the stamp of success on the monsoon. By August 31 only three states—Bihar, parts of Uttar Pradesh, and Himachal Pradesh—were deficient in rains. Even Madras drank deeply, as unusual sweeps of the southwest system held off disaster in Tamil Nadu.

And when the earth again offered its southern half to the sun, and the jet streams had shifted in the troposphere, the rains ebbed and eased out to sea. Asia exhaled.

The cycle done, the wheel turned, penance paid, the gods appeased, India turned once again to wait, searching the skies for clouds as others await the healing sun.

For the perception of rain and clouds differs profoundly between India and the West. In the West clouds signal sadness and

melancholy. A smile is sunny, every cloud must have a silver lining, shady ladies are, well, shady, and into each life some rain must fall.

But in India the monsoon clouds are pregnant with joy. The rain brings the mating cry of the peacock, and darkness the longing of lovers. When the rains come, people run into the street, their arms spread, their grateful tears blending with the sky's benediction. The patter of the rain is like the laughter of young girls, swinging in mango groves and singing a traditional song:

Swing, swing, Rani Raja, till the flowering of the rose.
Swing, swing, Rani Raja, till the flowering of the marigold.
Swing, swing, Rani Raja, till the flowering of the champa. □

TIGER!

LORD OF THE INDIAN JUNGLE

By STANLEY BREEDEN

Photographs by BELINDA WRIGHT

WE SET OFF at sunrise on this winter morning in central India, once again riding Pawan Mala, an old and venerable elephant. Out on the meadows the swamp deer stags are rutting. A tiger roars in the distance, a good omen.

Mahavir, the mahout, steers the elephant toward the tiger's stirring sound. We soon find fresh tiger footprints along a sandy ravine, or nullah—the broad strong pugs of a male. They lead us into dense forest.

We are on the right track; we can smell where the tiger has sprayed a bush to mark his territory. Belinda, my wife, sees the tiger first, an awesome vision in fiery orange and black stripes gliding through the green bamboo tracery. Ignoring us, he walks on and on. We are alongside him now, about 30 feet distant. Once or twice he glances at us and snarls, pale yellow-green eyes burning.

Suddenly the tiger stops in his tracks. He sees a herd of spotted deer browsing on bamboo at the edge of a small clearing. He makes not a motion—no tail twitch, no ear movement, not even a whisker quivers. He is frozen in the partial cover of a small patch of grass. As long as he is motionless, the deer cannot see him, even at 30 or 40 feet. There is no breeze, so they cannot scent him.

Snarling in threat, *a 300-pound tigress warns the authors, in an open jeep 15 feet away, against venturing closer. During the past ten years the team has tracked the great carnivore throughout India.*

Slowly the tiger lies down. For half an hour or more he watches the deer. Then, carefully placing one foot in front of the other so as not to make a sound in the dry leaf litter, he insinuates himself from bush to bush. Closer and closer he moves. It seems our hearts have stopped beating.

Though grazing quietly, the deer are alert. Some does are especially watchful. One sniffs the air; there must be a faint tiger scent, for the doe stamps a forefoot, a sign of mild alarm. The others look up.

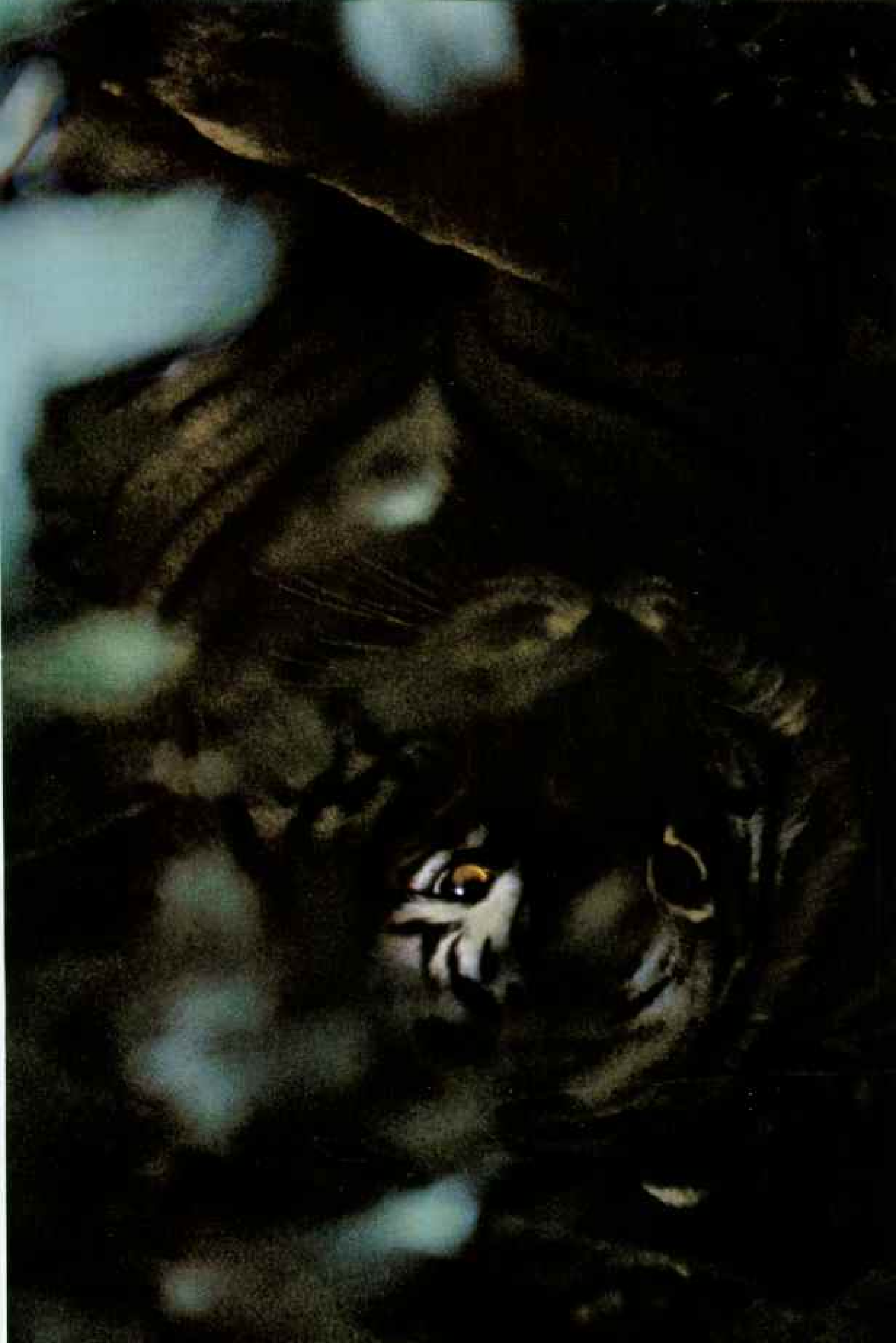
The tiger is rigid in a crouch, powerful hind feet gathered under him. The doe stamps her front foot again, raises her tail, gives her bell-like alarm call. The tiger bursts from cover, tail erect, ears forward. In unbelievably fast bounds he rushes the deer. They scatter. . . .

He misses, snarls, and utters a series of moaning roars. Then he rests, lying in a pool of sunlight. We go closer, to be greeted with

Solitary huntress, *Nikku checks her territory in Ranthambhor National Park in early morning, her tawny coat blending with dry grass, her stripes resembling shadows. Highly territorial, the tigress hunts, usually at night, on a home range of about six square miles; the territory of a resident male overlaps that of four or more females. When residents leave or die, transient tigers move in.*

a snarl and a low, rumbling growl. Never before or since have we seen a tiger with such a bad disposition. We name the tigers we study. This one is Snarl.

PAWAN MALA is tired after her long hike. She fidgets, letting us know it is time to return to camp. "Camp" is, in fact, a two-room cabin deep in the forests and bamboo jungles of Kanha National Park. It is an idyllic spot, far from India's



crowded cities and towns. The only people here are park officials and those who look after the park's six specially trained elephants.

Elephants are essential to tiger-watching in Kanha. Over the years elephant and tiger have come to tolerate each other. Even when the elephants appear with five people riding on them, many tigers ignore both the elephants and their strange cargo.

Ours has been a ten-year affair with the tiger, a quest that lured us back again and again to the Indian jungles. We have met some 90 individual tigers and have come to know a dozen of them well. We have tracked tigers throughout the country.

Mostly we have concentrated in two widely differing places. The first, where we spend more time than anywhere else, is Kanha, a reserve of 232,000 acres. The other, 41,000-acre Ranthambhor National Park, has no dense forest, no bamboo thickets; it is a bowl of scrub jungle and grassland, its harshness relieved by streams and lakes.

In these parks we have had the good fortune to see tigers regularly and at close quarters and to spend hours and sometimes days with them. Slowly we have learned something of their ways, of family life, relations between male and female, hunting techniques, territoriality. The stripes and squiggles on the tigers' cheeks and eyebrows are as distinctive as the fingerprints of humans, and Blue (Belinda's nickname, for her blue eyes) is able quickly to identify an individual, using her index of facial markings.

A FEW DAYS after we meet Snarl, we have a reunion with Arjuna, an old tiger friend, who is on a kill. He is as benevolent as ever. Small scavenging birds and a mongoose nibble at his sambar deer kill. Arjuna is not as tall at the shoulder as Snarl (whom we had seen about three miles away) but is much bulkier, broader in the shoulder. He oozes power, where Snarl is all athleticism.

That evening at dusk we sit on the veranda of our cabin listening to the calls of owls, stone curlews, and nightjars. A distant bark of alarm from a sambar suggests a tiger on the prowl. Suddenly an unearthly sound that shakes the forest brings Blue and me out of our chairs. The back of my neck prickles. All other sounds cease. These are the full-throated roars of two tigers in a life-and-death fight. For about ten minutes the roars continue. Then . . . quiet.

The terrible sound had come from the direction of Arjuna and his kill. The next day we set out in the predawn chill. We find Arjuna, still with his sambar—but he is a much changed tiger. A huge swath of skin and flesh has been ripped away between his eyes

Almost hidden in shadow, *an elusive tiger* ***(facing page)*** *watches the watcher, Stanley Breeden, who uses an 11-foot tripod to steady a camera while working from atop an elephant in Kanha National Park. The Breedens, veteran wildlife photographers, located some of the park's 80 tigers by listening for alarm calls of langurs, deer, and birds, by watching for paw prints and drag marks of a kill, and by scanning dense cover where tigers conceal themselves.*

and down his nose. Constantly he wipes a forepaw across it. We search for the other contestant. A mile distant we come upon Snarl, sitting in a thick patch of undergrowth. He bears a few slight wounds on his shoulder and on the inside of one of his front legs. He snarls at us, eyes burning.

Three months later Arjuna is found dead about eight miles away. His face had festered; unable to hunt, he had died. Snarl takes over his territory.

ONE DAY we sight a tigress and her three cubs under a beautiful *kulu* tree, its white sculptured bark a marvelous contrast to the surrounding black rocks. So we call her Kulu.

It is May and hot, 105°F in the shade. Kulu has dragged her kill, a spotted deer stag, to a cool and protected place—a rock pool surrounded by bamboo. In the early morning all four tigers are crammed into the small water hole. Their coats, sleek and glossy, shine in the sunlight.

After a few minutes Kulu gets up, walks up a small rise, and lies down in the shade. First one cub, then another and another, joins her, rubbing faces or rubbing the whole length of their bodies under her chin. She rubs faces in return and licks them.

Later that day we are out searching for tigers in the heart of Snarl's territory and pause where a few pools of clear water remain deep in a cool forest. We are about three miles from the place where Kulu usually lives with her cubs. We are astonished to find her sitting beside a tiny pool in the bed of a steep-sided stream. What is she doing here? Why has she left her cubs?

Kulu is restless and preoccupied. Normally she would lie asleep in the water or on her back in the sand. But she keeps looking down the nullah, lashing her tail incessantly. Occasionally she moans softly.

Suddenly she sits up, pricks her ears, and stares down the nullah. We follow her gaze. A magnificent male tiger, lean, lithe, and powerful, slowly walks along the streambed. Within about 20 feet of Kulu, he flops down in the sand. It is Snarl, grown larger and more muscular in the months since he defeated Arjuna.

This is no casual meeting. The easy familiarity between the two is quite evident. Kulu no longer lashes her tail. She lies down full-length in the sand. Snarl lies with his head held regally high.

Kulu snoozes. Then she gets up, yawns widely, stretches. Head low, she walks over to Snarl, who purrs in pleasure and friendship. They touch faces. The tigress lies down with all four feet under her, head on the sand. As darkness falls, Snarl gets up, walks over to Kulu, and straddles her.

They mate. Snarl bites her neck roughly and growls. Kulu turns her head, curls her lips, and roars right into his face. He roars back. Snarl walks a few paces and flops down again. Kulu rolls sensually onto her back. It is almost dark.

We wonder why Kulu would mate when she already has eight-month-old cubs. They will be with her another 13 to 15 months. If she conceives, a new litter will be born in about three and a half months. No tiger in the wild could possibly look after two litters. This mating, then, is most unusual.

A month passes. We see Kulu and her cubs regularly, Snarl occasionally. One morning after a heavy downpour we find the tracks of Kulu and her cubs—but also those of Snarl. They converge in a sandy nullah not far from where the pair had mated. There are signs of a struggle, spots of blood.

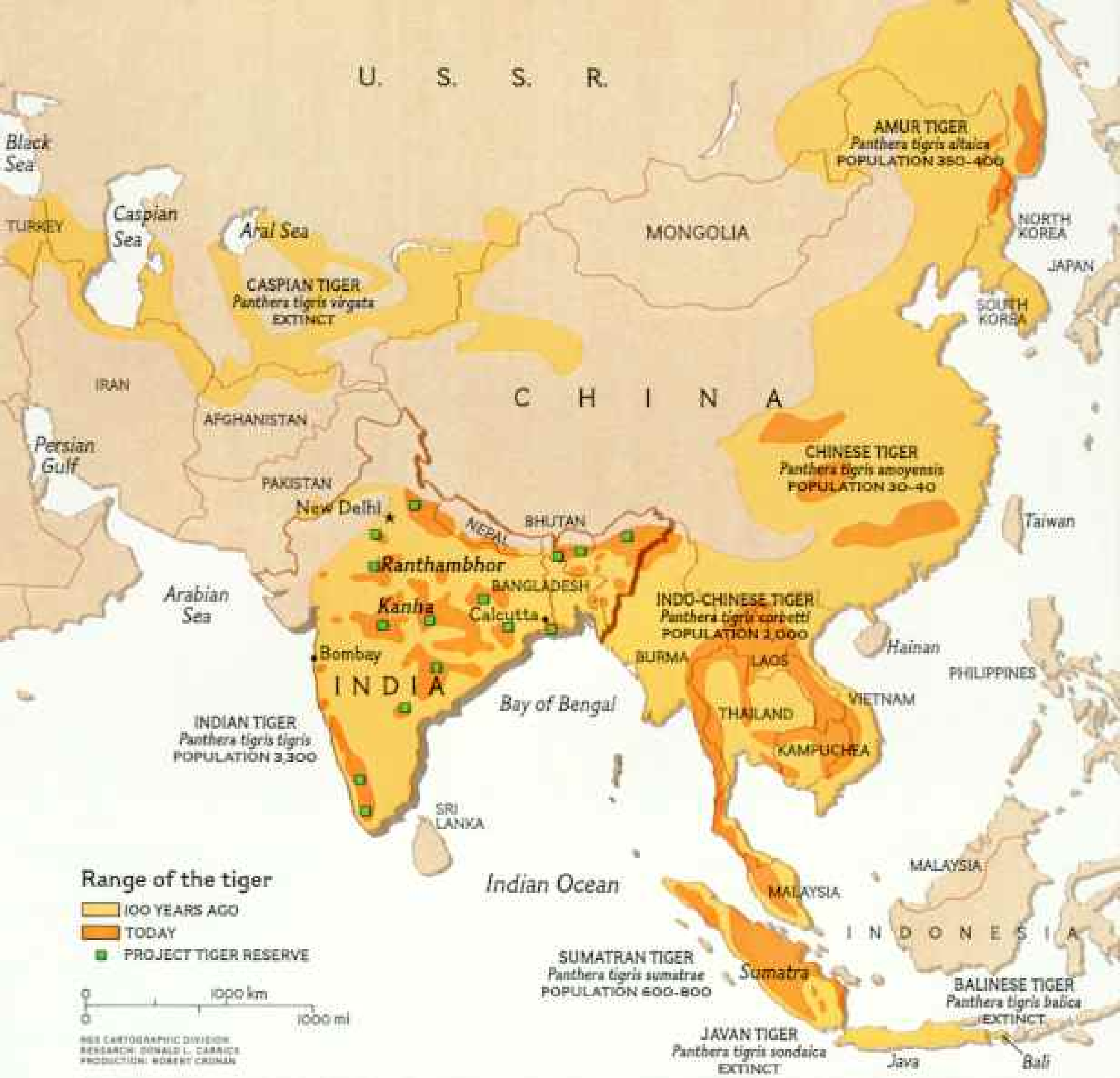
As we round a bend, Snarl sneaks out of a bamboo clump just ahead. Where he emerged, we find the remains of the male cub. Deep punctures in his throat show he died a violent death. Part of his hindquarters have been eaten. Snarl has killed again.

We have not long to mourn the cub. A tiger roars nearby, and moments later Kulu appears. Briefly she sniffs her dead cub, then raises her head and roars loudly—a sound unlike any we have ever heard. She turns and is quickly joined by her remaining two cubs.

They walk so close to her that she almost trips over them. The trio disappears into thick bamboo.

IN 1982 our dearest wish as wildlife photographers comes true. We will spend two and a half years making a National Geographic Television Special.* Most of that time we will work in Kanha.

*"Land of the Tiger" will air on PBS TV on Wednesday, January 16, 1985.



The shrinking range of the tiger

WIDESPREAD IN ASIA until the late 19th century, the tiger appears in the fossil record of the early Pleistocene, more than a million years ago. The carnivore adapted to diverse habitats and evolved into eight subspecies, or races, each with different size, coat pattern, and skull shape. In the past 100 years, with pressure from big-game hunting and the destruction of habitat, numbers dwindled and some races disappeared.

Now tigers enjoy protected status throughout their range. When India found that its tiger population had fallen from a possible 40,000 in 1900 to fewer than 2,000 by 1972, the government joined with the World Wildlife Fund in Project Tiger. Fifteen tiger reserves have been set up, saving varied ecosystems—from the teak-and-bamboo forests of Maharashtra to the mangrove swamps of Bengal. Poachers have been tracked down, education stepped up, and some 6,000 villagers relocated to create these protected islands in a sea of humanity. The number of Indian tigers has risen today to more than 3,000, a third in Project Tiger reserves.

Cooling off in the heat of a June day—*110°F in the shade—Kulu and her three eight-month-old cubs wade in a water hole in Kanha, soon to be flooded by the monsoon. Water, space, cover, and prey are the only necessities for these cats whose go-it-alone*

habits contrast with the lion's. As a mother, a tigress must by herself find food and train her offspring for about two years until they become independent. Patterns of facial stripes, as distinctive as fingerprints, help the authors recognize individuals.

We resume our pattern of tiger searching. On a cool April morning Blue rides on Shivaji with Sabir, his mahout. Shivaji is the pride of Kanha's elephants—a large male tusker, powerful and well proportioned. I am with Lucknoo, the best tracker and the mahout of a smallish female elephant called Pawan Kali. She is young, especially well trained, and good at standing absolutely still, which is essential for filming.

Soon Lucknoo spots tiger pugmarks in the sand—the large prints of a male. Deep green bamboo rises on either side of us. Its feather-like foliage reaches down to the grass, the golden stems looking like tiger stripes. Then I see something out of the corner of my eye that is more orange than yellow, with more black and more white than the bamboo.

We move closer, pushing through foliage dripping with dew. There lies Langra, a superb tiger of clean-cut pattern and classical features. He must weigh 500 pounds.

Langra stares at us with pale eyes. He keeps staring, which is unusual. Tigers that are used to elephants, as is this one, ordinarily flop down and go back to sleep

after a cursory inspection. We soon realize the reason. Half-hidden by a patch of bamboo lies the carcass of an enormous sambar stag—the largest I have ever seen, alive or dead. We retreat a short distance.

In the warmth of midmorning Langra leaves for a drink at a small pool half a mile away. We take a closer look at the sambar. Very little has been eaten, only about ten pounds of meat from the back of one hind leg, which suggests that he was killed only recently. Tigers begin their feeding from the rump and work forward.

I'm here: *Nikku sprays a palm tree with urine and a glandular secretion (**top**) that together proclaim her presence, her territory, and, during estrus, her readiness to mate. Reacting to such scent markings, Quiz grimaces (**left**), thus opening ducts in her mouth to an organ that "reads" the compounds.*

*A resident male moves through female territories at will. Some males on occasion kill cubs. Ill-tempered Snarl pierced the throat of Kulu's male cub (**above**) and ate part of the hindquarters.*

Langra killed the stag by seizing him by the throat and then asphyxiating him. The deep puncture marks of the tiger's huge canines are clearly visible. We see that the kill was actually made in the sandy nullah, after which the carcass was dragged about 150 yards to the protection of the bamboo, where it is invisible to even the keenest-eyed vulture. Weighing some 700 pounds, the deer was much heavier than the tiger, but Langra moved it on his own.

ELEPHANTS PROVIDE the only means by which we can follow tigers into the forest. But the big animals are slow and must rest frequently. For long forays over open terrain we use our jeep.

In central Kanha lives another territorial male. When we first meet him, some weeks after our encounter with Langra, the weather has again become hot. Water holes are the focal points for both tigers and their prey. We stop our jeep at the largest of the pools to see which animals may have come to drink. The water hole is deserted.

Langur monkeys sit high in the trees, and the troop's adult male barks occasionally in alarm: A large predator must lurk where the monkeys can see it. We drive closer to scan the entire pond, and we spot the tiger. His

Mating begins with a nuzzle *but ends with a roar. During estrus, the female initiates courtship with the resident or a transient male. Here Links strolls up to the reclining Abu (**above**), arousing his interest.*

*In a noisy finale (**right**), never before photographed in the wild, the tigress Banseri, left, mates with Langra. Mating episodes are repeated for up to three days. If conception occurs, a litter will be born in about 100 days; if not, the female comes into estrus again in about 25 days.*

gigantic shaggy head is raised high—he is watching us and trying to catch our scent. The rest of his body is hidden by grass and the water in which he lies.

Satisfied that we pose no threat, he lies down again, panting heavily. Tigers in Kanha are not used to vehicles and usually run when they see one. Encouraged by his disregard, we edge the open jeep closer. Finally we come within 50 feet, close enough to see that he has just eaten an enormous meal. His stomach is grossly distended. He is panting so hard that waves emanate from his heavy body and ripple across the pond.

For an hour we sit in the shade of a tall *saja* tree watching this giant in fascination. He ignores us, yawning disdainfully. His worn yellow teeth tell us that he is old. The tip of his lower right canine is broken off.

After an especially wide yawn, groaning with the effort, the tiger gets up and stretches, dripping water and mud. He is even larger than Langra, weighing around 550 pounds. He walks directly toward us. In the late sun he shares the saja tree's shade. No more than 15 feet from our jeep he sits and

With long-sought trust, *Banseri nurses her cubs within 50 feet of the authors, who had watched her movements since she gave birth in a cave five months earlier.*

licks the mud off his coat. We call him Saja after the tree that blesses us with its shade.

Ever since, we have enjoyed a special relationship with Saja. When he spies us, he often comes over and sits by our vehicle. Saja occupies Snarl's old territory. So the malevolent Snarl was not invincible.

When we are with wild tigers, when the great cats show that they trust us, we feel as though nature has revealed one of its greatest treasures. These feelings are engendered by the tiger's awesome presence, its power, and its uncanny ability to appear suddenly and quietly and equally suddenly vanish from sight. There is something special about being close to a lone hunter who moves by stealth and is rarely seen.

This feeling of privilege is heightened by knowing we are close to an animal that is not only formidable but also extremely rare. The tiger, because of overhunting and the massive destruction of its habitat, is an endangered species throughout its range.

At times we seem to develop an extra sense about tigers, to have a special rapport with them. *(Continued on page 768)*

Soon to be weaned, the cubs accompany Banseri to her kills. Over the next months they will learn to hunt; meanwhile, she sometimes cripples prey for them to dispatch.

Tale of persistence *stars Abu, an aggressive male in Ranthambhor. At sunrise the authors were drawn to this water-lily-choked lake by calls of alarm—the resonant bark of sambars, the cough of langurs, the honk of peacocks. There they found a perplexed Abu staring at the water (**left**). Twice he waded in, snarling and hissing (**lower left**). But each time he changed his mind and retreated to continue his long vigil. A few hours later, 150 feet away, the carcass of a sambar appeared on the surface surrounded by four muggers, the freshwater crocodiles of India. Possibly when Abu killed the deer in the water, the crocs frightened him off. Finally in late afternoon Abu regained his courage and charged through the lilies. He grasped the sambar at the throat (**above**) and, struggling with the heavy victim, swam his supper back to shore.*

On great cat feet *a tiger stalks a chital* ***(left)****, which cannot see the predator in the dry grass. Before making its final rush, the cat creeps to within 40 feet, its pads placed so carefully that there is no sound during the 20-minute stalk.*

Like a released spring, Abu explodes across the shallows ***(below)****, driving a sambar fawn into deep water where he will bring it down with a powerful bite in the neck, his canines piercing the vertebrae. An exceptional animal, Abu charges from as far as 150 feet; most tigers display only short bursts of speed. If the hunter misses, as the average adult does perhaps 19 out of 20 times, it gives up and seeks a different prey, sometimes lying in wait beside a game trail or water hole.*

With no concern for a former mate, Mario feasts ***(right)*** *on a sambar doe he stole from Lakshmi. Fastidious even when famished, a tiger carefully dresses its prey. Licking away any blood, it cuts through the skin of the hindquarters with shearing teeth, pulls out intestines with incisors, and carefully empties the rumen sack. The tongue, rough as a scraper, cleans the bones. In the end only the largest bones remain. Forty pounds of meat makes an average day's meal.*

Though sometimes within ten feet of them, we rarely know fear. They come up to us, or let us approach them, openly and inquisitively. Never have they stalked us, and only once have we been rushed in anger.

We never feed them or stake out baits to win their trust. We feel our mutual respect would suffer if the tigers came to see us merely as providers of food.

WE REGULARLY SIGHT five adult tigresses in Kanha. The beautiful, quixotic, and aggressive Banseri (after the Hindi word for bamboo flute) we come to know best. We have spent more time with her than any other tiger.

Perhaps Banseri becomes my favorite tiger because of the startling intimacy of our initial meeting. The first of the monsoon rains have come and gone. It is a bright morning in early July, sparkling with dew and clear light. Blue and I watch six elephants and their riders comb a small meadow searching for tigers. The mahouts see nothing of interest and move out of sight.

I decide that it is safe enough to go bird-watching. I follow a narrow animal trail that traverses the meadow. Across it I walk up the bank of a damp gully. Rising out of the three-foot-high grass, like slow fire, looms the head of a tiger about 15 feet away.

I look straight into Banseri's eyes, and I turn to ice. The cat is ready to spring. Our eyes lock for only a split second. Then she roars deafeningly, wheels, and runs off.

I walk back on rubbery legs to the jeep. There is no time to dwell on the incident. Soon Sabir, riding the tusker Shivaji, comes up excitedly to tell us they have found a tiger. It had come running from behind them. It is Banseri, fully stretched out and completely relaxed on the topmost rock of an outcrop of boulders. Trailing wisps of bamboo screen her on all sides.

Fiercely possessive, *Lakshmi lies close to her chital stag dinner to protect it from other tigers and scavengers. So protective are tigers of their kill that they fend off even small creatures like birds. After eating her fill, Lakshmi will cover the remains with leaves for her next meal. With another kill—a sambar doe brought down in a steep streambed—she could not drag the carcass to*

There is only one clear view of her, from a rocky ledge. It is wide enough for an elephant to stand on but has room for only three of his legs. Sabir gingerly maneuvers Shivaji into position. The ledge is less than 12 feet from Banseri and slightly below her.

Banseri at first acknowledges my presence by no more than a raised eyebrow. I begin to film. I look up from the camera to find, once more, my eyes locked with those of the tigress. This time we stare longer.

Because a direct stare can be a challenge to some animals, I eventually look away. Perhaps she recognizes me from our earlier encounter, for she hisses, spits, and snarls with her lips curled back. The moment passes. Banseri slumps, drapes herself over the rock, and sleeps.

As the months go by, there are periods when we see Banseri almost daily. In late January we notice as she lies beside her kill that she has swollen teats. She has cubs! We don't see them until April, when Banseri emerges from a cave followed by two small cubs about four months old.

A month later the family moves down the slope to a small, flat area of bamboo. The ground is covered with large, dry leaves. Banseri lies on her side, stretches luxuriantly. First one cub, then the other, comes over to rub faces with her and to nurse. It is utterly beguiling; the cubs, paws resting on their mother's flank, their faces moving up and down with her breathing, nurse and nurse. For 45 minutes they suckle uninterruptedly.

TO SEARCH OUT TIGERS in a very different habitat, we move on to Ranthambhor, about 370 miles northwest of Kanha. The park consists mostly of low, rounded hills covered with semiarid scrub. But lakes lie cradled in the hills, and it is because of this permanent water that tigers and their prey flourish here.

*cover and tried, unsuccessfully, to hide it with rocks (**above**). Ordinarily tigers feed only on other wildlife, but in rare instances they attack humans. Sometimes the man-eaters are wounded tigers or those disturbed by farmers who move cattle and plant fields inside the animals' ranges. Dozens of deaths have been attributed to tigers each year in India, far fewer than those blamed on elephants.*

The terrain is too rocky and scrubby for elephants. We follow the tigers in an open jeep. Blue drives while I sit in the back with the camera mounted on a short tripod. It is ideal for filming. Being lower and no longer perched on top of an elephant, we have a closer, more intimate view of the tigers.

On a cool morning in early spring we find the tigress we call Links (the pattern on her tail resembles links in a chain). She is stretched out on a prominent rock, absorbing the sun's early warmth.

Thoroughly warmed, she yawns once, then twice. In one fluid motion she rises and leaps down into the grass. We follow her bright, compact, and muscular form. She walks leisurely through a landscape of occasional trees standing in a sea of grass.

From a thicket of bushes and trees erupts a peacock's *kok, kok, kok, kok* of alarm; we see the bird fly up in panic. Crows soon gather in the bushes, cawing and looking down on the ground—typical behavior when they find a tiger on its kill. Walking, then trotting, Links heads for the disturbance. We expect her to be greeted by roars from another tiger defending its kill.

Instead, a jungle cat, about the size of an ordinary house cat, runs off. It had caught a peahen, which Links promptly steals. The tigress picks the bird up in her jaws, but in such a way that its wings fan out and cover her eyes. She blunders into bushes and trees. She tries walking backward, with no better results. The more Links runs into obstructions, the more confused she becomes. Almost panic-stricken, she finally sits down. Vision restored, she eats the bird. After her snack she stretches out to sleep.

In midafternoon Links walks to the edge of the thicket and scans the grassland. A herd of spotted deer is emerging from the

distant tree line. We are alerted by the change in her. She is suddenly tense, all senses directed at the deer, waiting intently as they move nearer. We back off a little so that we are no longer between Links and the herd. Slowly, almost imperceptibly, the tigress rises to a half crouch and slinks into the thicker grass. All we can see are the white spots on the backs of her ears.

She has gone 30 yards or so when she turns back in our direction, staring directly at us with an intensity we had not experienced before. Slowly she turns completely around and comes straight toward the jeep.

We shift in our seats. Has she become so hungry she is stalking us?

Instinctively looking behind me, I see what she is stalking. A yearling male sambar is walking up behind us. The wily Links is using us as cover. The unsuspecting sambar comes ever closer.

Tiger! Lord of the Indian Jungle

Links is crouched, frozen, taut muscles standing out in ridges under her smooth skin. Tautness and tension explode in one gigantic leap. With the claws of her front paws out and straining, Links reaches for the sambar. He barks in fright and races off, Links hot on his heels. Her claws must have grazed his skin, but he escapes.

Fifteen times we have seen tigers stalk a deer. Not once did they kill their prey. Few attacks, perhaps only one in twenty, are successful.

EXCITED AS WE ARE by these experiences, they pale into insignificance when Abu makes his presence felt. Abu turns out to be a supertiger, one of extraordinary power and assertiveness. He is faster, stronger, more athletic than any we have ever met. When he makes his move, he does so with great determination and force. Yet he is no larger and certainly less bulky than the other fully adult males with which we have been involved.

Abu is without malice. We often approach him very closely without being threatened. More than once he uses our jeep as cover to stalk a sambar or spotted deer.

On a chill and moonless night we sit beside a comforting fire under a huge banyan tree with our friend Fateh Singh Rathore, field director of Ranthambhor. Halfway through our evening meal, a full-throated roar resounds across the lake. Again and again the tiger roars, ever closer.

We had never recorded such calls. We unceremoniously leave our dinner, grab our tape recorder, and race off in the jeep, though ill prepared. The jeep's battery is almost dead; we can use our headlights only sparingly. Our flashlight produces only a glimmer.

The tiger is still roaring as we set off, but soon he falls silent. We stop where we think he has last called, and Blue sets up the recorder. Only the stars, crackling and blazing

Expert at doing nothing, *tigers spend most of their time conserving energy for the hunt. Lakshmi lolls in the dry leaves after feeding for three days on a chital stag. She won't hunt for two more days in a cycle of work and rest.*

in the cold sky, give us light—we are surprised at how much we can see. But we hear rather than see the tiger. Now he roars with full force only 40 or 50 feet from us—a thundering sound that makes our hair stand on end and our blood run cold.

As suddenly as they began, the roars stop. In the silence, our senses heightened by the flow of adrenaline, we can hear the faintest cricket chirp. An owl calling softly overhead startles us unreasonably. The crackling sound of footsteps on dry leaves and twigs comes toward us.

In the faint light we see the tiger emerging from the underbrush. He advances purposefully and steadily. When he is close, perhaps 20 feet, we turn on our feeble flashlight. Its beam is just enough to identify Abu. He walks past without a glance at us.

For four hours Abu walks around and roars, his volume never diminishing. Never before or since have we heard a tiger roar or produce any other sound for such a sustained period.

SAMBARS become compulsive lake visitors as March ends. Herds of as many as 30 animals descend from the hills two and sometimes three times a day to drink and to feed greedily on the water lilies. To reach the water, the sambars must walk through tall grass that fringes the lakes. This is when they are most vulnerable to ambush, in which Abu specializes.

One morning we track Abu to a lake where his pugmarks disappear into the grass. They do not reappear at the other side. We place ourselves with a good view of where we think the tiger will make his rush. Sambars arrive at the lake but stay on the opposite shore. Constantly they test the air with their sensitive noses. More deer come as the day wears on; the increase in numbers gives them confidence. Walking through the shallows, nibbling at waterweeds, they slowly move toward Abu's hiding place.

We see him begin to stalk. Slowly he creeps to the edge of the grass. Only a thin screen hides him. He lies down. None of the deer can see the tiger sitting immobile some 60 feet from them.

A doe with a small fawn at heel finally detects Abu, perhaps scenting him on the light breeze. She wheels. Before she has taken a single running step, Abu, in an explosion of power and speed, bursts from cover and chases the herd into deeper water.

In four gigantic bounds Abu pounces on the fawn, pushes it underwater, and grabs it in his powerful jaws. He shakes it. Trotting back to shore, he disappears into the grass. The sambars have vanished. In a few moments birds sing again and monkeys resume play. It is as though nothing has happened.

For the first time in a decade of tiger-watching, we have witnessed a kill.

HOWEVER RESOLUTE Abu is in the chase, he is even more tenacious when it comes to defending his kill. Blue and I know this too well. We watch for hours one day as he struggles to reclaim his sambar prey from the crocs in the lake and then haul it ashore and into the forest. He is eating hungrily when we approach him.

For Abu, our intrusion seems the last straw. Without warning he charges, bounding right up to the front of the jeep—claws lashing out, teeth bared.

We shout and wave our cameras and whatever else we can grab in his face. At the last moment he relents. Growling under his breath, he returns to his kill. As we slowly back away, he dashes snarling at us again, but we are able to keep our distance.

We can only assume that the tensions of the day have put Abu on edge. We had been much closer to him before, and have been since, without a threat from him.

A few days before we leave Ranthambhor and tiger country, Abu and Links get together, and we manage to film them in sometimes tender, sometimes violent intimacy. Our tiger story, thanks to Abu the supertiger, is complete. □

Beauty of the beast *reflects from a forest pool that draws animals of Kanha from great distances during the dry season. The tigress is ever aware of other tigers in her vicinity in order to avoid encounters. Brought back from the edge of extinction, the tiger remains an enduring part of India's wildlife heritage.*

RARE LOOK AT SPERM AND BLUE WHALES

The Unknown Giants

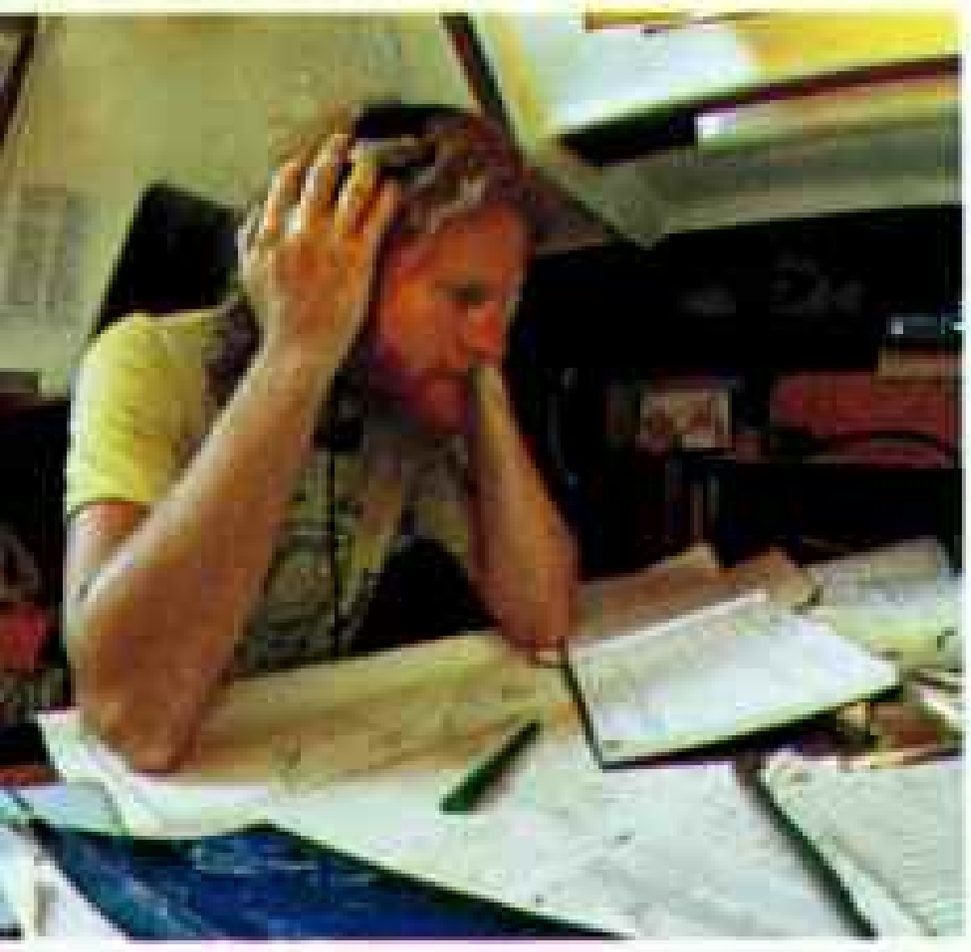
By HAL WHITEHEAD

Surprisingly agile for its imposing size, a sperm whale heads for the depths of the Indian Ocean. The giant has been hunted for its prize oil for centuries, yet the mysteries of its behavior are just now being unraveled.

Photographs by FLIP NICKLIN

Six lolling sperm whales *(above) chat in their mysterious clicking language. Codas—unique patterns of clicks—may permit individuals to identify each other. Other clicks may act as sonar to locate and, some believe, to stun prey. Aboard the research vessel* Tulip, *the author* **(below)** *tracks sperm whales in the northern Indian Ocean.*

Sri Lanka has won worldwide gratitude and congratulations for its role in establishing the Indian Ocean as an international marine mammals sanctuary. Leaders in that effort have been Sri Lanka's National Aquatic Resources Agency and its affiliated Centre for Research on Marine Mammals of the Indian Ocean.



IT IS AT NIGHT that I feel closest to the sperm whales. During this three-hour watch my four fellow crew members aboard the research vessel *Tulip* are asleep, and I am alone with the sounds.

Through a sensitive hydrophone suspended beneath *Tulip*, I hear the clicks of a family group of about 15 whales half a mile below me, spread out over an area of several square miles. Some of the whales are silent, but most are clicking regularly, about once every second, as they hunt for food in the depths. To me they sound like several galloping horses.

Most scientists believe that these regular clicks are a form of echolocation by which sperm whales find their prey and home in on it. As I listen, one of the louder series of clicks suddenly pauses, then begins again at a faster rate—perhaps three clicks a second.

I can visualize the scene below as the whale approaches its prey, probably squid or fish. The clicks grow faster as the distance narrows, until the whale sounds like a creaking door. Then all at once the clicks stop abruptly, and the hunt is over. Soon a different series of clicks begins to speed up, and another chase is on.

Such nightly foraging is vital to these sperm whales, who must fuel their massive 12-ton bodies with an average of about 800 pounds of squid and fish a day.

Over the past three years my colleagues and I have studied these fascinating, little-known creatures in the waters off Sri Lanka in the Indian Ocean (map, left). We soon learned that although the whales have eyes, and sometimes seem to be studying *us*, sound is more important to them than vision. It is principally with their clicks that they "see" the world around them.

Thus, to me, these clicks resounding in the depths give a clearer sense of the life of the sperm whale than do the strange, wrinkled bodies we see in daylight on the surface.

But the clicks are more than a means of echolocation; they appear to be a form of communication. Dr. William Watkins of the Woods Hole Oceanographic Institution in Massachusetts has detected what he calls codas, which are distinctive patterns of clicks that seem to be different for each individual whale.

We often hear these codas when the whales are socializing—maneuvering close to one another at or near the surface, usually at midday. The whales seem to "talk" by means of the codas in patterns we have come to recognize but cannot yet understand.

During my three-hour watch that night I heard few codas, for the whales were at work down below, hunting rather than socializing. As dawn swept the ocean, I knew my colleagues and I would soon be able to see the whales.

We were a well-matched team: Jonathan Gordon, an English research student at the University of Cambridge doing his doctoral thesis on sperm whales; Americans Margo Rice and Martha Smythe, both experienced observers of whales; Gay Alling, a graduate student at Yale University interested in dolphins and the smaller whales; and I, a research associate at the Newfoundland Institute for Cold Ocean Science at Memorial University in St. John's.

We were all a long way from home, and so was *Tulip*. She was built in France as a sailing yacht, with a 33-foot fiberglass hull, a 25-horsepower diesel engine, and room enough below to sleep five. She had been named after the flower symbolic of the Netherlands, in honor of the country whose people supplied funds for our study through the World Wildlife Fund of the Netherlands and the International Union for Conservation of Nature (IUCN).

Over the course of our study between 1981 and 1984, a dozen students and scientists, all sailors, were to come and go aboard *Tulip*, but that April morning of 1983 was typical in terms of crew and daily routine.

AS THE EASTERN SKY grew lighter, I adjusted *Tulip*'s sails and self-steering gear to a heading of 135°, the direction the whales were moving at a leisurely two knots. Then I went below, put the kettle on for tea, made an entry in the ship's log, and shook Martha lightly.

"Wake up. Your watch—we're still with the whales."

Minutes later Martha came on deck with two steaming mugs and handed me one. "Where are the whales?" she asked.

"Heading southeast at about two knots," I said. "You'll hear them on the hydrophone."

Dangerous mission of mercy: *Risking becoming ensnarled themselves, crew member Philip Gilligan, left, and Terry Nicklin, the photographer's assistant, attempt to cut loose a fishing net dragging from a sperm whale's flukes. "It was really scary," the photographer recalled. "If they had gotten caught in the net, they would have had it." The would-be rescuers could remove only part of the*

net before the whale dived; its chances of survival were uncertain. Hopes for the future of the species as a whole were bolstered in 1979 when the government of the Seychelles proposed that the Indian Ocean be declared off-limits to commercial whalers, though there was no assurance of universal compliance. Scientists aboard Tulip conducted a three-year research project in the new sanctuary.

An hour after sunrise we spotted the whales on the surface, and our crew stationed themselves at various points aboard *Tulip* for daytime observation. Jonathan climbed the mast and suspended himself in a canvas bosun's chair at the crosstrees, draped with cameras, a tape recorder, and an intercom unit to Martha on deck. Martha recorded Jonathan's observations and relayed directional signals to me at the helm. As usual, Gay and Margo stationed themselves at the bow with cameras. Thus nearly everything that happened would be recorded by at least one member of the team.

Like the whalers of old, we normally sighted sperm whales by spray from their low, slanted blows at the surface. Unlike the whalers, however, we were engaged in "benign" research—that is, research based on observation of living whales rather than on examination of harpooned carcasses. One of the pioneers of benign research on whales is the distinguished American cetologist Dr. Roger Payne, who joined us aboard *Tulip* for several days in 1983 and 1984.*

On that April morning the whales allowed us to sail within a few yards as they sauntered along at the surface. We approached one of them cautiously as I eased the sails and we drifted gently alongside. Only the click of cameras and the regular blowing of the whale itself broke the silence.

With practiced routine we took the whale's portrait. Jonathan photographed it from above to determine its length, at the same time tape-recording its blows to establish their number and frequency. Gay and Margo concentrated on photographing the dorsal fin, a key element in the identification of sperm whales. Martha noted a distinguishing feature of the dorsal.

"It's a female; she's got a callosity," she said, pointing to a large pale callus at the top of the fin. Mature male sperm whales do not exhibit this phenomenon.

After 15 minutes on the surface and precisely 60 blows, the whale arched her back and accelerated. The great square forehead thrust upward for a final blow, the whale arched down, lifted her massive flukes, and was gone. At the last moment Gay and Margo managed to photograph the flukes, an equally vital feature for identification.

*See Roger Payne's NATIONAL GEOGRAPHIC articles on right whales (March 1976 and October 1972) and humpbacks (April 1982 and January 1979).

PHILIP GILLIGAN, WORLD WILDLIFE FUND/BRUCE COLEMAN, LTD.

But our portrait was still incomplete. As the smooth slick from the whale's sounding began to spread, we hurried to the spot and with a dip net scooped up some of the feces she had released on diving. As usual the feces contained squid beaks, one of the few materials that seem to survive the sperm whale's digestive system (below). Most of the beaks were almost half an inch long, remnants of squid roughly one to two feet in length and two to four pounds in weight. One beak, however, measured roughly an inch, indicating a squid about seven feet long and weighing as much as 80 pounds.

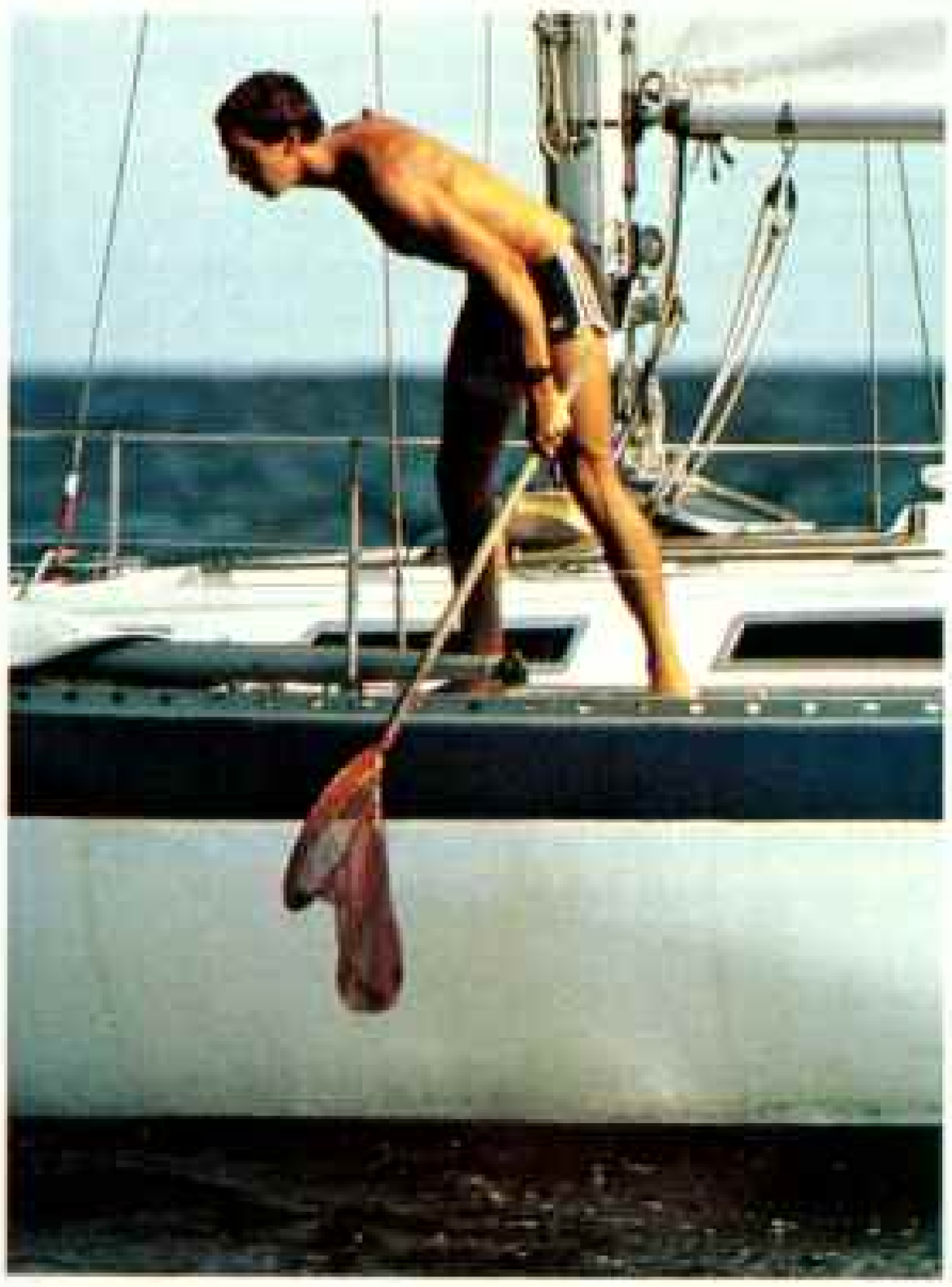
FROM HUNDREDS of such days and nights we slowly gathered data on what Herman Melville described in *Moby Dick* as "the most formidable of all whales to encounter; the most majestic in aspect." Probably Melville was referring to the full-grown bull sperm whale, which can reach a length of 60 feet and a weight of more than 60 tons. During our study, however, we encountered one species of whale that is more majestic if not more formidable than the bull sperm whale. This is the great blue whale (pages 786-9), whose bulk can equal that of 33 African elephants and which remains the largest creature ever to inhabit the earth.

Yet despite its somewhat smaller size, the sperm whale to me is a more fascinating animal, one that has few equals when it comes to concentrated might. Among all the great whales the sperm whale alone has teeth; the rest have baleen with which to strain their food from the sea.

On the surface the sperm whale is admittedly unimpressive, resembling a huge, wrinkled log. Were it not for the periodic blows, in fact, one might scarcely know the great animal was alive.

Once underwater, however, sperm whales are different creatures—flexible, graceful, wonderfully maneuverable.

Still, the sperm whale is decidedly weird in appearance. Its front quarter consists of an enormous bulging "case," a vast forehead filled with the finest oil known to man. Early whalers mistook the oil for sperm and named the animal accordingly. Once the oil's value was known, the sperm whale was relentlessly hunted down and reduced from estimated original stocks of more than a million to several hundred thousand today.



With misguided affection, *a newborn calf (**left**) nuzzles the hull of Tulip. The author theorized that the calf may have mistaken the pings of the boat's depth sounder for the clicking noises of its parent. To study feeding behavior, which occurs at great depths, crew members gather whale feces (**right**) as indirect evidence. The feces contained squid beaks (**above**), which were saved for species identification.*

Scientists still debate the function of the case and its huge reservoir of oil. Some regard it as a focusing system or echo chamber for the sperm whale's clicks, while others consider it a form of buoyancy regulator. No one yet knows the answer.

Another puzzle concerns the sperm whale's jaw. After long hours of observation above and below water, we concluded that the jaw is used mostly in social circumstances. For example, we have seen adult sperm whales "mouth" calves with their jaws or touch one another with them, as though kissing. At other times adults will clap their jaws in the air or underwater in what appear to be aggressive displays. The latter interpretation is supported by the appearance of parallel scars on the heads of large bull sperm whales, apparently inflicted by teeth in the lower jaw during fights.

Though sperm whale teeth are impressive, they may be secondary when it comes to feeding. We observed one seemingly healthy whale off Sri Lanka with a badly deformed jaw, and similar cases have been reported elsewhere. Moreover, most squid that sperm whales eat are swallowed whole. Dr. Kenneth Norris of the University of California at Santa Cruz, a widely respected authority on whales, offers the fascinating theory that whales may use extra-loud clicks to stun their prey before devouring it.

Adult sperm whales feed at depths where calves never venture, but we saw females take turns baby-sitting offspring at the surface. Like other mammals, they nurse the calves until they can forage for themselves at about two years. While snorkeling behind *Tulip*, we have sometimes seen a sperm whale calf nuzzling in the area of an adult female's nipples. Once two calves seemed to be suckling the same female. But since there is no evidence of surviving twin calves, one of the youngsters probably wasn't nursing from its own mother.

Calves appear to remain with the group in which they were born for about five years. At this point the males separate and form bachelor groups; the females either join them or remain with the family group.

As the male sperm whales grow, they move to colder and colder seas. Full-grown bulls spend most of the year in arctic or antarctic waters, returning to the tropics only for a few months to mate. By contrast, adult females spend their entire lives in warm waters, where they raise their calves.

IT WAS in the autumn of 1983 that we witnessed an actual sperm whale birth. At the time my companions aboard *Tulip* were Chris Converse, a champion sailor; Philip Gilligan, a longtime companion in my studies of whales; Caroline Smythe, Martha's twin sister; and Lindy Weilgart, a graduate student in whale acoustics at Memorial University of Newfoundland.

We had been following a group of some 15 whales for a day and had noticed a calf with part of its umbilical cord still attached,

Floating reservoir, *the whale's head contains 10 to 15 barrels of high-quality oil. Scientists speculate that the oil chamber may amplify the whale's clicking sounds or help control buoyancy.*

evidence of very recent birth. Early on the second morning an adult whale, whose callus on the dorsal fin identified it as a female, suddenly surfaced 30 yards off *Tulip*'s bow, flexing her body so that at times both her head and flukes were out of the water. Moments later she rolled over, presenting her belly to us, as a torrent of blood gushed from her genital area. A dark object followed, materializing within seconds into a tiny sperm whale calf with curled flukes and a bent dorsal, bobbing alongside its mother.

Lindy was instantly overboard with a mask and snorkel, and I was up the mast. We watched in amazement as the calf separated itself from its mother and approached closer and closer to Lindy.

"I could see the umbilicus attached to the calf," Lindy said later, "as well as the afterbirth protruding from the mother. I was astonished that the calf had bright blue eyes."

Soon the calf was put through a rigorous ordeal. Four adults gathered to inspect the newcomer, pushing and squeezing it among themselves as though to get closest to it. At one point the calf was lifted bodily out of the water. Finally the visitors retired, and the calf caught sight of Lindy again, hovering a dozen yards away. Obviously intrigued, the calf swam clumsily over to investigate and stopped a yard from Lindy while the mother hung back, watching.

Lindy was awed by being within touching distance of such a newly born creature.

Later, when Lindy returned aboard, Caroline remarked, "You know, that calf spent more time with you in the first half hour of its life than it did with its mother!"

As the calf hung motionless inspecting Lindy, it suddenly discovered *Tulip*.

Tulip's propeller was stopped, but the echo sounder was operating, emitting a series of pings. To Lindy's surprise, the calf swam over and nuzzled the boat's hull where the echo sounder was located, possibly mistaking *Tulip* for another adult.

By this time there was no longer any sign of the calf's mother. We were horrified at the

thought of the calf as an abandoned waif, a victim of starvation or of the first predator to come along. There was nothing we could do but leave, for to stay with the calf might prevent the mother from rejoining her offspring. An hour later, to our great relief, we saw an adult female—the mother or some other member of the group—with the calf.

FOR ALL their decimation of whales, commercial whalers left one useful legacy to the conservationists: They have told them where to look for survivors. In choosing the area for our study, Jonathan Gordon and I had examined 19th-century records that described the Indian Ocean as a vast and inexhaustible whale sanctuary.

Inexhaustible it is not, but a sanctuary it has become, thanks largely to the government of the Seychelles. In 1979 the Seychelles proposed the Indian Ocean as an international refuge for whales and suggested that studies of them be conducted there.

Ours was one of the first studies, and during it we encountered not only sperm whales but also giant blues, Bryde's whales, and rare beaked whales. We also heard the haunting underwater songs of humpbacks. We saw dolphins, too, and thanks to Gay Alling's research, Sri Lankans are aware of the tragedy befalling these beautiful creatures. Throughout the Indian Ocean, as elsewhere, they are being unintentionally caught and killed by the tens of thousands in drift nets set by commercial fishermen.

Nor is the Indian Ocean entirely safe from whaling. Although the International Whaling Commission has declared a worldwide moratorium on commercial whaling beginning in 1986, Japan and the Soviet Union have objected and may continue whaling, possibly in the southern Indian Ocean.

In the long run education will also help save the whales. As one of the most important elements of our work, Margo Rice visited the schools of Sri Lanka and talked with the students about whales, the ocean, and their conservation. The response from her audiences was enthusiastic, but Margo's lectures—like the *Tulip* project itself—are only a beginning on which we must capitalize.

And what does *Tulip* leave in her wake? To begin with, identification of more than 200 individual sperm whales, with invaluable data on their lives and behavior. As our research continues and the identification files grow, scientists will be able to explore the long-term relationships among sperm whales, to trace their home ranges, and to estimate their numbers far more accurately.

During our days spent tracking the whales, we charted their exact movements. We recorded their daily routines of resting, feeding, and socializing, for instance the reciprocal way in which groups of females care for one another's young. Thus the elaborate and hitherto little-known social relationships among these mysterious animals have begun to unfold.

Research techniques developed aboard *Tulip* prove that sperm whales need not be killed to investigate their populations. Most information provided by examining slaughtered carcasses can, with sufficient time and effort, be obtained by methods used and refined aboard *Tulip*.

But there is more to whale research than numbers. During our study we were privileged to live in the waters with the whales and dolphins, to swim with them and probe the surface of their great secrets. That privilege was the gift of many generous people from the Netherlands, the World Wildlife Fund, and the IUCN. The National Geographic Society contributed superb photography, and the Sri Lankan government's National Aquatic Resources Agency furnished invaluable advice and support.

More such people and additional research are needed if whales and dolphins are to be protected against the accelerated use and development of their environment by man.

Now, whenever I put on the headphones and hear the whales sounding the mysteries of their strange world, I pray that the oceans may never be silent. * * *

On its ceaseless commute, *a sperm whale heads for the depths to hunt after taking air. Analysis of stomach contents suggests that it may dive as deep as two miles. But the extent of its realm, like much of its behavior, remains unknown. "Far above all other hunted whales," wrote Herman Melville, "his is an unwritten life."*

BLUE WHALES

Looming like a submarine, a young blue whale off the coast of Sri Lanka measures about 45 feet long. With maximum lengths of nearly 100 feet, blue whales easily outstrip dinosaurs as the largest animals ever to live on earth.

Blues start out big—20 to 25 feet at birth—and gain weight at the rate of 200 pounds a day while nursing. After weaning,

they are finicky eaters, feeding almost exclusively on certain species of krill.

The whale's size and speed discouraged harvesting until steam-powered ships and guns that fired explosive-tipped harpoons were introduced in the late 1800s. Subsequent slaughter reached a peak in 1931, when nearly 30,000 were killed. Under pressure from the International Whaling Commission, hunting nations in 1966 agreed to worldwide protection of the blue.

Taken by surprise, *the crew of* Tulip *found the appearance of a number of blue whales a pleasant bonus to their studies, addressed primarily to sperm whales. Normally seen in colder climates, the whales evidently found the feeding opportunities off the Sri Lankan coast to their liking during winter months.*

To meet their prodigious food requirements, blues lunge through concentrations of krill with their mouths agape, then force water out of their mouths to trap the krill behind long fibrous plates called baleen. It takes about four tons of the tiny

crustaceans a day to satisfy an 80-ton blue during its heavy feeding cycle.

Just the rear section of one of the giants, as it begins a dive (**left**), *rivals the length of the 33-foot research vessel. And the flukes of a sperm whale* (**right**), *even at ten feet across, pale in comparison to those of a blue* (**above**), *which approach 20 feet in breadth.*

Like the sperm whale, the blue possesses its own mysteries, including a low-frequency moan that continues to challenge the understanding of man. □

"The one less traveled by..."

A Journey Down Old U.S. 1

PHOTOGRAPHS AND TEXT BY

BRUCE DALE

NATIONAL GEOGRAPHIC PHOTOGRAPHER

TALKED MY EAR OFF, did "Auntie" Frances Wood. Oh, well, I guess she's earned the right. For 40 of her 91 years she taught school. Her great-great-grandfather came to West Goulds-boro, Maine, to build roads in the early 1830s, and as a child she bounced along what was to become U. S. Route 1 in carriages whose hard bottoms are still vivid in her memory. Her uncle also traveled the road. He was a tax collector who drove his one-seated buggy from home to home and was often invited to stay to dinner. He wouldn't be welcome today, Auntie said, "Nowadays nobody would be to home."

That's her picture above, waving goodbye. I was just beginning my own journey down this first U. S. highway to reach from Canada to Key West. It covers a lot of ground, from brawling cities to backwater

swamps, but all along the way I found people like Auntie, whose families had staked out their piece of the young America and stayed on.

Since those families first set out roots, much of the nation has moved west, and much of the old road has been encrusted with the fast-food joints of suburban strips. But there are still glorious stretches of shaded highway. Some 30 miles north of Boston I traveled a stretch where the autumn foliage seemed to fluoresce against the dark asphalt ahead; even the brilliant yellow dividing line harmonized with the environment. And there are still forgotten bridges that shelter swimming holes, and small towns where life remains quiet as a leaf changing color. They take the traveler back to an earlier time, when roads were for visits and people were just neighbors.

Motoring

THE AUTOMOBILE had begun the revolution of American life by the 1920s, and freewheeling families took to the road by the millions. The Federal Highway Act of 1921 unified the rapidly growing system of roads under the slogan "Get the farmer out of the mud." U. S. Route 1 was designated in 1925. For 40 years it flourished as the East Coast's premier highway during the golden age of motoring.

In the far north the road was buried under snow half the year; during the other half, motorcycle cop Sam Michaud (below), still living in Van Buren, Maine, rode in mud or

COURTESY SAM MICHAUD

Linking 14 states, *Route 1 stretched 2,500 miles from Fort Kent, Maine, to Key West, Florida, when it was completed in 1938. Interstate 95, part of the still uncompleted limited-access system launched in 1956, roughly parallels Route 1 but bears more directly south from Petersburg, Virginia, to Jacksonville, Florida, saving the traveler 100 miles and many hours.*

National Geographic, December 1984

out of the mud...

stifling dust. He didn't bother much with bootleggers during Prohibition. In fact, he says, "I used to get a little bit myself."

Many highway stretches were once coach roads that connected towns of the 13 colonies. From Baltimore north the road linked seaports—Philadelphia, New York, Boston. South of Baltimore it veered inland to connect communities that had grown up at the farthest points of navigation in coastal rivers, such as Richmond on the James.

Overland travel was hardship and adventure for 300 years, and many wrote wills before starting out. Some sections that became Route 1, still dirt in the 1920s, were regarded as satisfactory if the mud didn't top travelers' boots. South of Washington, D. C., in 1918, below right, construction workers struggle in spring ruts near what is now Fort Belvoir. In the cities, cars vie with trolley traffic, as shown on West Broad Street in Westerly, Rhode Island, in the mid-1920s, below left. Route 1 soon became synonymous with vacation trips to Florida, where in 1922, bottom, travelers stop for oranges. But the halcyon days ended in the early '60s as the United States geared up the Interstate Highway System.

PROVIDENCE JOURNAL COMPANY

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TIME has now bypassed Route 1. You can still drive its entire length, but long-distance travelers don't use it much any more. Too slow, they say. Some add that the highway is also too dangerous; "Old Bloody," they call it. Most prefer Interstate 95, but as a limited-access highway it whisks the traveler past the towns and villages of the eastern seaboard and past its 80 million people with hardly a friendly glance.

Route 1 is almost suffocated with access. Many folks back out of their driveways onto it. Where it struggles through huge and indifferent cities, it's just another street. In the country it divides a landscape of sagging toolsheds, guest cottages, old billboards, and rusting gas pumps overgrown with wisteria.

Have you ever driven through a museum? That's Route 1, an open-air exhibition whose displays change with the seasons. The old car peering from its garage I photographed in Maine; I liked the way the flowers swayed in the breeze.

The abandoned gas station and store near Waycross, Georgia, left, was typical along remote sections. When the Interstates took the tourists away, many businesses folded.

"It used to be the old General Patton Store," neighbor Nora Gene Brooks told me. "It was owned by Mr. McNeese, but I always called him 'Uncle Mac.' He was a good old man. There'd be potholes in the highway in front of the store, and he'd get a shovel and fill 'em in."

The old Ford tractor, festooned with weeds, plowed many a field near Norlina, North Carolina. Its owner, Mr. Theo Hecht, bought it from a man "on the condition we would not let the junkman have it."

PEOPLE I MET—some of them—are pictured on these pages. Sure, they're all as different as Connecticut Yankees and Georgia Crackers. But what they seem to share is a deep and quieting sense of home, of belonging. They are the bedrock for a restless nation.

An elderly friend in a brisk, clean, pine-scented New England town told me why her family didn't migrate elsewhere. "Look around you. Why would anyone want to leave?"

Staying has left layers of history so distinct that a Smithsonian Resident Associates program sponsors "commercial archaeology" tours along the highway north of Washington. Tour director Peter H. Smith writes: "Today we revere the restored colonial heritage of Williamsburg. It is easily conceivable that, two hundred years from now, the culture represented by Route 1 will be equally revered."

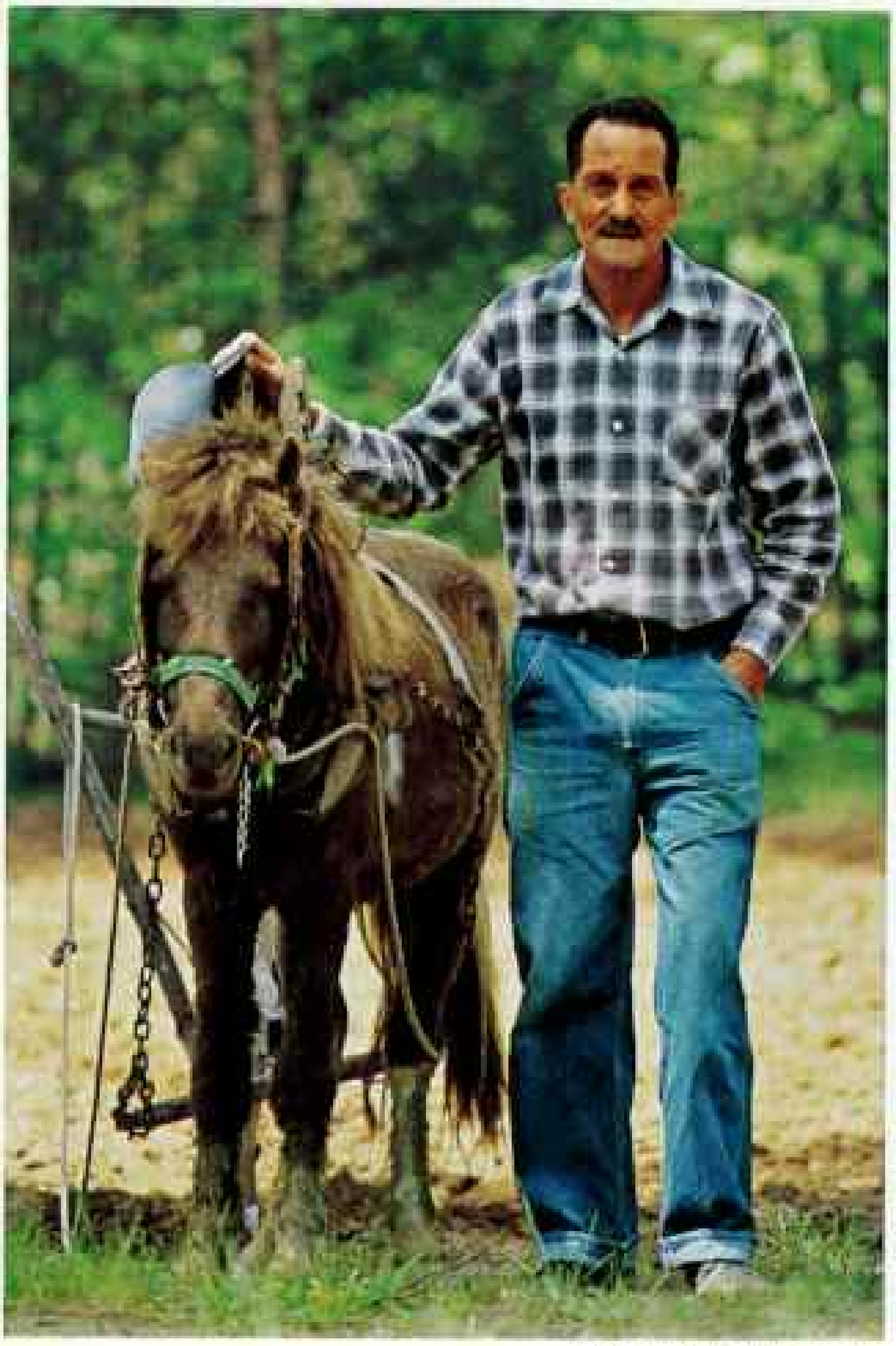
When I set out to document this grand attic of a highway two years ago, I had no idea it would become an addiction. I have learned to love its character and its people. And I have been drawn back again and again to certain innocent places on the highway —a snow-covered hill in the North, a sharecropper's home in the South—and I have not fully known why.

But I can say with Robert Frost, who wrote of another eastern road, "I took the one less traveled by, and that has made all the difference."

BAKERS, NORWALK, CONNECTICUT

BRIDGE WORKER, WISCASSET, MAINE

CHIEF OF POLICE, PATRICK, SOUTH CAROLINA



FARMER, PALMER SPRINGS, VIRGINIA

ONION PICKER, LYONS, GEORGIA

WINTER severity in northern Maine is often measured by the local people according to the number of times they have to shovel their roofs. More than twice, for example, is a bad winter.

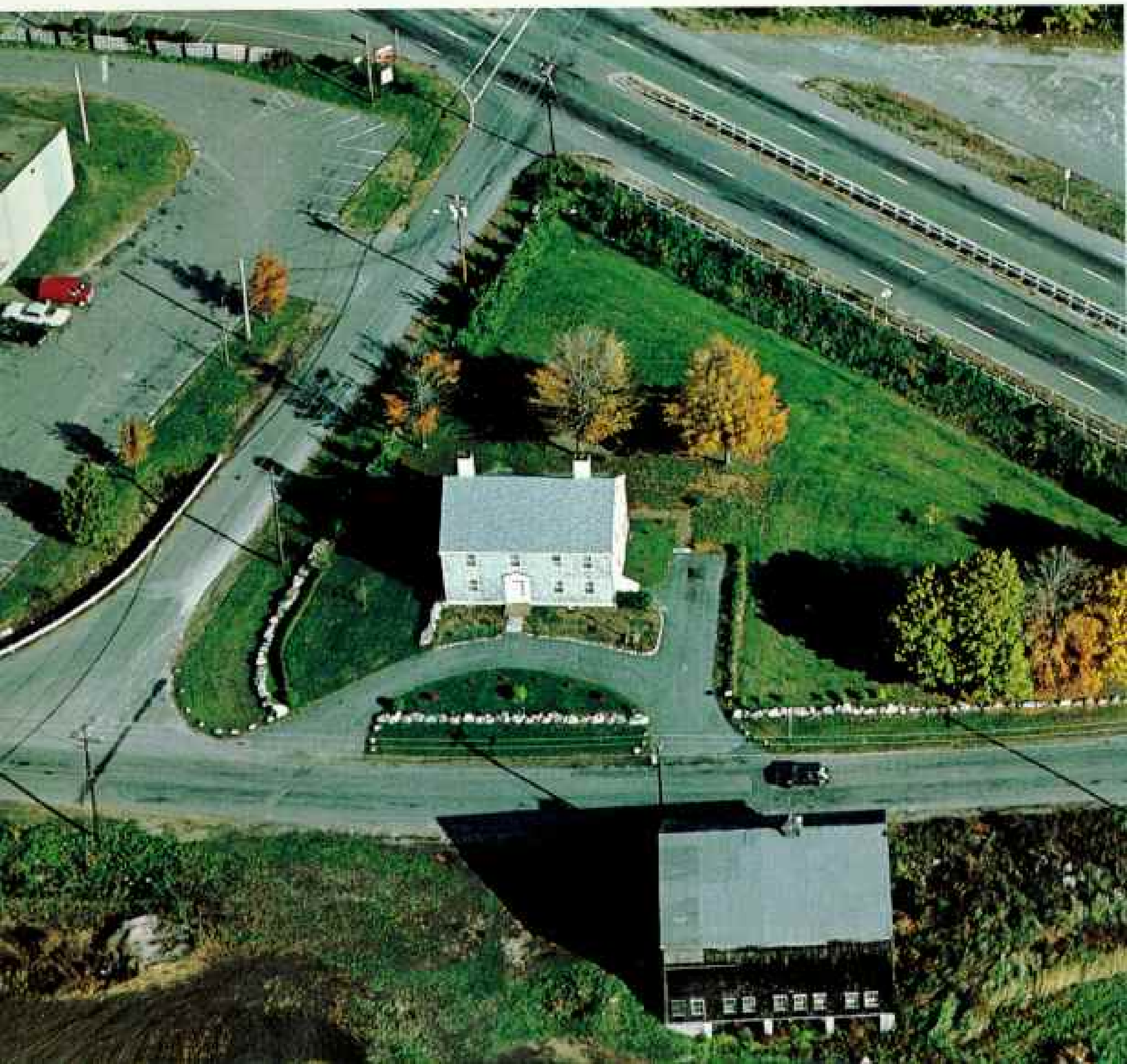
This stretch of highway between Van Buren and Caribou can get very nasty during a storm but is usually kept open by snowplows. The little picture below shows the same hill, with the home at

its foot, in summer.

Early road conditions kept rural Maine in isolation. When Lauriston R. King, the first lawyer to settle in Caribou, arrived in town on April 14, 1865, the road was built mainly of corduroy—rows of logs—alternating with swamp. The stage horses, an old history book states, were "slumping at every step in the soft, deep snow."

That night President Lincoln was assassinated in Washington, but the news didn't reach Caribou for about two weeks.

COURTESY NORMAN SMITH



SOMETIMES I LOST the original highway where it merged with a modern bypass, and I stopped to ask directions. That's how I first met 80-year-old Norman Smith, the gentleman at left, a field engineer in the area for many years. Norman lives with his wife, Edith, on a triangular piece of land along Route 1, below, in Newburyport, Massachusetts.

Although I didn't stop for a history lesson, I sure got one. This was no ordinary home. The plank floors were too wide, the ceilings were too low, and the fireplace was too large, at least by today's standards.

"How old is this house?" I blurted out, almost before saying hello.

"Well, it's never been out of the Smith family," replied Norman. "Part of it was built in 1678. I'm the tenth generation to be born here."

Now that set off a conversation.

Later Edith dusted off an old photograph of the house taken about 1890, far left. The homestead had 19 rooms in those grand times, but the wings were eventually removed. Norman peered at the boy and goat in the foreground and chuckled: "That's my father with his billy goat, the one that ate my Aunt Annie's go-to-meeting hat!"

Norman Smith's ancestors came from Romsey, England, in 1635. One of them, Sgt. Thomas Smith, met his maker in 1675. His company, returning from a mission, stopped to "gather grapes, which hung in clusters in the forest that lined the narrow road," an old journal explains, when "they were surprised by an ambascade of Indians." The event was later called the Battle of Bloody Brook.

Norman's grandfather headed west after the Civil War and packed supplies for the Union Pacific Railroad, until Chief Red Cloud's Sioux uprisings twice drove off his mules. Then he came back to Massachusetts.

And here the family stayed.


See Her CHANGE
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TICKET
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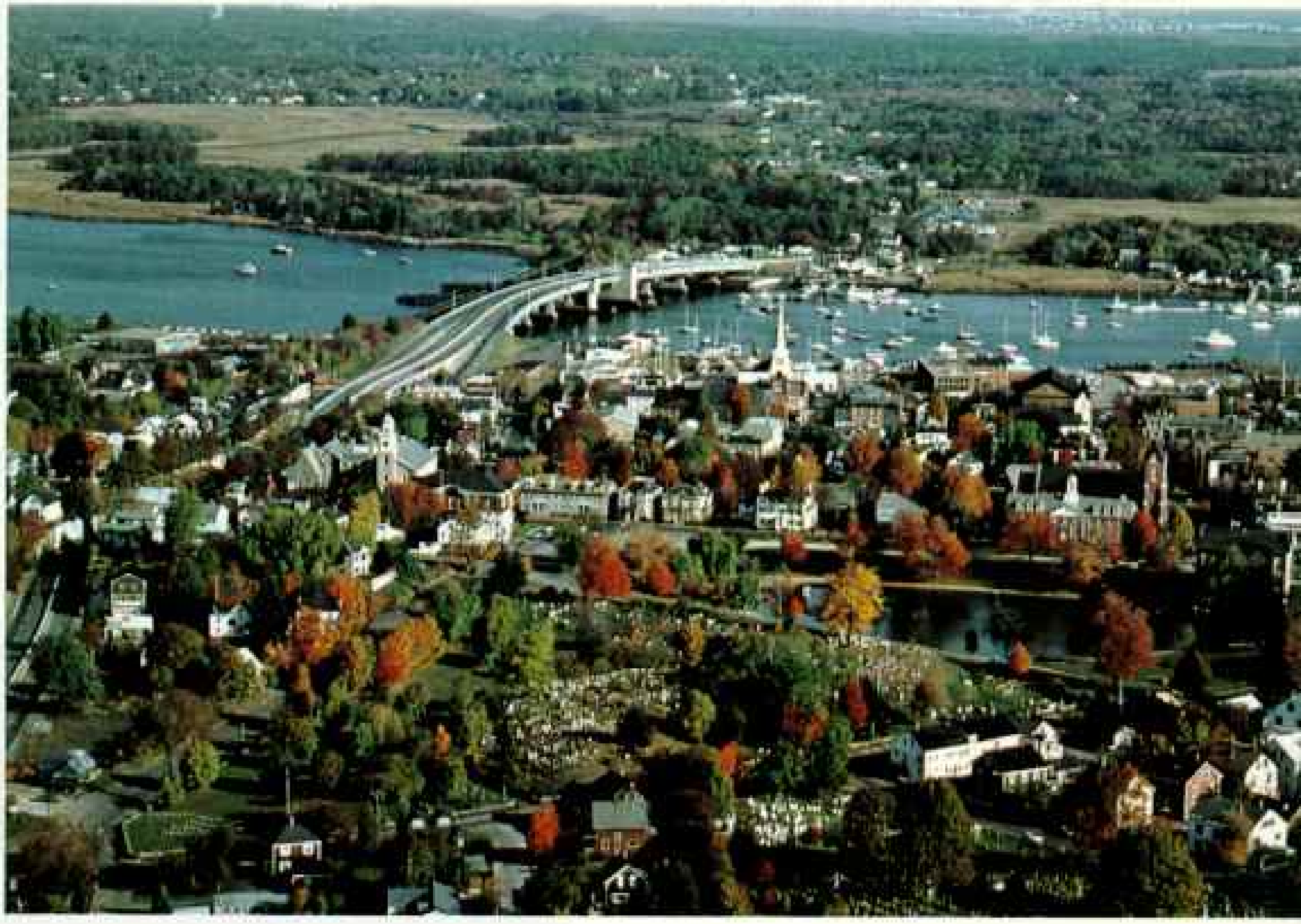
"*STEP RIGHT UP!* See the lovely Princess Gaborah, the strange young lady with the uncanny ability to transform herself into an ugly old 480-pound gorilla! See the hair sprout from her body!"

That's how barker Joel Geensburg captured thrill seekers for his sideshow at the Topsfield Fair in the town of Topsfield, Massachusetts. I was there loaded with cameras, trying to capture the feeling of the midway as the lights suddenly came alive at dusk. I remember that we eyed each other suspiciously, each wondering what kind of illusion the other was trying to perpetrate.

The fair has been entertaining local crowds for 160 years. People from nearby towns such as Newburyport, below, have gathered over the years to marvel at oxen plowing matches, new cattle breeds, the best draft horses, hooked rugs, prizewinning jellies, and a succession of technical developments, such as a noisy collection of gasoline engines exhibited in 1903.

They have also marveled at Zachinni the Human Cannonball and Bud Hamilton, who in 1935 performed here his famous "Dive of Death," 70 feet into a tank of water. He missed and landed on the ground, but only broke his arm.

From the air Newburyport looks a lot like it did during its days of glory in the early 19th century, when sailing ships so crowded the Merrimack River that a man could walk across without getting his feet wet. Today smaller sailing craft cluster near the bridge that carries Highway 1, while old warehouses at dockside undergo renovation into apartments and shops.



DECKED OUT in city lights at dusk, Route 1 crosses the Hudson River on the George Washington Bridge, passing the glitter of Manhattan's skyline. In New York City the highway has been rerouted several times over the years. Today, where it cuts through the heart of the Bronx, Number 1 does double duty as a parking lot, a ball field, a playground, and, occasionally, a junkyard with stripped forgotten cars, far right.

That's Hector Lopez jogging the Bronx streets. "I didn't know it was Route 1," he told me. "We call it Webster Avenue. It's a pretty tough neighborhood. There was a time when I almost gave up running. But when the tough guys would ask, 'How's your running?' they actually inspired me to keep at it.

"May I ask you a favor? It would make me feel very good if you could mention Mr. Kor in your magazine. He was my high-school teacher and also my gym teacher."

Sure, Hector.

"*WE COULD NEVER* go more than three miles an hour," complained Thomas Jefferson in the winter of 1790 about a stretch of road that became Highway 1.

Dear Mr. Jefferson: On some days it isn't much better now. Crossing the Potomac River from Washington, D. C., to Virginia in rush hour can still eat up a lot of time and try anyone's patience.

If you look out this window atop the Washington Monument, you can see Route 1 going past Mr.

Jefferson's Memorial at center. The nation prints money in the building at left.

Both Jefferson and George Washington knew the road quite well back when it was called the King's Highway. Washington spent much of his life a few miles south of here at Mount Vernon.

This is also Civil War country, and feelings still run strong. In a restaurant called the Smythe's Cottage, in Fredericksburg, Virginia, a picture of Union Gen. Ulysses S. Grant hangs mockingly upside down in the taproom, near the bourbon.

The Smythe's Cottage owner, Joyce Ackerman, told me why: "Union men captured my great-grandfather Maurice Evans, who was a scout for Jeb Stuart and fought in the Battle of Fredericksburg. In prison they hung him by his thumbs for refusing to dig entrenchments. So when I got the restaurant, I said, 'Well! We'll hang Grant upside down so that Great-grandfather can rest in peace.' "


HELIN
SPUR

IF YOU LOOK carefully, you can still see traces of the original Route 1—old stone bridges, overgrown embankments, and asphalt ridges leading nowhere. These were left behind by the changes of modern highway engineering. This byway near Bethune, South Carolina, is preserved more by chance than by design and is quietly being reclaimed by the land.

Many modern thoroughfares started as narrow Indian trails about a foot wide. The white man widened and deepened them with his hobnailed plodding. Then came the packhorse trail, the carriage road, and finally the automobile highway.

Today travelers who venture off the Interstate system often have to make their way through a forest of commercial enterprises, emblazoned with neon—souped-up strips that clash with the environment, such as this one in Columbia, South Carolina. It could be Anywhere, U.S.A.

IT WAS IN WOLF PIT, North Carolina, just above the South Carolina border, that I first met Eligah King Hamilton and his wife, Lillie.

Later I went back to this rural village astride Route 1 for Lillie's "home-going," a simple, emotional funeral witnessed by family and friends who had come to say good-bye. At the funeral they sang, "Lean on Jesus, He won't let you down." And as the pallbearers carried Lillie from the church, bottom, the choir leader laid down a soul-searing Gospel boogie-woogie on the piano that reaffirmed the glory of God.

On that sad day I took this family portrait of King in his front yard, surrounded by a half brother, a son, and two of Lillie's sisters. Later I followed Lillie's granddaughter Lula Mae Ratliff as she carried a rose to Lillie's gravesite.

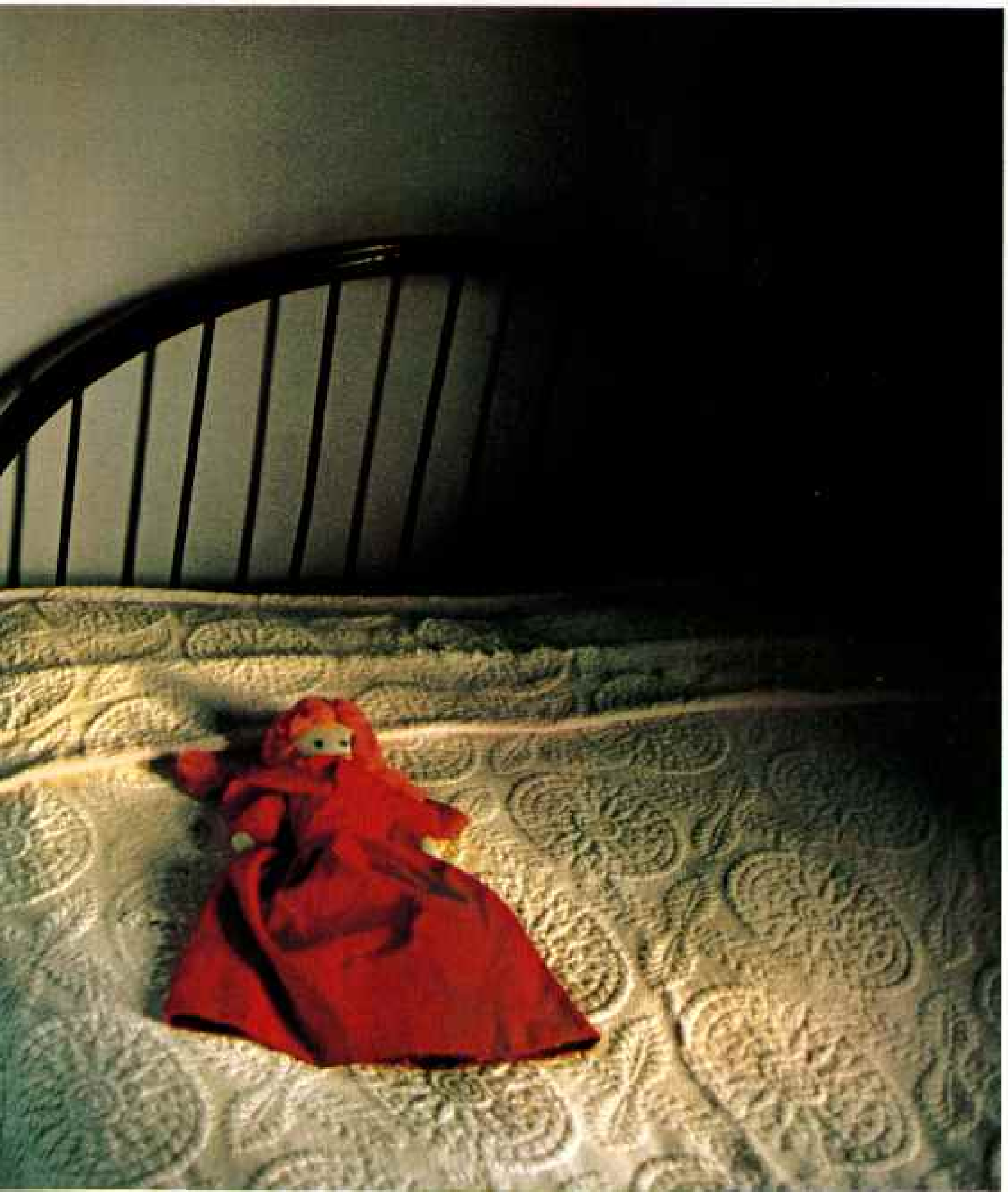
On the day of the funeral King took me across the fields and pointed out the landmarks of his life. "I got Lillie from right there," he said. "I was living over that hill near them pine. We were married over yonder top of that hill there. Fifty-nine years ago.

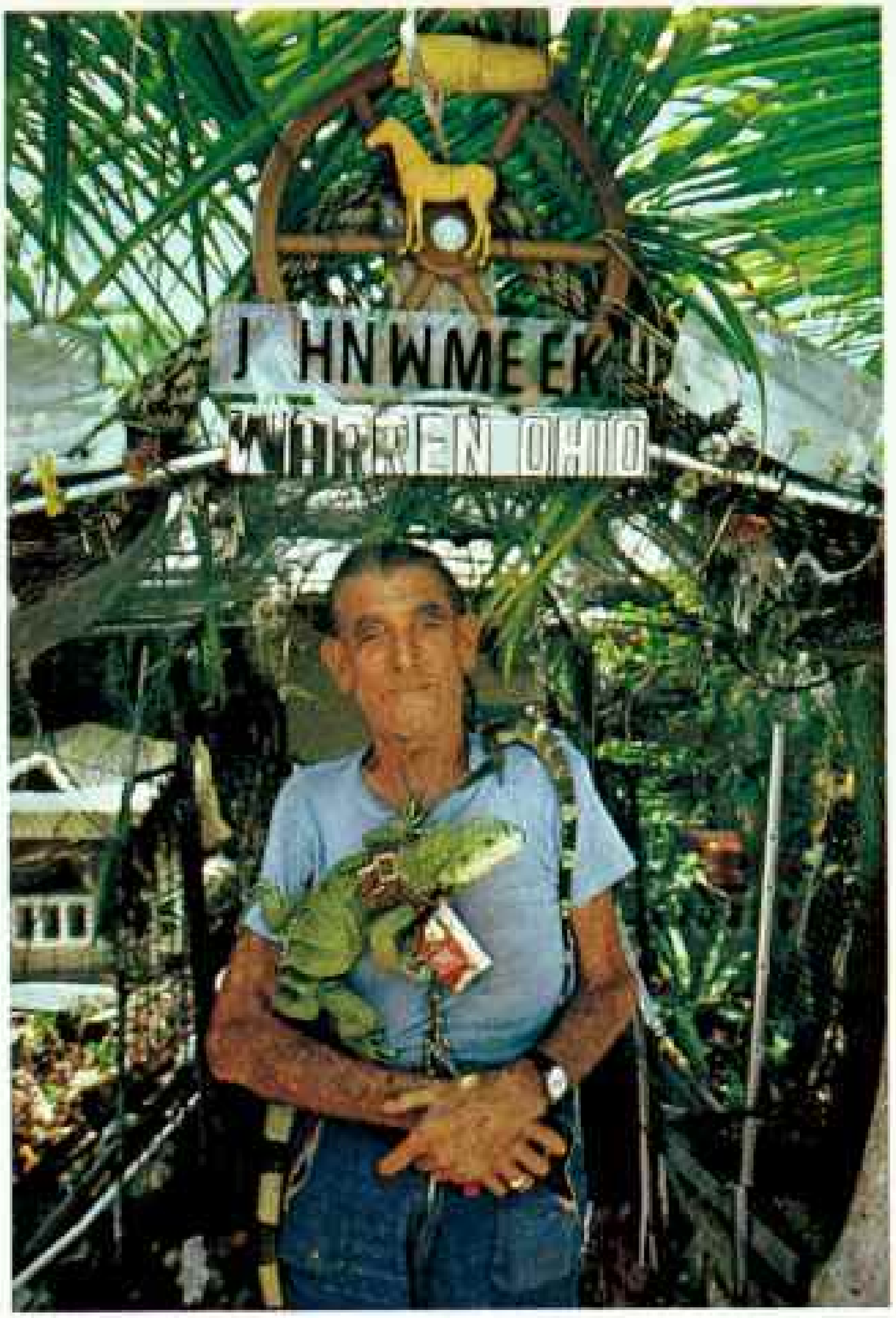
"I was born in nineteen-o-one, the tenth day of July. I knowed when this wasn't nuthin' but sand. Oh, it was so beautiful o'er yonder. Big cow pastures and everything. They got tractors now that can plant eight row. What a poor me! When I come on, I had to do it from a pair of mule. I plowed a many mules up and down that hill."


ALMA HOTEL

HIGH HOPES were held for the New Alma Hotel when Mr. Braswell Deen, U. S. Congressman from south Georgia, built it in 1938 in the small town of Alma on the great north-south tourist route. The hotel flourished, welcoming Georgia governors and other distinguished guests. Then it died, like many others, especially with the coming of the Interstate. It lay idle for years, serving as a local rooming house and an occasional way-stop for quail hunters.

Then in 1980 Jay and Elizabeth Williams turned the lobby into an antique shop and craft store and converted other rooms—many with their original furniture—into storage and additional display areas. Touring the rooms is a fantasy. Open one door and find a roomful of mannequins, arms missing and legs askew. Open another to see a dismantled Austin-Healey sports car. Rooms like this one, below, offered a sense of sweet nostalgia for the not-so-distant past.





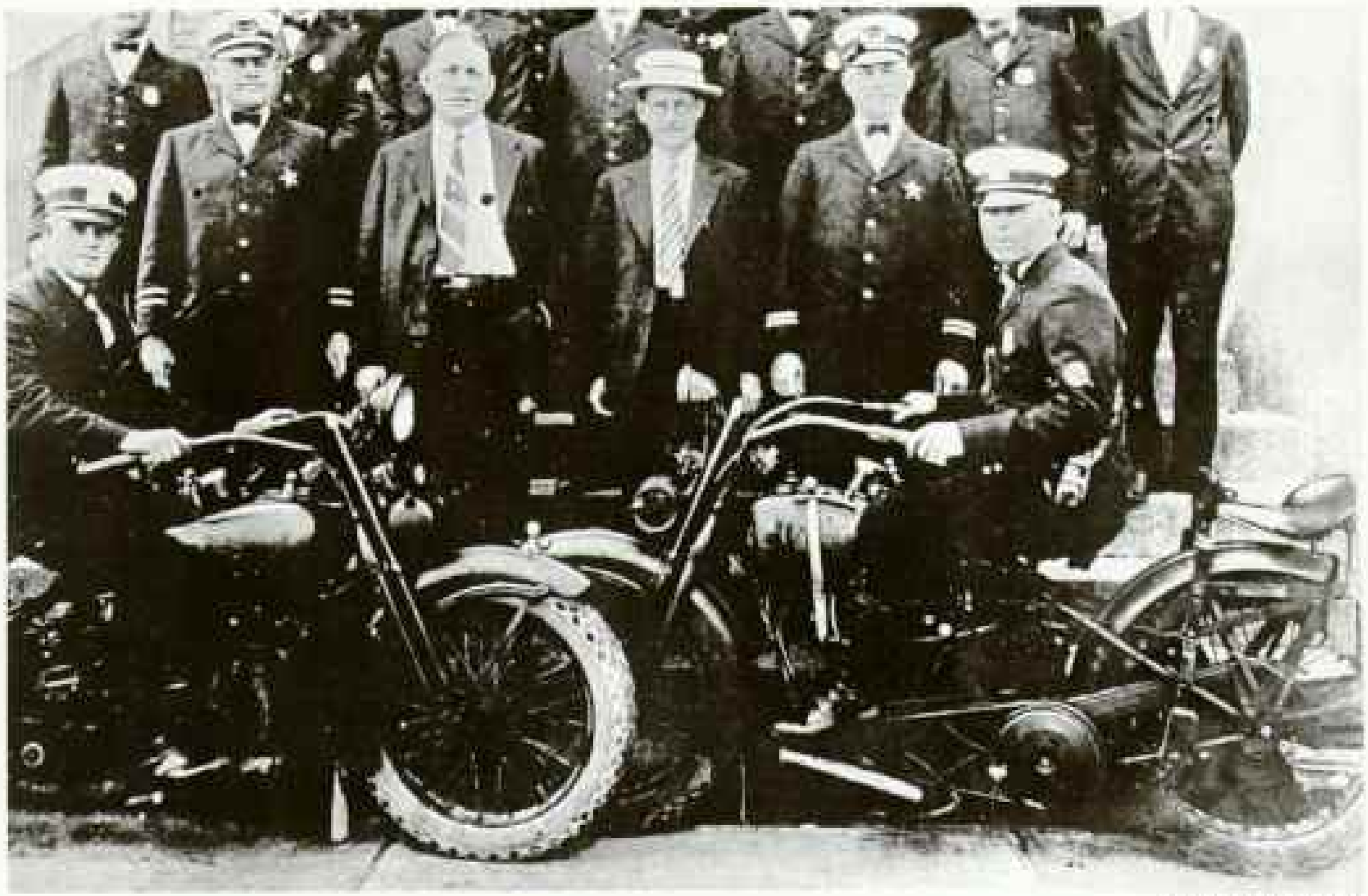
WILDERNESS of green, the great Okefenokee Swamp straddles the Georgia-Florida border; Route 1 just skirts it to the northeast. The vast wetland is actually the source of both the St. Marys and Suwannee Rivers. Here I photographed Johnny Hickox, right, poling tea-brown water, the fifth generation of his family to live near the Okefenokee. Chief guide and jack-of-all-trades, Johnny informed me that "There's not a single mosquito in the swamp. . . . They're all married and have children."

In Fort Lauderdale, Florida, I noticed this man and his macaw sharing some secret on a park bench, upper left. Later he gave me his business card: Leroy H. Moe, Circuit Judge.

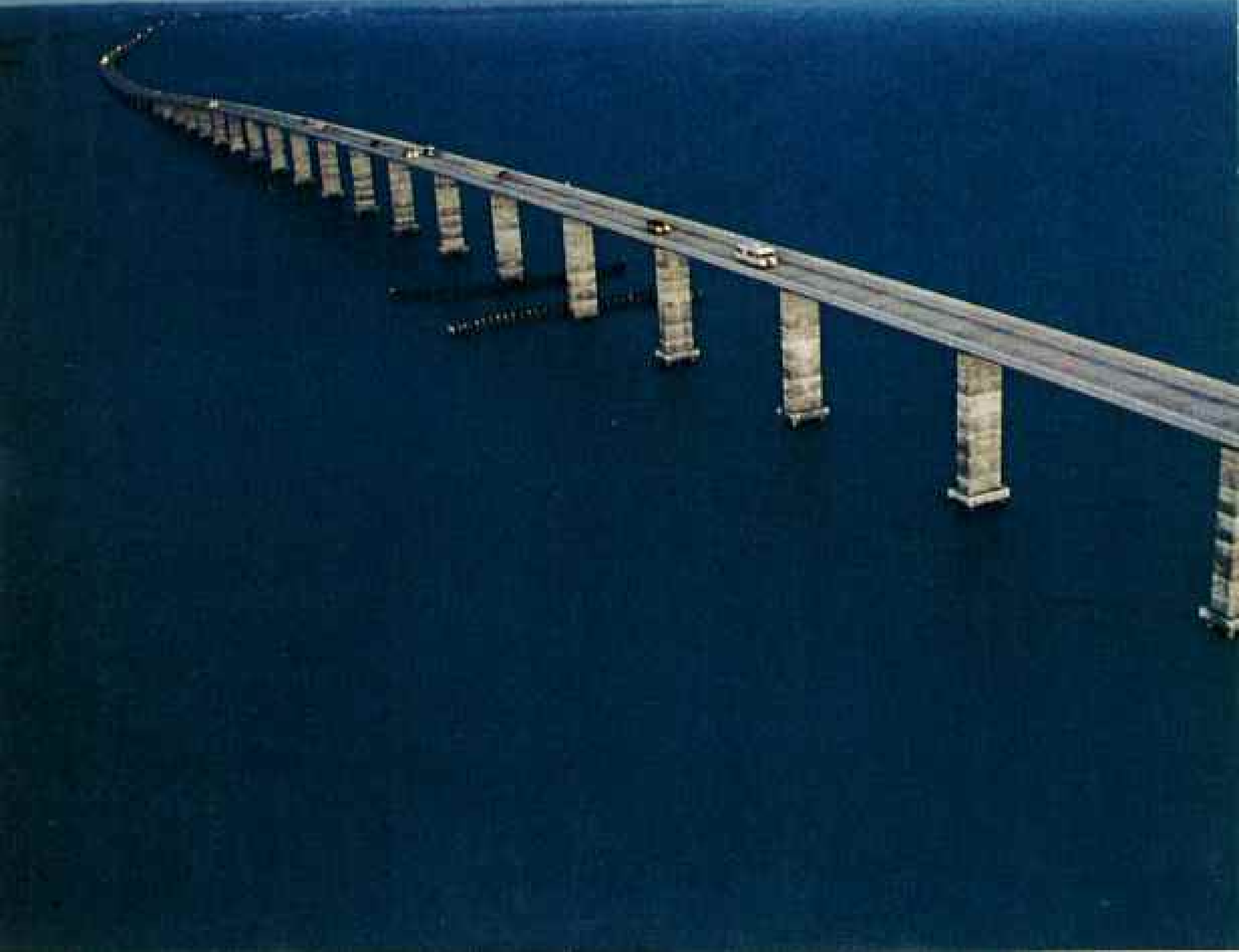
In Key West you usually find John Meek at Mallory Square pier in the evenings. At his nearby home, left, he raises iguanas. "I've got Tony, Pancho, Cisco, and Iggy," he told me. "They're a hundred percent tame, but they're primitive as hell. They are not affectionate pets, although everyone thinks they are. The temperature drops, and their instinct tells them to seek out heat. My dog, or my neck and shoulders."

When did he come here?

"Let's see, wait'll I figure out what I was driving. . . . Yeah, a '65 Merc. It was 1965."



COURTESY EVERETT RIVAS



ISLAND HOPPING south from Key Largo to Key West, Route 1 begins its countdown. At mile marker 50, Seven Mile Bridge seems to head off into the open sea. Completed in 1982, it replaced a much narrower one, originally the old Flagler railroad bridge. Before hitting the north end of the bridge, I always fortified myself with a piece of Key lime pie from the Seven Mile Grill.

Onetime deputy sheriff Everett Rivas, left, began patrolling the lower Keys on a Harley-Davidson motorcycle, as he told me, "a moon short of '27." That's him on the right in an old photograph, sitting on his Harley. Bootleggers hauling in liquor from Havana took up much of Everett's time in those Prohibition years; speeders got off easier.

"I used to do a lot of calling down," said Everett. "You can get better results talking to a person than you can by saying, 'Hey, here's a ticket.' "

He once found it necessary to reprimand one of Key West's most famous residents, Ernest Hemingway, whose house, now a museum, sits on Route 1 just a few blocks from its end.

Said Everett: "One night Ernest came out of Sloppy Joe's Bar where he hung out, and I told him, 'Ernie, I don't give a damn if you kill yourself, but you got innocent people in this street you're liable to run over and kill. And if you get behind that car wheel, I'll put you in jail.'

"He looked at me and said, 'I do believe you mean it.' "

Everett and I reminisced into the balmy tropical evening about this great old highway, and I told him how I would never forget the people I had gotten to know along the way.

"Sure," he said. "You know, strangers are just friends who never met."

And that's what I have learned on Number 1. □

BEYOND SUPERMOUSE Changing

By ROBERT F. WEAVER

THE TWO MICE closely resembled each other—the same brown hair with patches of white, the same beady eyes. Indeed, they were siblings, from the same litter. Yet in one respect the difference was shocking: One was normal in size, the other a colossus, more than twice as big. The contrast called to mind science fiction movies in which a mad scientist inadvertently makes animals grow to monstrous size.

The explanation for this "supermouse," however, lay not in fiction but in elegant scientific work. Molecular biologists had given it a working human gene—a gene that produces the growth hormone in human beings. The gene obviously works well in mice too.

This is one of the showier achievements of biotechnology, a burgeoning field in which I work as a molecular geneticist at the University of Kansas. Its powerful new techniques, as awesome in their way as splitting the atom, promise help in resolving three of our planet's toughest problems: hunger, sickness, and energy shortages.

We are nearly five billion people in this world and multiplying fast. Many countries have too little food, and hunger even more widespread looms ahead. Thus genetic engineers are trying to modify crops so they will make more nutritious proteins, resist disease and other stresses, and even provide some of their own fertilizer. Biologists are producing vaccines against diseases that attack livestock, and eventually they may be genetically engineering finer animals.

In the field of medicine, biotechnology promises aid for millions of people who suffer from diabetes and for thousands of youngsters afflicted with dwarfism. Deadly human ailments including heart disease and cancer are beginning to yield to biotechnology's weapons. So, too, may intractable genetic disorders such as sickle-cell anemia.

Mounting an assault on the energy shortage, molecular biologists are modifying bacteria to convert common wastes such as

As the genetic structure *found in the cells of living things is gradually deciphered, scientists learn to combine the genes of*

Life's Genetic Blueprint

Photographs by TED SPIEGEL BLACK STAR

one species with those of another. A technician at Agrigenetics Corporation, Madison, Wisconsin, extracts material containing the genes of a common bean to see if they will be accepted and reproduce in another plant species.

garbage or cornstalks into alcohol or natural gas, and studying a tree whose oily sap could serve as diesel fuel.

Some of these wonders are only dreams. But there are realities too, and every day sees new advances.

This promise generates great excitement, not least in the stock market. When Genentech, a San Francisco biotechnology firm, offered its stock for sale in 1980, speculators snatched up more than a million shares at the opening price of $35 each, then bid them up to $88 on the first day. Though the price soon fell, this was a buying craze many Wall Streeters had not seen in a lifetime. Today in the U. S. alone, some 200 companies vie for the rewards of what Britain's *Economist* calls "one of the biggest industrial opportunities of the late 20th century."

A POTENT TOOL of the biotechnology revolution developed during the past decade is the marvel of gene cloning. Essentially cloning is a process that can produce unlimited numbers of identical organisms. We can insert a gene—the determinant of heredity in a living thing—into a bacterial cell and allow this passenger gene to reproduce along with the host cell. This way we clone the gene and bacterium simultaneously.

The possibility of cloning human beings has fascinated novelists. The rulers of Aldous Huxley's *Brave New World* produced legions of mindless automatons this way. Similarly, the young Hitlers in Ira Levin's *The Boys from Brasil* were created from genes in the dictator's cells.

Higher organisms can indeed be cloned. As long ago as 1961 Dr. J. B. Gurdon of the Medical Research Council Laboratory of Molecular Biology in Cambridge, England, manipulated frog eggs to produce identical tadpoles.

Some cloning occurs naturally; identical twins are an example. But even if scientists overcome formidable technical problems, intentional human cloning will probably never occur (in this country, at least) because of ethical reservations.

To understand gene cloning, consider that genes are part of extremely long, chain-like molecules of deoxyribonucleic acid—DNA. They form the chromosomes that are part of the cells in all living things. These DNA chains carry coded instructions that a cell follows to make proteins—the stuff that makes life possible. Thus a gene is a blueprint for a protein, a program followed by an organism during its life but susceptible to manipulation by the genetic engineer.

One such manipulation produces recombinant DNA, the heart of genetic engineering. Producing it is a task that Carolyn Rankin, a University of Kansas graduate student, often performs in my laboratory.

Carolyn begins the process by filling a test tube with dead caterpillars, victims of an insect virus we are studying because of its simple genetic structure. In a small centrifuge she separates the heavier virus from the lighter host material, just as milk and cream are separated in a dairy.

Her goal is to separate the viral genes and reproduce each of them in handy amounts. To do this, she isolates the DNA of the virus in a test tube and cuts it into pieces. This cannot be done with a scalpel; DNA is too small. But it can be done with certain enzymes that act as molecular knives. For reasons that we do not fully understand, such an enzyme recognizes certain sequences in the DNA strands, attaches itself to them, and by chemical action snips them apart.

Carolyn mixes these fragments with a cloning vehicle—in this case a DNA fragment from the workhorse of genetic engineering, the common intestinal bacterium *Escherichia coli*. It has been cut with the same molecular knife, so that the viral and bacterial DNA fragments can combine, forming recombinant DNA. This is the well-known gene splice, accomplished by a complex enzymatic reaction whose development led to international recognition for several scientists. Finally Carolyn inserts her DNA hybrids back into the *E. coli* cells and spreads the cells in a laboratory dish. At first they are invisible. But after a few hours we detect growths that resemble beads of tapioca. These are individual clones. Each has become a factory for reproducing its own recombinant DNA.

In effect, gene cloning is like cutting a printed page in half, inserting a new paragraph in the middle, and photocopying the altered version over and over to reproduce the new material along with the old.

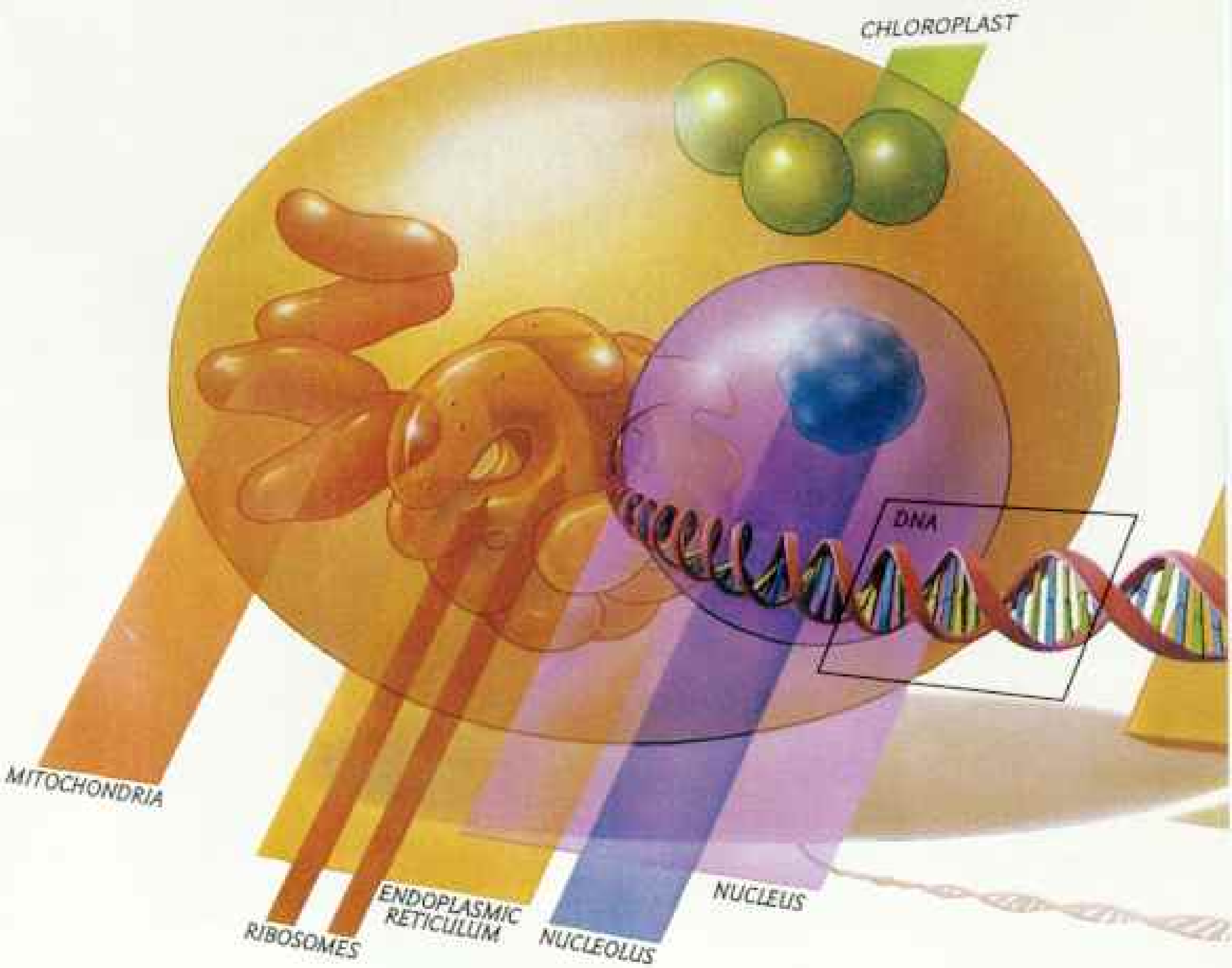
ROBERT HAMMER AND RALPH BRINSTER

Eyes of hope. *Ten-year-old Tracy Moreno of California (**above**), born with a growth-hormone deficiency, grew five inches in one year of treatment with a man-made hormone.*

Scientists at Genentech Inc. in San Francisco inserted human growth-hormone genes into common bacteria. As the bacteria multiplied in a fermentation vat, they produced quantities of the hormone, later harvested.

*In 1983 scientists at the Universities of Pennsylvania and Washington inserted human growth-hormone genes into mouse embryos, producing a giant mouse (**right**). This was the first time that a human gene functioned in another animal.*

Changing Life's Genetic Blueprint



A T G C: A simple code of four parts spells out life

functioning body. The machines are called cells.

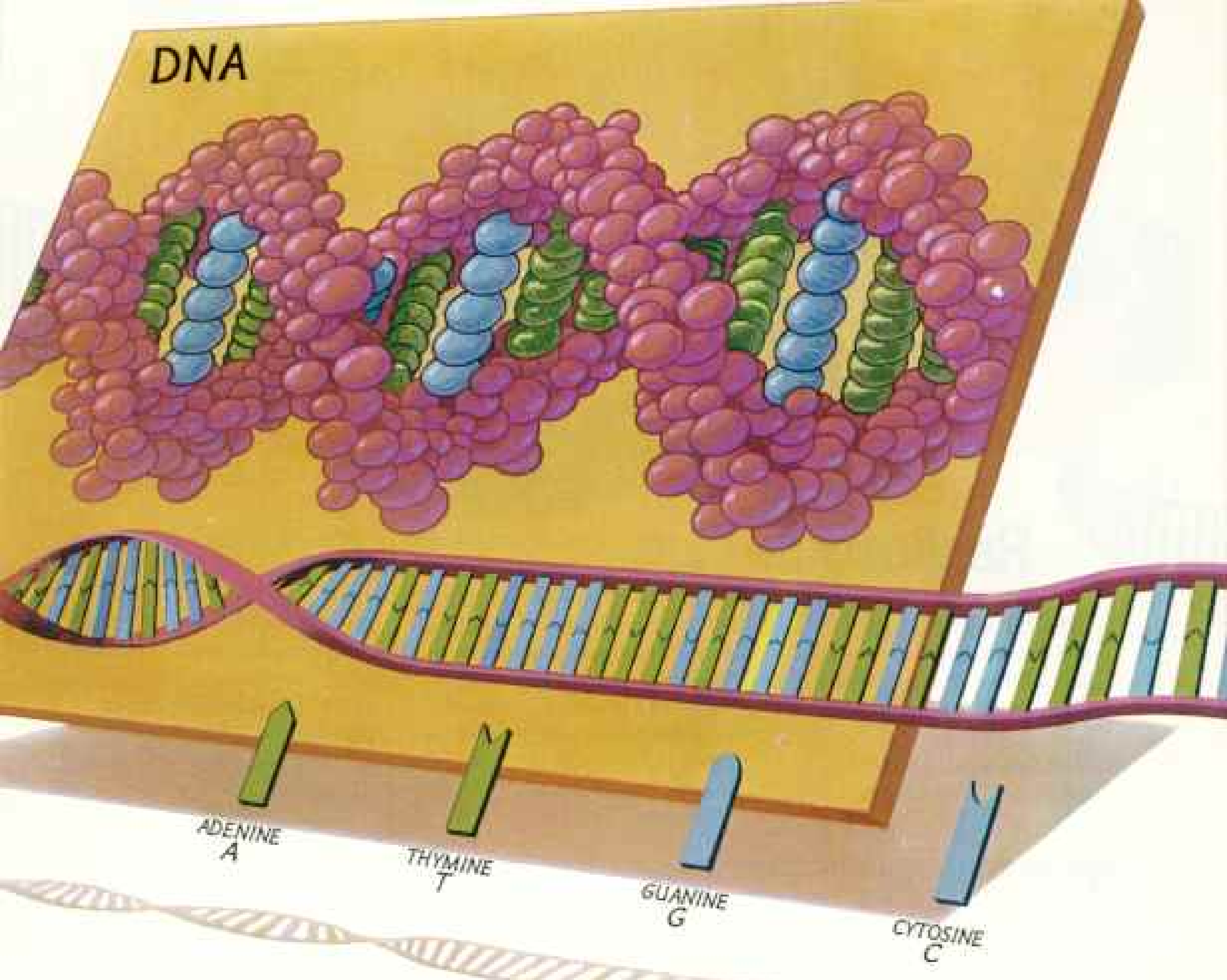
In a cell (**above**) *the nucleus functions as the control center, containing tightly packed coils of thread-like molecules called deoxyribonucleic acid, or DNA—carrier of the genetic blueprints for an organism. The strands of DNA in a human cell are less than a trillionth of an inch thick, but if unraveled would stretch out almost two yards.*

In the nucleus, some of the blueprints are copied, to be dispatched like detailed drawings to the factory of the endoplasmic reticulum. Here tiny shops called ribosomes, built with proteins and material from the nucleolus, use the drawings to assemble amino acids into the proteins that the cell needs.

Mitochondria provide energy for the cell by burning sugar products. In plant cells chloroplasts use sunlight to synthesize sugars.

A schematic strand of DNA curves out of the nucleus and unwinds to reveal its chemical structure in the form of a ladder. Twin backbones of sugars and phosphates, colored in red, make up the sides of the ladder. Two pairs of chemical bases form the ladder's rungs. Adenine, A, joins with thymine, T, both shown in green. Guanine, G, joins with cytosine, C, blue.

Another model of DNA, above the ladder, shows the molecule's characteristic double-helix form much



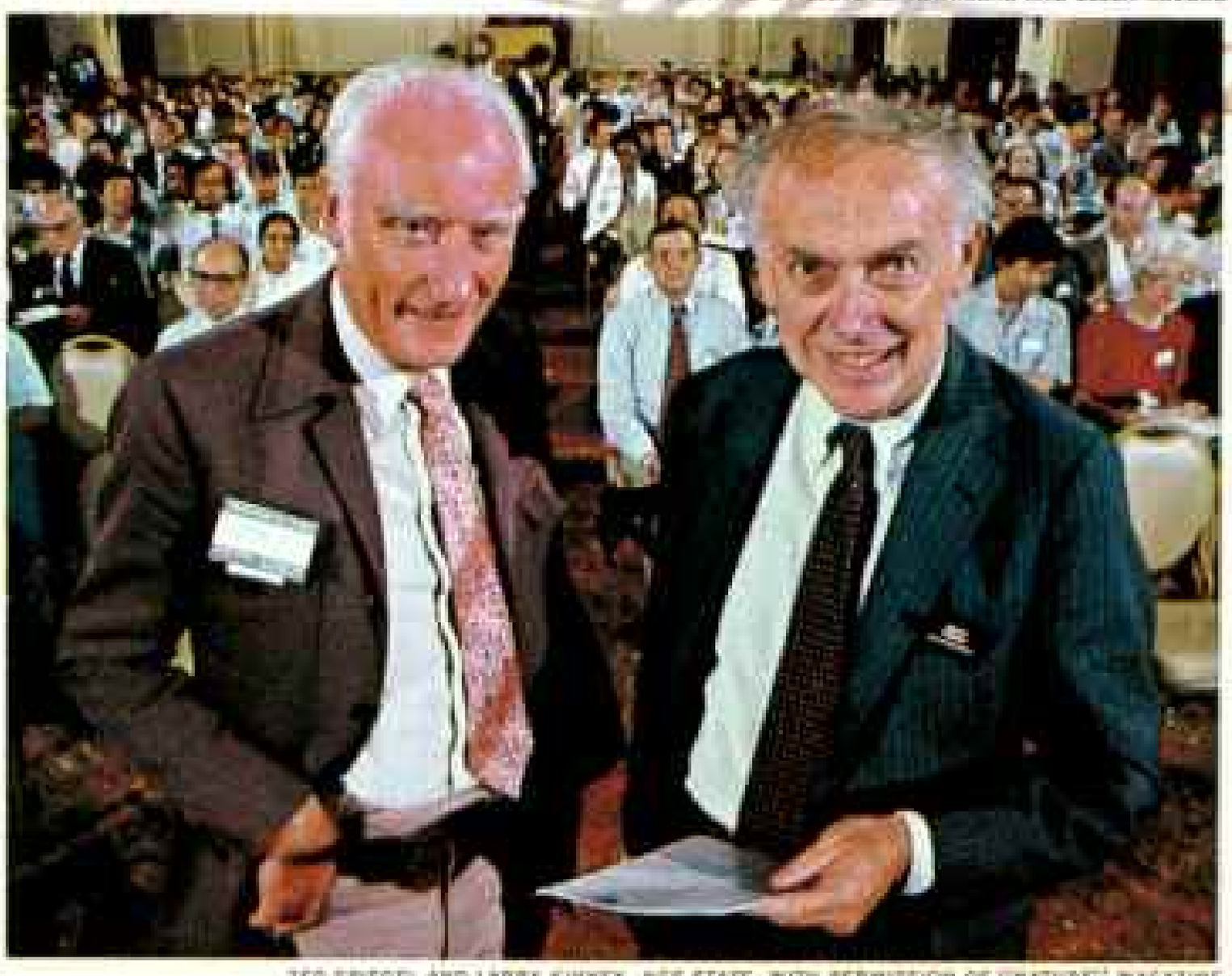
as it occurs in nature.

The sequence of the base pairs—the ladder's rungs—spells out the DNA's genetic messages. Each complete message detailing the blueprint for one protein is a gene.

Read along one side of the ladder, a gene message might begin ATGC—for adenine, thymine, guanine, cytosine. Some 5,000 base pairs could encompass the entire set of genes—the genome—for a simple virus.

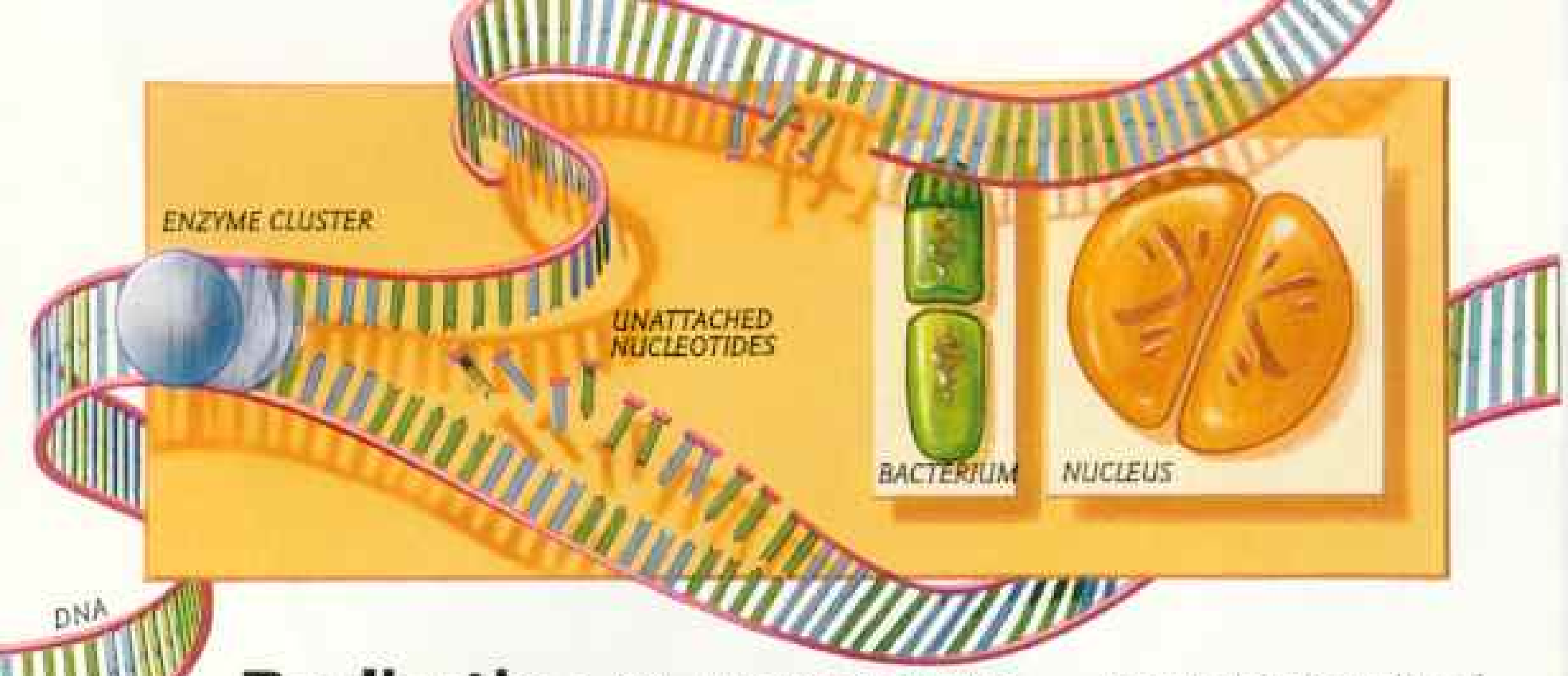
To spell out the blueprint within each human cell, though, would require more than a million pages of the NATIONAL GEOGRAPHIC. *Wonderfully simple, deeply complex—like life, like nature.*

PAINTING BY JASON A. JOHNSON AND ELLEN KUZIRA



TED SPIEGEL AND LARRY KINNEY, NGS STAFF, WITH PERMISSION OF "NATURE" MAGAZINE

Pioneers of molecular biology, *physicist Francis H. C. Crick, left, and biochemist James D. Watson deduced the double-helix structure of DNA in 1953. They later received a Nobel prize for their historic discovery.*



Replication

TO CONTINUE LIFE, *the cell must duplicate its DNA blueprint, a process called replication, in order that new cells may grow.*

Before a cell divides, enzymes—seen here as a blue ball—pass along the length of its DNA molecules inside the nucleus, unzipping them. Other enzymes pair unattached nucleotides—ladder rungs joined to fragments of ladder sides—with corresponding nucleotides along the original DNA strands to form exact copies.

In bacterial cells, replicated loops of DNA migrate to opposite ends of the cell, which then divides. In more complex cells, such as human cells, the replicated molecules of DNA move apart within the nucleus. The cell divides across the nucleus to form two new cells.

THE EARLIEST FRUITS of recombinant DNA have brought clear benefits through the manufacture of human insulin. Millions of diabetics depend upon regular injections of insulin, usually derived from pigs and cattle. But animal insulin differs slightly from human insulin—some people are allergic to it—and its supply varies with the livestock market.

In 1978 scientists at Genentech endowed *E. coli* bacteria with synthesized human insulin genes. As hoped, the bacteria responded by making the human protein. Produced by Eli Lilly and Company and sold originally in Europe and now also in the United States, this first pharmaceutical product of recombinant DNA can be made by microbes in unlimited quantities.

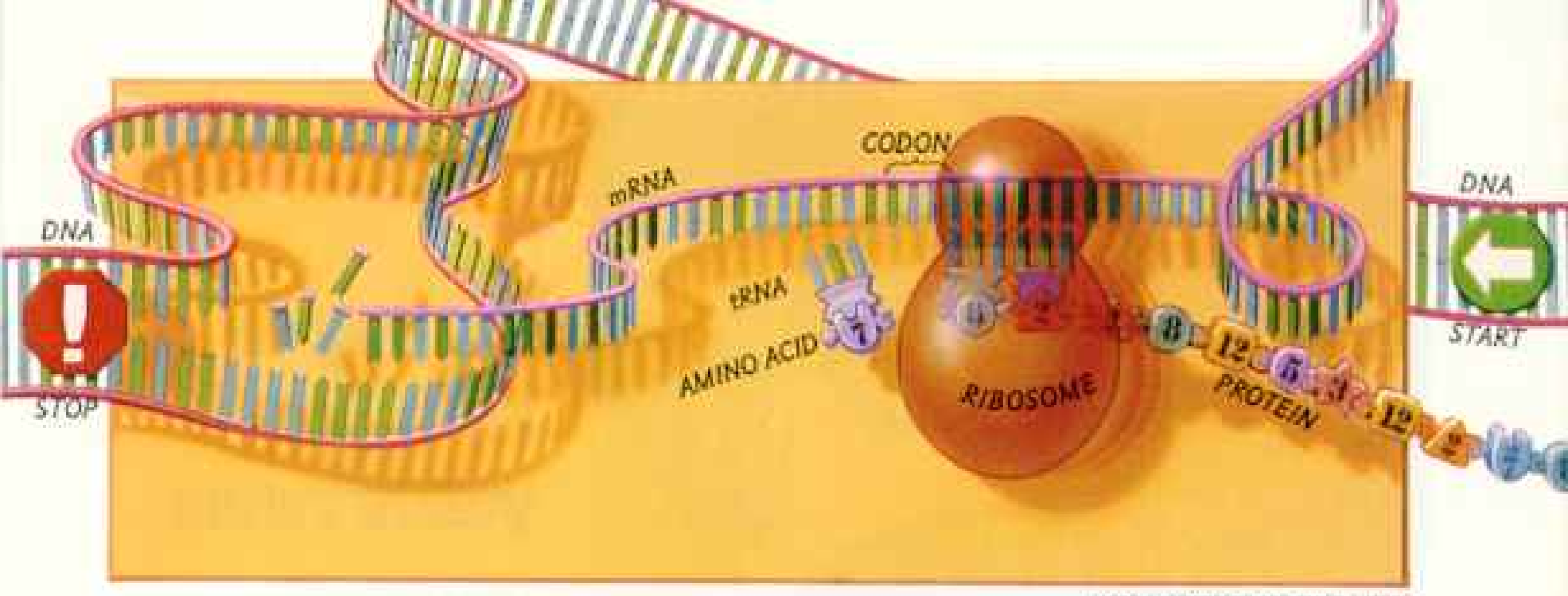
I spoke with Sandy Atherton of Derby, Kansas, who was the first diabetic in the U. S. to receive the engineered hormone. "I read in the paper about this product and asked to be included in tests at the University of Kansas School of Medicine at Wichita. Fortunately, I was chosen. My father was a diabetic for 30 years before he passed away, and he had watched people die of the disease before there was any insulin at all. I am very thankful for the progress scientists have made."

Today's microbial drug factories also produce human growth hormone, or HGH—the stuff of supermouse. Its potential beneficiaries: children, several thousand in the U. S. alone, who suffer from a type of dwarfism that occurs when the pituitary gland makes insufficient HGH.

Doctors traditionally obtain HGH from the pituitary glands of human cadavers. But it takes hormones from 50 cadavers, extracted at great cost, to treat a child for a single year. This limits treatment to one patient in five. Worse, a black market in HGH has diverted some of the precious protein to the bodybuilding fad.

Dependence on cadavers persists, but already genetic engineering can produce enough HGH to treat every case of hypopituitary dwarfism. However, Food and Drug Administration approval is needed before this product can be marketed in the U. S.

Human growth hormone holds promise for treating other growth-stunting conditions. It also may help people whose bodies have been stressed, as by severe burns or by widespread cancer. In response to the



LLOYD K. TOWNSEND AND ELLEN SUTORO

Expression

CELLS PRODUCE, *or express, thousands of proteins. First a chemical signal makes a small opening in a DNA molecule at a coded start signal. As the opening ripples along the DNA toward a stop signal, it exposes the bases, whose sequence is the blueprint for a desired protein.*

In a process similar to replication, the blueprint is copied, resulting in a one-sided molecule called messenger RNA, often abbreviated as mRNA. Within the ribosome other molecules, such as transfer RNA, or tRNA, read the mRNA code in groups of three bases called codons.

Each codon corresponds to one of 20 amino acids in the cell. The ribosome arranges the amino acids in the proper order and links them to make the protein.

stress the body consumes itself, a phenomenon known as wasting syndrome. Experiments show that growth hormone helps combat this dangerous reaction in animals, and treatments that work with animals often help people.

SCIENTISTS are also closing in on America's leading killer, heart disease. Gene splicers at Genentech have produced a protein that activates the substance known as plasminogen found on blood clots. When activated, it dissolves clots that obstruct coronary arteries and cause heart attacks. It is so potent and specific that it may even arrest a heart attack under way. Another biotechnology firm, Collaborative Research in Massachusetts, soon will enter the clot-dissolving sweepstakes. Says Dr. Orrie Friedman, chairman of the board, "We have high hopes. It's one of the hottest things we have going."

Finally, hundreds of scientists are turning biotechnology against the disease we probably fear most, cancer. Tremendous advances are being made in understanding this frightful affliction.

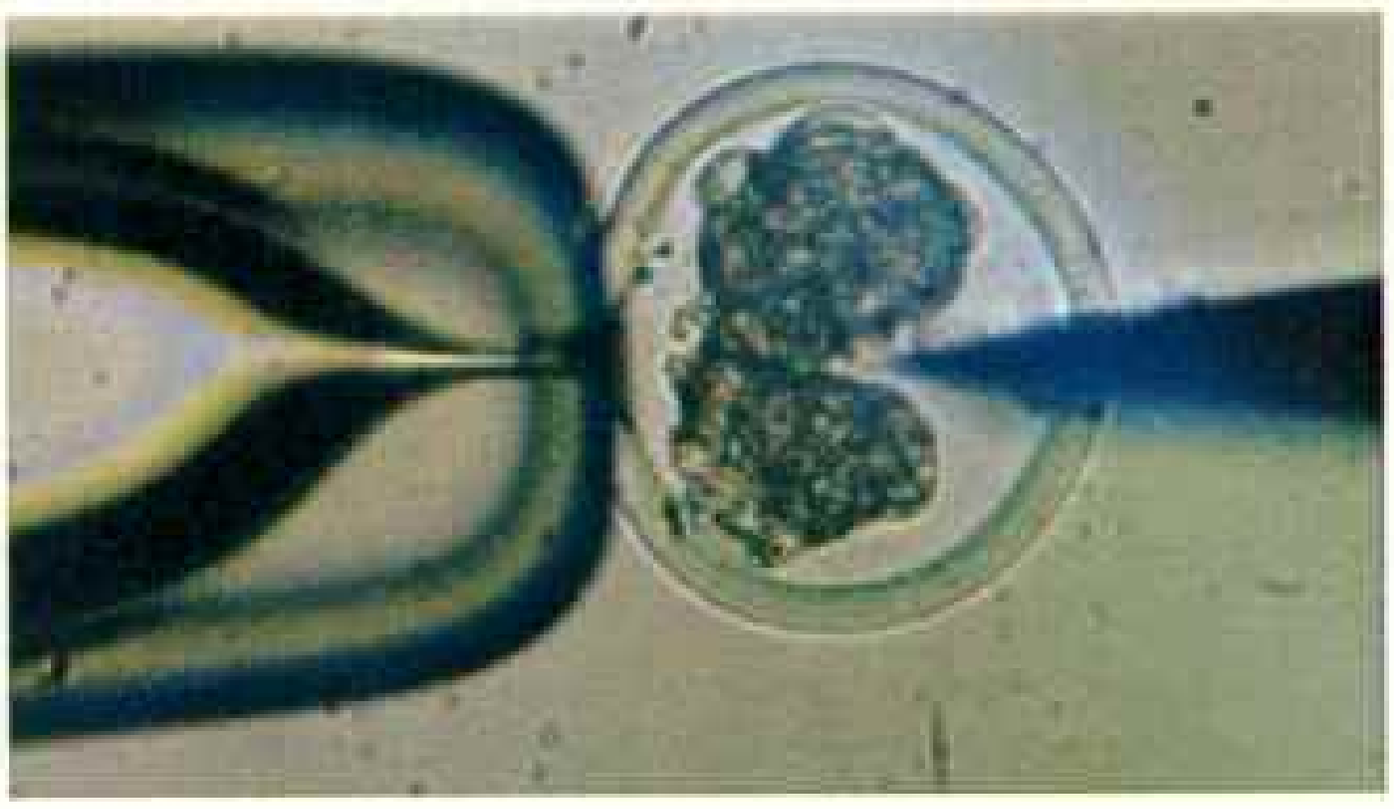
Cancer can be so devastating, growing so inexorably and absorbing the body's nutrients so voraciously, that it almost seems a foreign invader. Yet malignant tumors descend from normal cells that stop acting cooperatively and become parasites.

What transforms a cell from team player into killer?

It now appears that we carry, in most of our trillions of cells, a group of at least 20 so-called proto-oncogenes. These are very similar to oncogenes, found in certain viruses, that can transform cells from normal to cancerous. Proto-oncogenes may help with routine cell life until something goes wrong—from radiation, chemicals in cigarette smoke, or other environmental influences—and the gene mutates, or changes. Or the surroundings of the gene may change and make it hyperactive.

By itself, such a change is probably harmless; the person's life goes on unaffected. But if another of these special genes is disrupted, and it too mutates or becomes hyperactive, the cell begins the unfettered division that signals cancer.

The brilliant research that led to this concept depended on cloned genes; only they could produce *(Continued on page 830)*



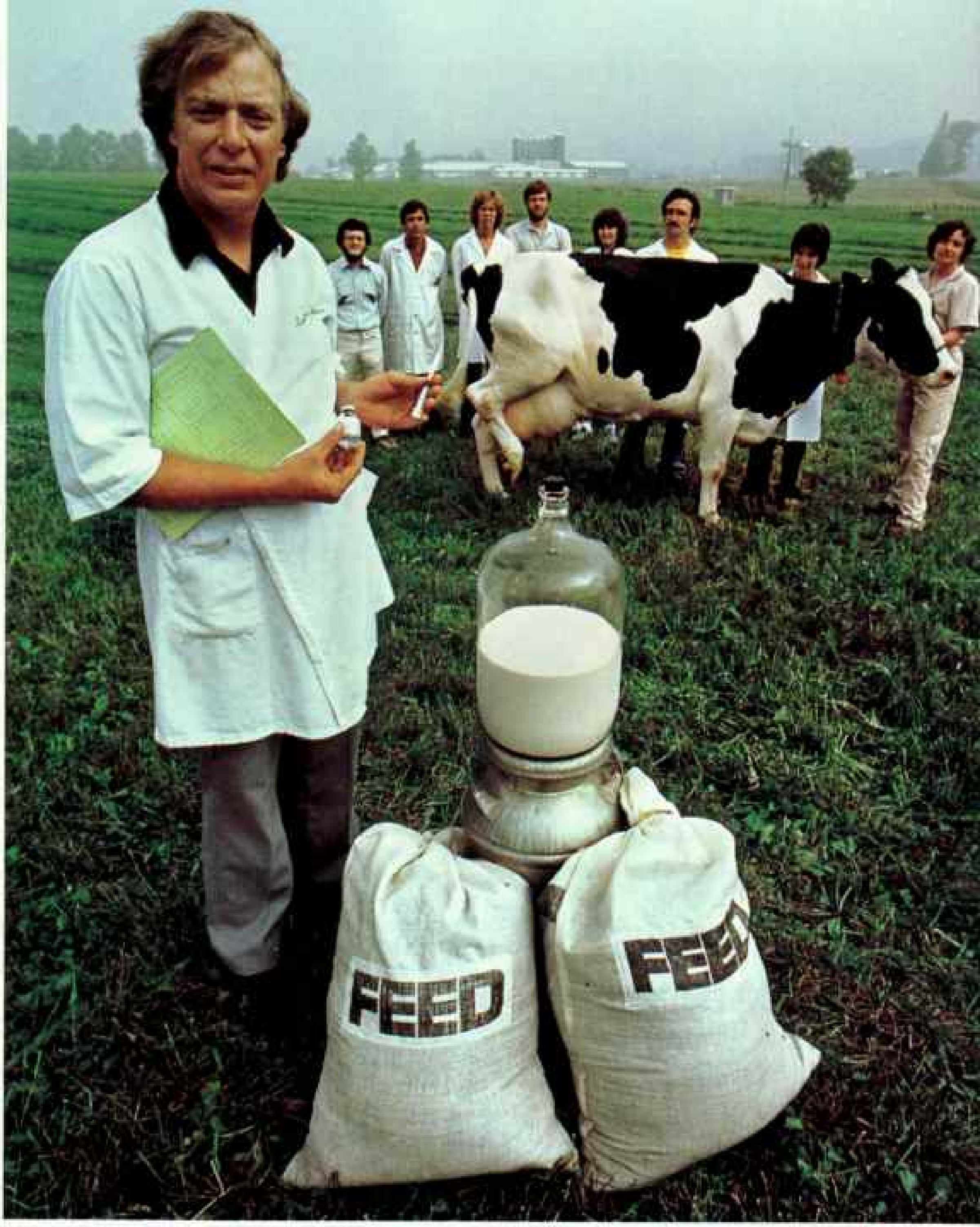
Cutting an embryo yields twins

TWO FOR ONE. *The technique of embryo splitting and transfer, developed by scientists at Colorado State University, can produce two calves from a single embryo. This increases the reproduction rates of superior animals as well as providing genetically identical twins for laboratory studies.*

Demonstrating the procedure at the school's Embryo Transfer Laboratory at Fort Collins, Dr. Tetsuo Takeda (**left, top**) *prepares to move a hollow glass pipette, indicated by his finger, into a petri dish containing cattle embryos a week old.*

Looking through the microscope, Dr. Takeda secures an embryo for splitting (**left, center**). *The pipette, at left, immobilizes the embryo, center, by gentle suction. Then Takeda maneuvers a microsurgical blade, right, that pierces a gelatinous sac and cleaves the embryo in two. The embryos are then transferred to two surrogate mothers.*

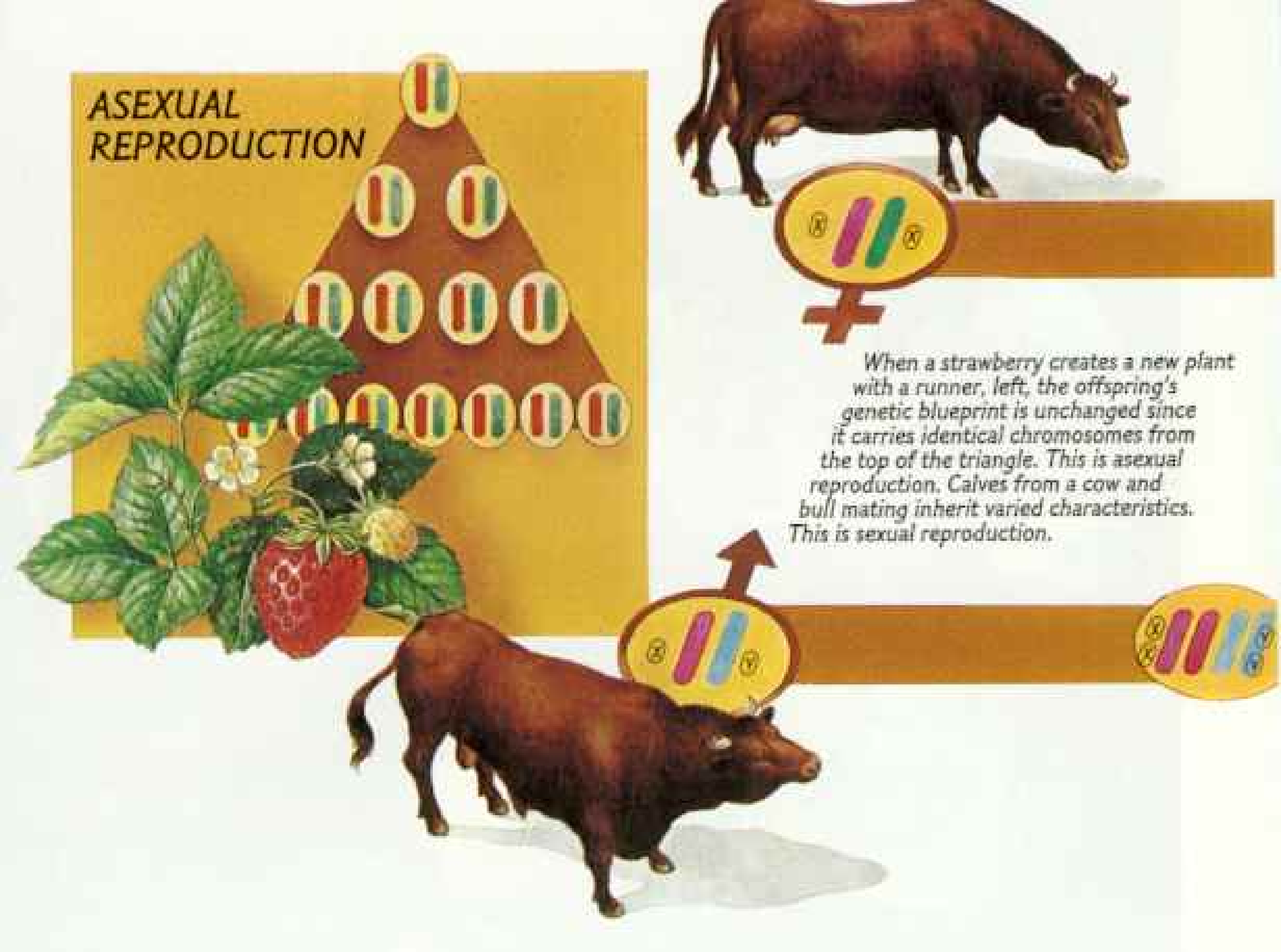
Bull calves (**bottom**) *that resulted from such a procedure wear backpacks in a puberty-inducing study. From its backpack, the calf at right receives regular injections of a hormone that may stimulate earlier sperm production. The calf at left, an ideal control since it is a genetically identical twin, receives injections of an inert saline solution.*



Cows gave more milk *when Dr. Dale Bauman, a nutritional biochemist at Cornell University, Ithaca, New York, and his research team administered daily injections of bovine growth hormone. The hormone, ordinarily produced by a cow's pituitary gland, was synthesized by Genentech for the Monsanto Company.*

Each Holstein treated in the 188-day study gave as many as ten quarts of milk a day over the usual 30 quarts.

Commercial application of the new technique awaits approval by the Food and Drug Administration to ensure the safety of the treatment for animals and the safety of the product for consumers.



When a strawberry creates a new plant with a runner, left, the offspring's genetic blueprint is unchanged since it carries identical chromosomes from the top of the triangle. This is asexual reproduction. Calves from a cow and bull mating inherit varied characteristics. This is sexual reproduction.

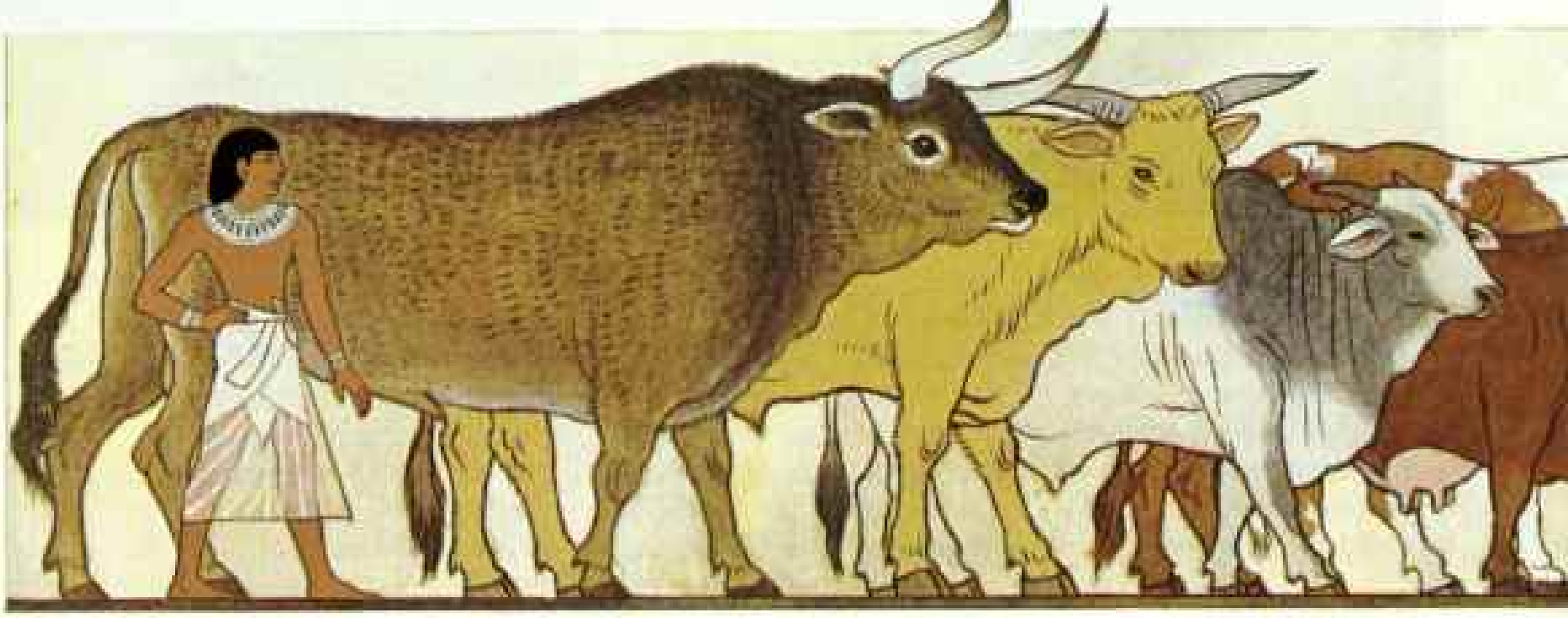
Nature's variety improves the breed

LONG BEFORE *the genetic basis of heredity was understood, farmers bred animals and plants to enhance desirable traits. In a sense the first genetic engineers, they recognized that selecting superior parents produced improved offspring.*

*Since domestication, cattle have been bred for strength at the plow, for fighting spirit, and, as early as 1700, for more milk or beef (**below**).*

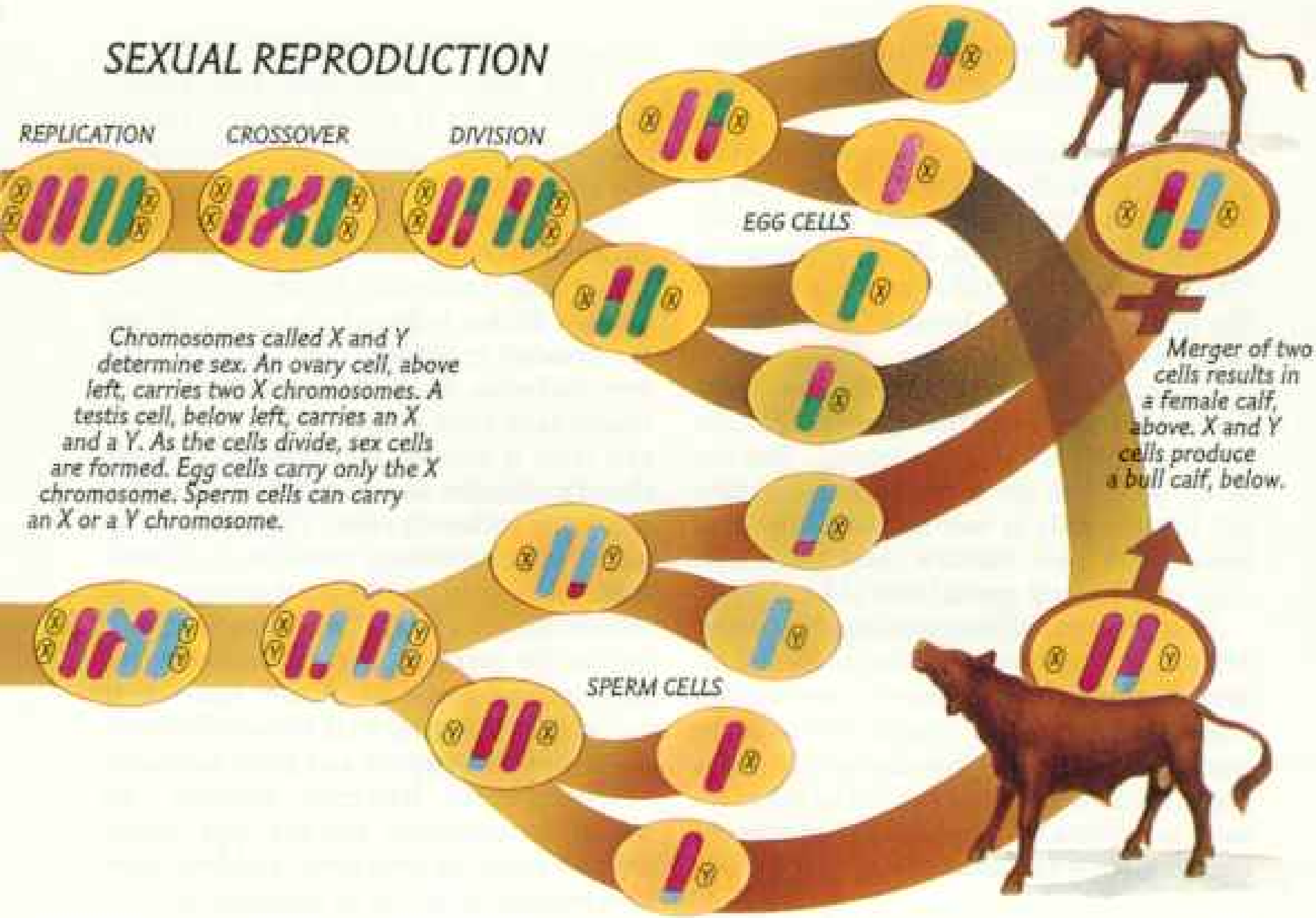
Unlike asexual reproduction, in which an entire organism grows to the genetic blueprint of a sole parent, sexual mating is nature's way of varying the genetic pattern by combining elements from two blueprints.

As DNA within the ovary and testis cells replicates,



WILD AUROCH, 8000-5000 B.C. DRAFT OX, 3000 B.C. ZEBU, 3000 B.C. DRAFT, MEAT, MILK LONGHORN, 1493-1880 HIDES, MEAT

SEXUAL REPRODUCTION



Chromosomes called X and Y determine sex. An ovary cell, above left, carries two X chromosomes. A testis cell, below left, carries an X and a Y. As the cells divide, sex cells are formed. Egg cells carry only the X chromosome. Sperm cells can carry an X or a Y chromosome.

Merger of two X cells results in a female calf, above. X and Y cells produce a bull calf, below.

a number of DNA molecules in chromosomes cross over and exchange genetic information before the cells divide. The resulting cells' blueprints have the same general order but new patterns.

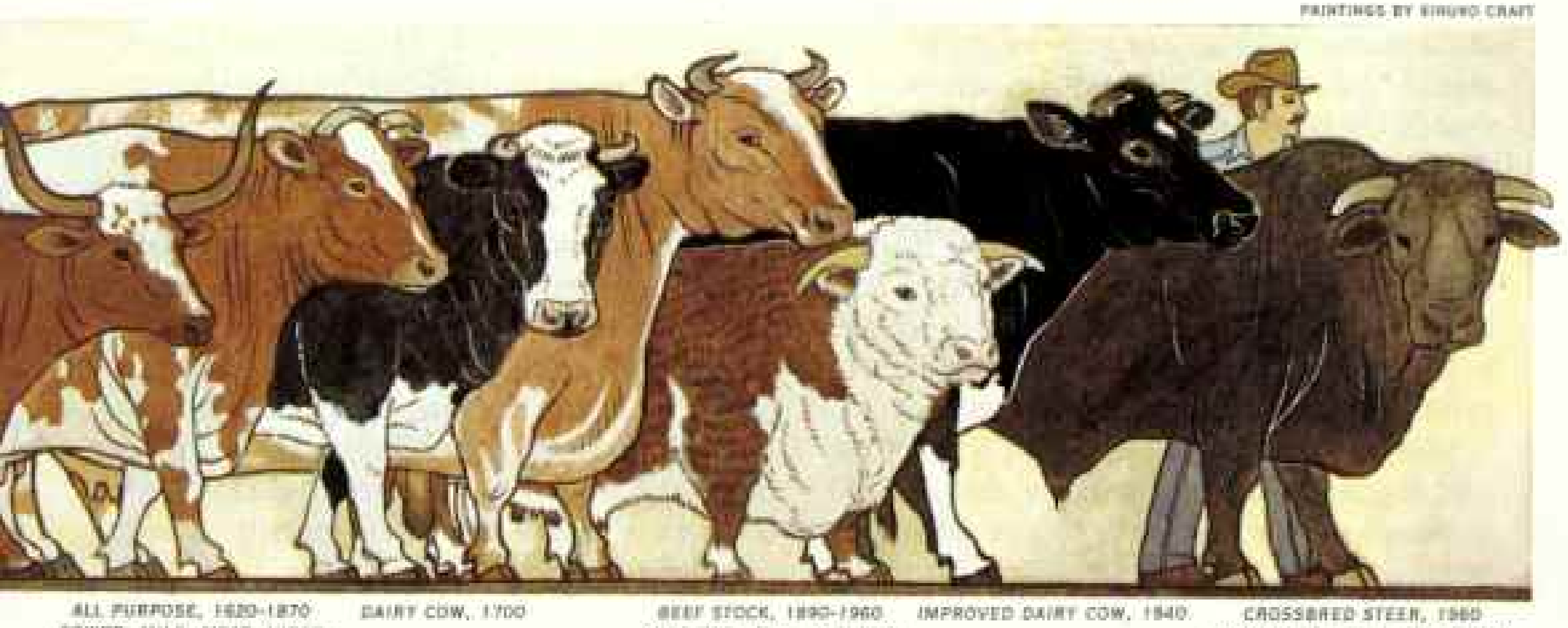
When the sex cells divide for the second time, creating egg cells and sperm cells, a change occurs. The number of chromosomes is halved, so that the joining of sperm cell and egg cell will constitute a normal double set of chromosomes.

Traits passed on by the parents to the new cell's genes may appear or lie hidden. A dominant trait is expressed even when only one parent contributes it. A recessive trait is not expressed unless it is passed on by both parents.

Some genetic traits, like color blindness, are sex linked. Since only X chromosomes carry these genes, males inherit them from their mothers, while females inherit them from both parents.

Thus nature, the ultimate genetic engineer, fashions creatures of seemingly infinite variety.

PAINTINGS BY KINUKO CRAFT



enough DNA to reveal the subtle differences between the altered genes and their normal counterparts.

Much of cancer's notorious resistance to therapy lies in the ability of tumor cells to metastasize—break off from the primary tumor, migrate through the bloodstream or lymph system, and colonize other areas of the body. This often foredooms surgery or local radiation treatment.

Chemotherapy, which treats the whole body, offers at present the best hope of a cure once cancer has begun to spread. But the drugs now used are powerful poisons; they kill healthy cells in hair follicles, intestinal lining, and bone marrow, and cause hair loss, nausea, and partial loss of immunity.

New products of biotechnology that could kill cancers without harming normal cells may eventually supplement conventional chemotherapy. Most would stimulate or mimic the body's own immune system, helping it repel cancer cells as well as invaders such as viruses and bacteria by producing defensive cells and antibodies.

IT WILL NOT be easy. Established cancer cells can frustrate almost any defense. Like master spies they even seem to disguise themselves in order to evade the immune system. To penetrate these disguises, the body needs clever counterspies, which biotechnology can provide in the form of monoclonal antibodies.

These agents were merely a doctor's dream until Cesar Milstein and Georges Köhler created them in 1975 at the Medical Research Council laboratory in Cambridge, England.

Drs. Milstein and Köhler began by injecting a mouse with an antigen, a foreign substance that elicits an immune response—that is, the body produces antibodies to repel the invader. Taking antibody-producing cells from the immunized mouse, they fused them with mouse tumor cells, conferring on them the ability to divide indefinitely like cancer cells. The resulting cells—called hybridomas—have the staying power to produce the antibody continuously.

Molecular biologists devote a lot of time and ingenuity toward making monoclonal antibodies more deadly to cancer cells. One approach is to tag them with a radioactive element. Such "hot" antibodies bind to tumor cells and zap them with their radioactivity. Scientists at several research centers around the country have aimed these agents at a variety of tumors.

In the hands of Drs. John Kersey and Norma Ramsay at the University of Minnesota, monoclonal antibodies isolated by immunologist Tucker LeBien have dealt a blow to the dreaded malignancy of the bone marrow, leukemia. In their procedure, the physicians take bone marrow from the patient and treat it outside the body with monoclonal antibodies and certain blood proteins to kill the leukemia cells. Then the patient receives chemotherapy and a dose of radiation sufficient to kill the bone-marrow cells remaining in his body. This would be lethal but for the precious marrow cells removed and cleansed earlier, and now returned to the patient. If all goes well, these cells repopulate the bone marrow and grow normally.

Twenty-three leukemia patients, for whom conventional therapy had failed, have received the treatment, and four of the first thirteen were still in remission after 16 months, in the summer of 1984.

Monoclonal antibodies also aid the fight against leukemia by assisting in the transplant of bone marrow from a healthy person. Marrow produces the cells that reject transplants. However, when marrow itself is transplanted it can reject its new host, causing the life-threatening graft-versus-host disease. But pretreatment of the marrow with antibodies kills the cells that would cause this disease, so the guest marrow accepts its new quarters.

To strengthen the antibodies' punch, teams of researchers are coupling them to a potent toxin. Dr. L. L. Houston and I have collaborated on this approach at the University of Kansas.

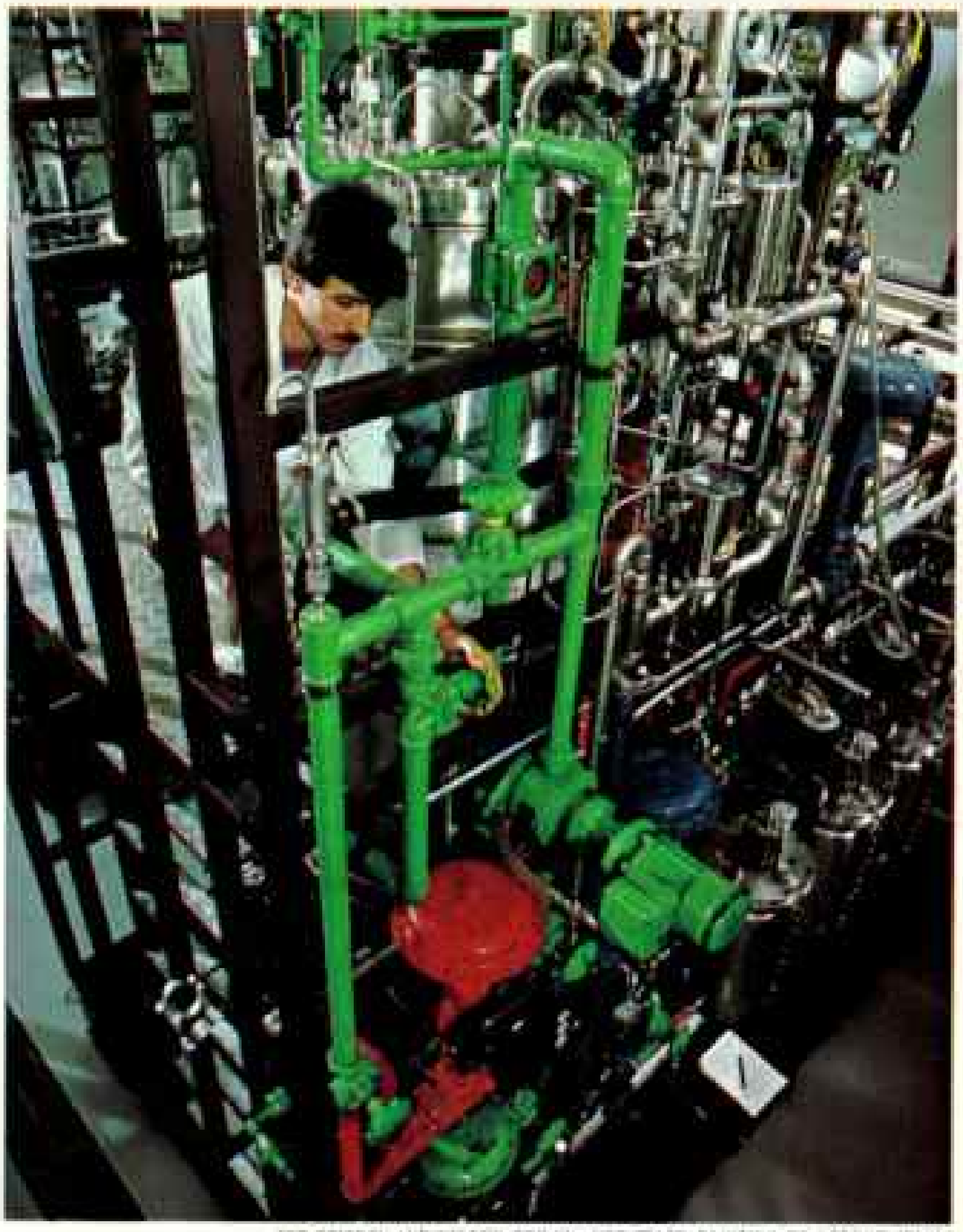
One of our toxins comes from the castor bean, a cause of accidental human poisonings since antiquity. A lethal ingredient is ricin, a two-part protein composed of the poison and an agent that binds it to the victim's cells. This castor poison alone would be a poor antitumor agent because it also kills normal cells. But what if we replace the binder with a monoclonal antibody that can home in on enemy cancer cells? Dr. Houston has shown that such

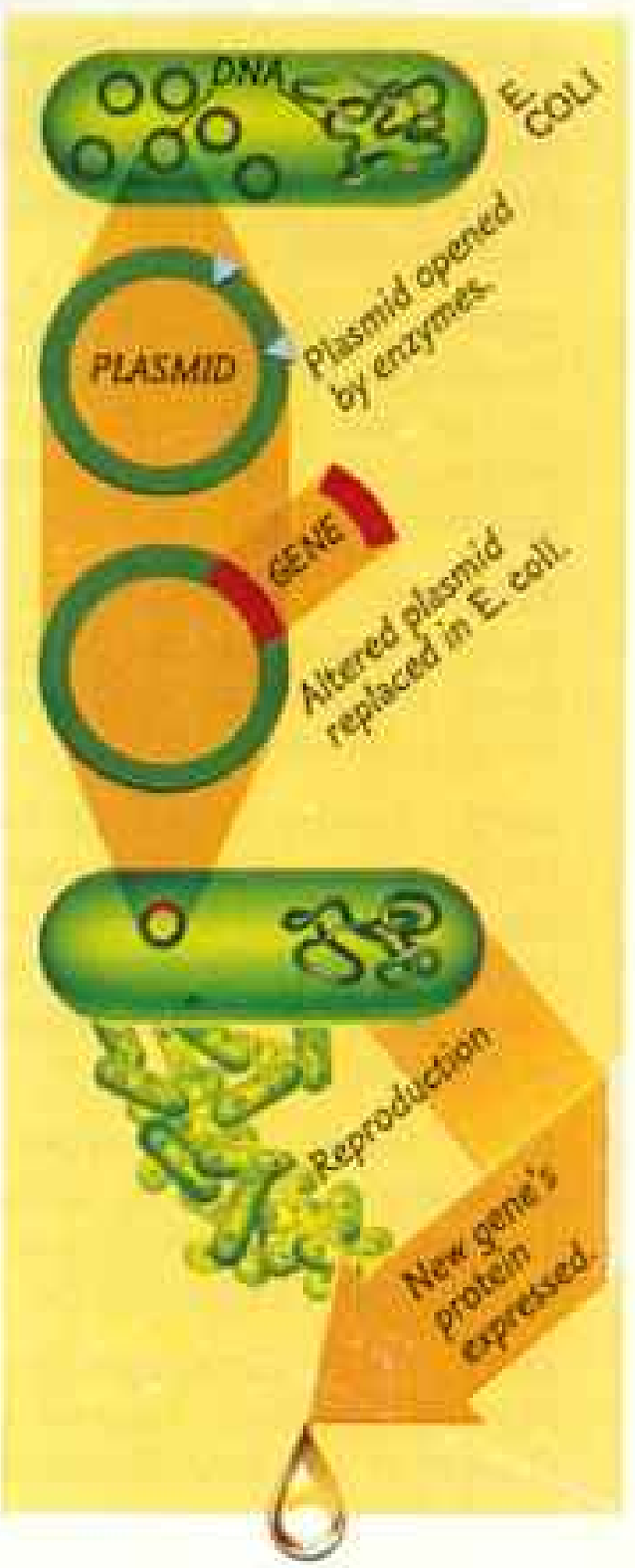
immunotoxins can protect mice from tumor cells, and clinicians are already conducting trials with human cancer patients.

My colleagues and I, supported by Eli Lilly, have also cloned the poison gene, so we will be able to shape it and its protein products to our own design, a process that has given rise to the pun "designer genes."

ANOTHER FRONT in the war against cancer involves cloning genes for rare proteins that stimulate the body's natural defenses. One of these is interferon, sometimes touted as a miracle cancer cure. The two earliest types of cloned interferon show some activity against certain kinds of cancer, but in most cases they appear to be less effective than conventional treatment, and they can cause severe flu-like side effects. A recently cloned third form—gamma interferon—is being tested on humans in the U. S., Europe, and Japan and may yet fulfill the protein's early promise.

Interferons may also be effective in fighting viral infections, one of their normal activities. Doctors are already testing interferons against several viruses, including those evasive agents that cause hepatitis,





TED SPIEGEL AND NELSON BROWN, NGS STAFF; PAINTING BY GEORGE KELVIN

"Designer genes" produce insulin

*IN A MAZE of pipes a fermentation vat at Biogen in Cambridge, Massachusetts (**above**), grows E. coli bacteria found in the human intestines. These scientific servants synthesize interferon, insulin, and other drugs using recombinant DNA.*

*Rings of DNA called plasmids (**right**, top) are isolated from E. coli. Like chemical scalpels, restriction enzymes cut the rings, allowing new genes, such as those for insulin, to be placed in the plasmids and reinserted into E. coli. The E. coli reproduce, manufacturing insulin.*

herpes infections, and the common cold.

The interferons belong to a class of protein hormones called lymphokines that work by regulating the immune system. Gamma interferon, for instance, stimulates macrophages, cells that prowl the bloodstream to search out and eat enemy cells, including cancer cells.

In time lymphokines may help reverse dangerous immune suppression caused by cancer and its treatment. Interleukin-2 developed by the West Coast firms Cetus and Immunex is being tested in clinical trials. Lymphokines may assist victims of acquired immune deficiency syndrome (AIDS), a growing health threat. And they may benefit children born with immune-system defects so severe that they must live in germ-proof plastic chambers—the plight of the nationally mourned "bubble boy," David.

Occasionally our immune system works too well. Then it turns the body against itself in self-destructive diseases including rheumatoid arthritis, multiple sclerosis, and juvenile diabetes. Work is afoot to produce lymphokines that depress such immune systems and thereby halt the destruction. This eventually could benefit the millions of us afflicted with less severe forms of immune hyperactivity—allergies.

Cancer specialists like to emphasize that if we detect tumors early in growth, they will be easier to treat and may not have metastasized to remote areas of the body. Here again biotechnology is looming large.

Monoclonal antibodies that are able to recognize tumor cells may make ideal cancer detectors. Dr. John Weinstein of the National Institutes of Health injects cancerous guinea pigs with antibodies tagged with radioactivity, then scans with a detector to locate metastases. This technique is beginning to be applied to humans.

WHEN THE SALK polio vaccine came on the market in the early 1950s, physicians vaccinated millions of patients, possibly including me, before discovering that monkey cells used for growing the vaccine carried unwanted viruses. One of these was a rodent tumor virus. Fortunately the vaccine caused no known increase in human cancer.

But as this case illustrates, most vaccines

Milestones

1869 *Elegant experiments with pea plants enable Austrian monk Gregor Mendel to describe the mechanisms of heredity.*

1944 *Working with a bacterium that causes pneumonia, O. T. Avery of Rockefeller University and colleagues discover that genes are made of DNA.*

1953 *The double-helix structure of DNA is discovered by Francis H. C. Crick and James D. Watson.*

1965 *RNA is used to achieve protein synthesis in a test tube. Scientists demonstrate that sequences of three nucleotides specify amino acids to be linked together to form proteins by the ribosome. The genetic code is cracked.*

1970 *Hamilton Smith and Daniel Nathans of Johns Hopkins University discover and use a new class of restriction enzymes, the chemical scissors that slice and separate DNA molecules.*

1972 *Paul Berg and others at Stanford University combine the DNA from two viruses, a technique that yields what is called recombinant DNA.*

1973 *Stanley Cohen of Stanford and Herbert Boyer of the University of California at San Francisco insert recombinant DNA into host bacteria that reproduce, or clone, the foreign DNA. The age of genetic engineering begins.*

1977 *Genentech, one of the first genetic engineering companies, embarks on the biosynthesis of important drugs by recombinant DNA methods.*

1977 *Frederick Sanger of the British Medical Research Council and Walter Gilbert of Harvard University independently discover techniques for the rapid sequencing, or reading, of the order of nucleotides in DNA molecules.*

1978 *Sickle-cell anemia is diagnosed before birth of an infant by analysis of its DNA.*

1982 *Human insulin produced by recombinant DNA techniques is marketed under the trade name Humulin.*

carry an assortment of risks. Each contains, in dead or weakened state, the virus it seeks to defeat. This way it presumably will not cause disease but will provide the proteins that stimulate the patient's production of antibodies—a key part of immunity. Occasionally, however, this weakened virus causes serious, even fatal, reactions. A smallpox vaccination today is more dangerous than the almost nonexistent risk of contracting the disease itself.

Gene cloning can avoid such hazards. We simply produce the viral protein that stimulates our bodies to make antibodies, purify it, and use it as a vaccine, free of contamination by the whole virus.

Genentech already uses gene cloning for developing a vaccine against the foot-and-mouth virus that attacks cattle and swine, sometimes forcing the destruction of whole herds. Defective vaccines themselves have caused outbreaks. In the U. S. the disease has been eliminated, and even research on the virus is banned on the mainland. Genentech and United States Department of Agriculture (USDA) scientists had to journey to the Plum Island Animal Disease Center, off the tip of Long Island, to clone foot-and-mouth-virus protein genes.

Scientists at Biogen in Geneva, Switzerland, have applied the same approach to hepatitis in humans. And their vaccine could have deeper implications: A hepatitis virus can lead to liver cancer as well, and vaccination could prevent both diseases. This may become the first instance of using the immune system to prevent, rather than treat, cancer. This would be the ideal answer to cancer: Never let it start.

One researcher who believes strongly in the potential of purified vaccines is Professor Ariel Hollinshead of George Washington University in Washington, D. C. Collaborating with Dr. Thomas Stewart of the University of Ottawa, she feels she has scored success in a challenging area, lung cancer.

Savagely aggressive, lung cancer usually has metastasized by the time the patient seeks help. In cases when the cancer is detected early, one out of two surgery patients survives at least five years. But in clinical trials, three out of four patients who undergo surgery and injections of experimental vaccine enjoy a five-year survival rate.

Glossary

Antibody *A protein that binds to an invading antigen prior to the destruction of the antigen.*

Antigen *A foreign substance, usually a protein, that triggers the body's production of a specific antibody directed against the antigen.*

Bacterium *A single-celled microorganism with a primitive nucleus.*

Chromosome *A segment of DNA containing many genes.*

Clone *One or more genetically identical organisms.*

DNA *Deoxyribonucleic acid, the stuff of which genes are made, a long chainlike molecule composed of nucleotides.*

E. coli Escherichia coli—*a common intestinal bacterium, studied by generations of biologists, that has probably provided more knowledge of biochemistry and genetics than any other living thing.*

Enzyme *A protein that catalyzes one of life's chemical reactions.*

Gene *A segment of DNA containing the coded information for making a specific protein.*

Hormone *A substance secreted by one type of cell that carries a signal to another type of cell.*

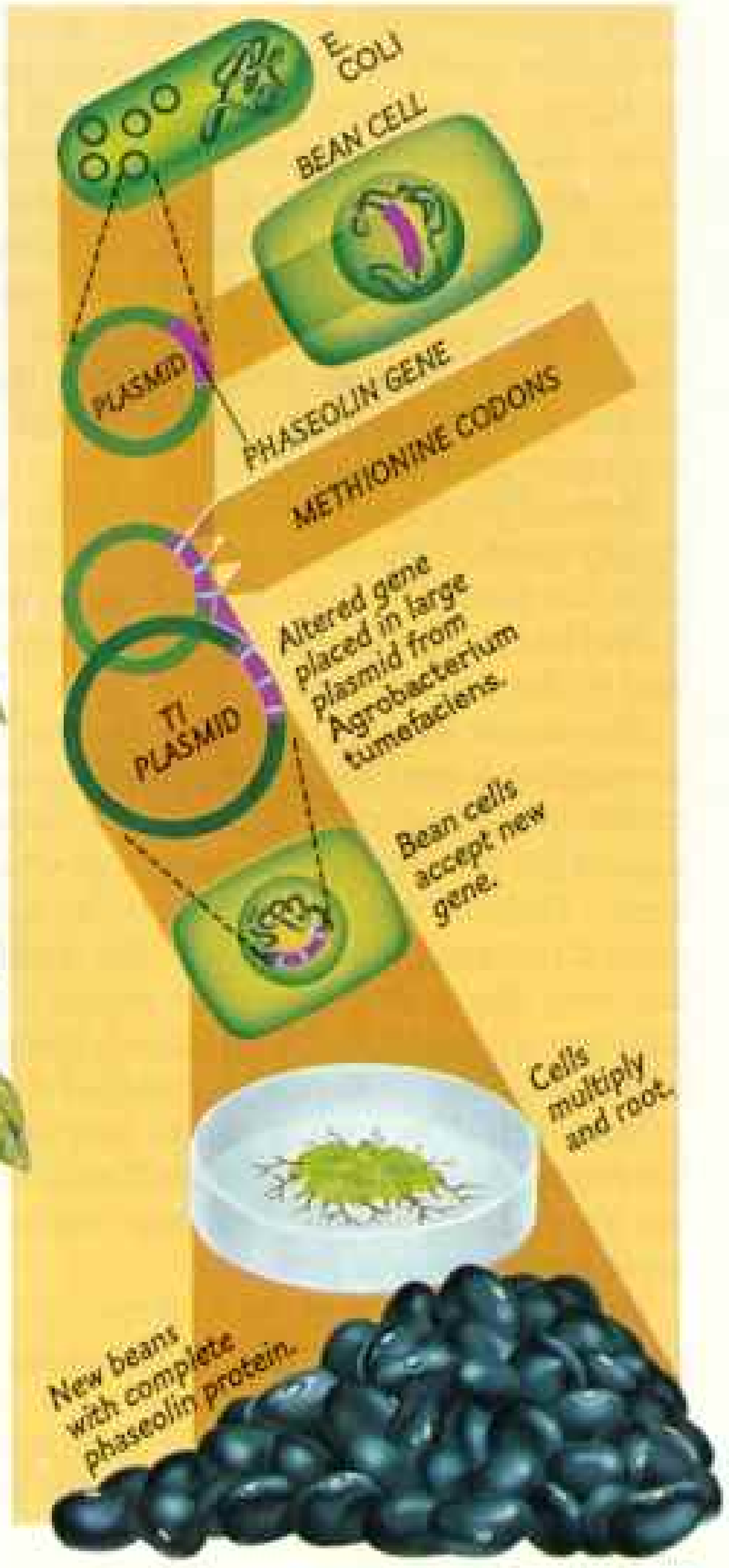
Monoclonal antibodies *Identical antibodies cloned from a single source and targeted for a specific antigen.*

Nucleotide *Building block of the DNA molecule composed of an organic base, a sugar, and a phosphate.*

Plasmid *A self-replicating circular DNA molecule found in bacteria and carrying two or more genes.*

Protein *A molecule of linked amino acids. Proteins serve primarily as biochemical catalysts and as structural parts for an organism.*

Recombinant DNA *A new combination of genes spliced together on a single piece of DNA.*



PAINTINGS BY GEORGE KELVIN

Engineering new plants

CAN A FOREIGN *gene be introduced into a plant? If so, then plants could be engineered to resist disease or drought, or to improve their food value.*

Seeking answers, scientists at Agrigenetics Corporation use a soil microbe to carry a foreign gene into a crown gall at the base of a sunflower (**facing page**).

But could a foreign gene be expressed in all the cells of a plant? A French-bean gene was inserted into a Ti plasmid (**above left**) *from a microbe. The plasmid was then returned to the microbe, which was used to infect a tobacco plant.*

After cells from the plant's crown gall were cultured, hormones caused the cells to form a tiny plant, which was grafted onto the stem of a tobacco plant. The bean gene was successfully expressed throughout the new plant, now called a Tobean.

What next? In theory a bean's primary protein, phaseolin, could be made nutritionally complete by increasing a single amino acid, methionine. Clamped into the workbench of an E. coli plasmid (**above right**), *a phaseolin gene is supplemented with methionine codons.*

The altered gene is transferred to a Ti plasmid, which carries it to bean cells whose own phaseolin genes have been destroyed. The cells grow to produce a new bean.

Going a step beyond treating the disease, the team plans to launch an immunization program for people likely to contract lung cancer: heavy smokers who work with asbestos. Although it will be years before we know finally how well either program works, Dr. Hollinshead is confident. "In the future," she asserts, "we will be able to use immunology for the prevention of cancer."

ENTREPRENEURS have been quick to recognize the enormous value of monoclonal antibodies for diagnosis, therapy, and biochemical research.

In San Diego, California, I toured the pioneer monoclonal company, Hybritech, now all of six years old. Moving from lab to lab, we stopped at each door to manipulate a push-button combination lock. "Our products are valuable and highly portable," commented my host, Cole Owen. "These discourage theft."

In the labs, animal rooms housed hundreds of mice—the antibody factories. There I watched technicians inject the animals with antigens, turning on the production of antibodies.

Some were nude mice—homely, hairless creatures, whose hair-growing powers were sacrificed in the process of building in other genetic traits (page 841). One such trait is an inability to reject foreign tissue. When one of the mice is injected with hybridoma cells, instead of rejecting the foreign cells the mouse serves as an incubator or factory in which the cells can grow and produce large amounts of antibody.

I watched the technicians take tissue from mice that already were producing antibodies, then followed them to the fusion lab, where the tissue cells were joined with tumor cells to give them staying power.

From the fused cells, staff members would later choose the most promising and inject them into the abdominal cavities of other mice. This is the actual factory, the favorable environment in which the cells produce antibodies in copious quantities. A single mouse, I learned, can produce in a few weeks antibodies that may sell for $20,000—well worth keeping behind locked doors!

The first commercial return comes not from drugs, which take years and millions of dollars to develop before marketing, but from diagnostic aids that can be used in simple laboratory tests.

A pregnancy test developed by Hybritech yields results in minutes. Similar Hybritech kits diagnose allergies, anemia, and even heart disease.

Sexually transmitted diseases can be diagnosed by monoclonal antibodies developed by Genetic Systems Corporation in Seattle. So far the tests detect gonorrhea, syphilis, herpes, and other infections.

One of the most intractable of human diseases, sickle-cell anemia, has a genetic origin, so we hope that its cure, too, lies in genetic engineering.

The disease, found almost exclusively in blacks, evolved in tropical Africa, where malaria is rampant. As a defense against malaria, nature provided many Africans with a mutant gene that enables red blood cells to resist invasion by the malarial parasite. Unfortunately, one in four children of healthy parents who are sickle-cell carriers receives two mutant genes. Under stressed conditions the mutant gene product, a type of hemoglobin, crystallizes in the blood cells, distorting them from round to sickle-shaped. Sickle cells can painfully block small blood vessels, or burst and leave the patient anemic, often leading to death.

Since a defective gene causes this malady, a cure may be to introduce a normal gene into the patient's blood-forming bone marrow cells. Many of the basic procedures needed for this task already exist.

DESPITE THE EXCITEMENT generated by medical gene splicing, some experts predict it will be overshadowed by applications even more profound in agriculture.

Consider a few of the possibilities: Seed proteins deficient in some amino acid building blocks could be made whole. We could equip crops with disease resistance and pest resistance. Optimists believe we might even modify cereal plants such as corn and wheat so they can make some of their own nitrogen fertilizer.

One of the best-known companies pursuing the new agronomy is Agrigenetics Corporation, whose location in Madison, Wisconsin, facilitates cooperation with scientists at the state university.

To enter the grounds of Agrigenetics is to realize that these people care about plants. Flower beds line the walkways between buildings; the lawn is lush and green; thriving greenery fills an atrium forming the entry to the main building. Remarked Dr. Timothy Hall, then director of the laboratory, "I guess we'd *better* know how to grow plants."

Seed companies traditionally improve their products through selective breeding: mating plants to maximize desirable features and eliminate the undesirable. However, this is a slow process. It often requires many plant generations spread over years.

A more direct route is to introduce new genes directly into the crops themselves—not easy, but precisely the role of genetic engineering.

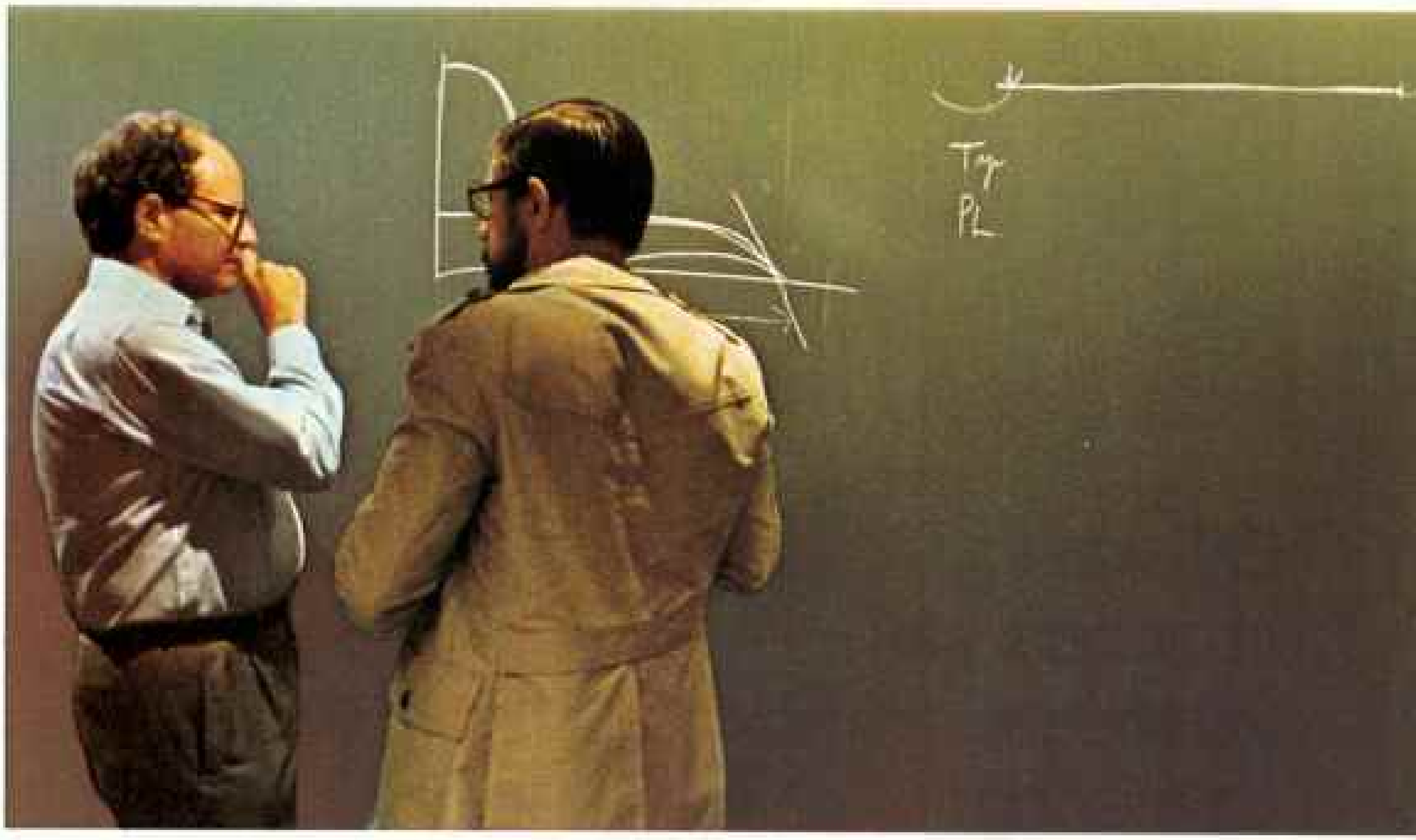
For example, researchers at Agrigenetics are concentrating on a gene for phaseolin, a major protein of the French bean. This bean is well known for its protein, but phaseolin is low in one amino acid, methionine. This deficiency reduces the bean's food value.

To manipulate this phaseolin gene, it must first be removed from the parent bean and introduced into another host so it can be observed in isolation.

Agrigenetics engineers led by Drs. Timothy Hall and John Kemp have successfully transferred the gene to sunflower cells in culture. Their creation is the fancifully named "sunbean." The sunbean is actually an unfanciful callus, an amorphous mass of tissue resembling a slimy piece of cauliflower.

But this callus does something no ordinary sunflower can—it makes a bean protein. Ultimately it could enable Dr. Hall and his colleagues to alter the cloned phaseolin gene so that its product possesses more methionine. The improved gene could then be put back into the bean plant. This should enhance the crop's nutritional value.

IN A WORLD that lives from harvest to harvest, fertilizers are of crucial importance. Their production can take considerable energy, and during the past decade energy costs have risen astronomically.



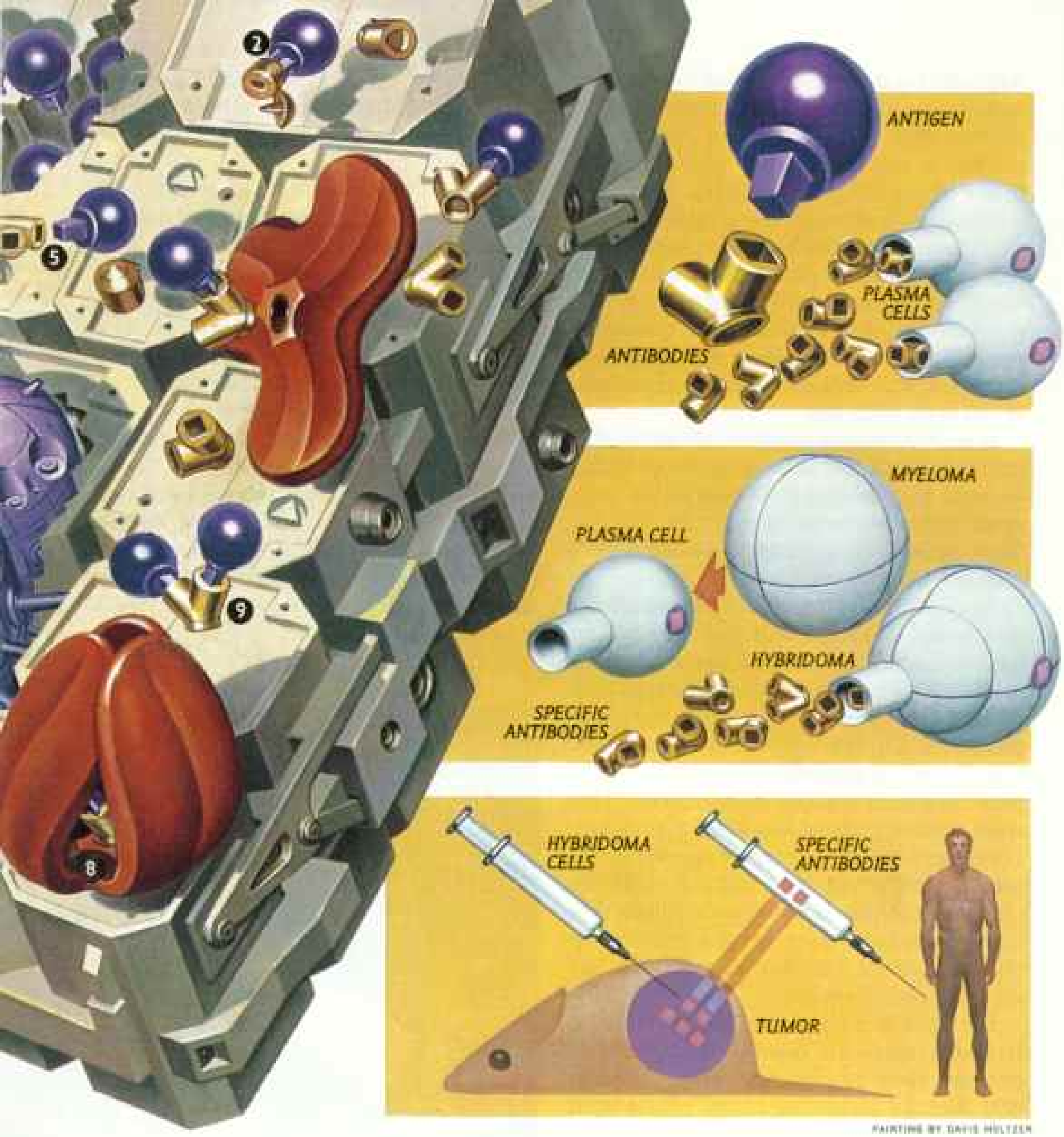
Nobel prizewinner *and former Harvard professor Dr. Walter Gilbert, left, helped found Biogen, which in 1979 cloned a gene for interferon—believed useful in treating certain cancers. Here in Biogen's Cambridge, Massachusetts, offices Gilbert confers with Dr. Walter Fiers, a Belgian colleague.*

Cell wars: attackers and defenders on a living battleground

A FANTASY battleground portrays the daily warfare that rages between invaders and defenders within our bodies. Each cell in the body has a distinct shape on its surface **1** *that distinguishes it from foreign cells.*

The body's army—its immune system—patrols for unfamiliar shapes using special troops produced in the bone marrow. A macrophage ***(left, top)*** *is ready to engulf and digest an enemy. A plasma cell* ***(left, middle)*** *learns to recognize the molecular signature, or antigen, of an invader and produces antibodies capable of locking onto it. The T cell* ***(left, bottom)*** *recognizes invader signatures and summons macrophages with chemical signals. It can also destroy an enemy with a toxin* **2**.

In this battle ***(above)*** *invading cells* **3** *carrying a new antigen shape enter through a rift in the cellular*



PAINTING BY DAVID HOLTZER

structure. Days pass before plasma and T cells recognize the new shape. Meanwhile, the system battles previous intruders **4** *and* **5**.

Antibodies lock onto invaders **6**, *then bind to a macrophage* **7**, *which surrounds and digests them* **8**. *Antibodies can also immobilize invaders by locking onto more than one* **9**.

Cancer cells **10**, *produced within the body, frustrate the immune system because their recognition shapes* **11** *are similar to the body's. T cells, however, may attack them or signal a macrophage to destroy them* **12**.

*Forging a new weapon, scientists grow plasma cells that respond to a specific antigen, yielding a small number of antibodies to fight that invader (***right, top***). To make more antibodies, the plasma cells are merged with long-lived tumor cells called myelomas (***right, middle***), producing hybridoma cells, which have genetic information from both parent cells.*

*A hybridoma is cloned—multiplied from a single cell—in the laboratory and injected into a mouse (***right, bottom***). The tumor that grows within the animal makes large quantities of a monoclonal antibody, so called because it is descended from a single genetic source. Such antibodies are being tested against disease in humans.*

Agricultural costs have soared correspondingly, while malnutrition has spread, particularly among peoples of poorer nations.

Genetic engineering may offer a solution to the rising price of fertilizer. Since the dawn of gene cloning, some molecular biologists have dreamed of transferring certain genes to cereal plants, the backbone of world agriculture. Ideally these genes would produce enzymes enabling the cereals to synthesize nitrogen fertilizer from the nitrogen in the atmosphere, just as legumes such as beans do naturally.

In reality legumes produce nitrogen fertilizer only with the help of nitrogen-fixing bacteria that inhabit little nodules on their roots. Cereal plants, unhappily, do not form the nodules normally associated with nitrogen-fixing bacteria.

To give cereals this gift of nitrogen fixation would be a difficult task. We would have to collect the 15 or so bacterial genes needed to fix nitrogen, rebuild them so they could function in a plant, and introduce them into a plant cell. From this cell we would have to generate a plant that would pass the priceless genes on in its seed. This regeneration process has been a problem: Scientists have been unable to regenerate cereal plants. Perhaps most difficult of all, the plant must somehow provide an oxygen-free environment, because oxygen profoundly poisons one of the key enzymes in the nitrogen-fixing system.

For these and other reasons Dr. Winston Brill of Agracetus in Wisconsin, another important plant-engineering firm, believes that directly endowing cereal plants with nitrogen-fixing genes is impractical.

He favors alternative tactics. "We could induce cereal roots to form nodules that nitrogen-fixing bacteria would colonize," he explained. "Another avenue is to engineer nitrogen-fixing bacteria to associate with cereal roots even in the absence of nodules." Already, bacteria from Dr. Brill's laboratory can meet one percent of a corn plant's nitrogen needs. This seemingly small achievement meant screening thousands of corn plants. Additional selective breeding might improve this to 10 percent.

As of today we do not know how to insert new genes into cereal-plant cells. A solution to the problem may emerge from a discovery made in 1948 by Dr. Barbara McClintock in her work on corn genetics—studies that only last year won a Nobel prize for the 81-year-old pioneer.

Dr. McClintock found that certain genes do not necessarily stay in one place in a chromosome, but can jump from one place to another, and even to different chromosomes. Skepticism greeted her findings until such "jumping genes" were discovered in bacteria, fruit flies, and other organisms. Now we see these transposable elements as potential carriers of engineered plant genes.

Dr. James Peacock and his colleagues at the Commonwealth Scientific and Industrial Research Organization in Canberra, Australia, were able to isolate one of McClintock's controlling elements. The team hopes to use the transposable elements as vehicles to introduce genes of agronomic importance into corn.

Diagnostic sleuths, *monoclonal antibodies on the surface of a bead* ***(above)*** *are used to detect the presence of hepatitis B virus in donated blood at Massachusetts General Hospital*

Why are we working so hard to increase plant yields when United States farms already produce surplus food? In answer, David Padwa, chairman of Agrigenetics, picked up the day's newspaper and pointed to headlines he had circled in red. They told gloomy stories of drought, crop devastation, and farmers' bankruptcies.

Padwa amplified: "In one year our surplus stocks fell by 55 percent, to a razor-thin 5 percent above absolute need. The world ordinarily has only a five-to-ten-week supply of food on hand. Near ten weeks, prices plummet and farmers go broke. At the five-week level, food gets scarce and expensive, and consumers revolt; the drought of 1983 pushed us toward that lower level. Even when we have a surplus, millions in poorer countries go hungry."

How soon will genetic engineering make its contribution to agriculture? David Padwa expects only a trickle of products until the end of the decade, then a steady increase. In a more optimistic vein Dr. Brill says, "Two years ago I would have predicted it would take ten years to get to where we are today. We are going to be even more surprised in the future."

BIOTECHNOLOGY'S ROLE in our energy future is at first less obvious than for health and food, because we cannot clone inanimate things such as oil and gas. Nevertheless, we will probably be using genetic engineering to increase our supplies of these substances.

One resource is petroleum that refuses to flow from spent wells. There may be as much as 200 billion barrels of this oil, worth trillions of dollars, trapped under the United States alone. Dr. Orlo Childs of the University of Arizona explains: "Most of the oil

in Boston. The new test is nearly twice as sensitive as previous ones.

Injected with hybridoma cells, the ubiquitous laboratory mouse ***(above)*** *serves as a living incubator to produce quantities of a monoclonal antibody at Hybritech Inc., in San Diego, California. By such means, scientists hope to revolutionize the diagnosis and treatment of many illnesses.*

The gauge of success *in the treatment of 23-year-old Cheryl Gasper, mother of baby Gregory, is monoclonal antibodies. After Cheryl received a kidney from an unrelated donor two years ago, Dr. A. Benedict Cosimi, right, began using monoclonal antibodies (MABs) to detect her body's level of T cells—fighters against infection and other foreign entities. Within a week a high level of T cells indicated an attempt to reject the alien kidney. To suppress the T-cell level, Cheryl was given an injection of a specific MAB known as OKT3. Here Dr. Cosimi takes samples of her blood to continue the monitoring of her T cells. This precision prescription is the first broad-scale use of MABs for therapy as well as detection.*

remains underground even after we flush with water, because it clings tightly by coating the rock surface. Think of what happens when you pour oil, water, or mercury onto a glass plate. The oil actually wets the plate, forming a thin film, just as it sticks to rock in a well. The water beads up and leaves only a few wet streaks. The mercury beads, on the other hand, dance across the glass as if in a hurry to leave, not wetting the plate at all. The trick is to make the oil behave more like mercury."

Bacteria could help if they could be modified to release agents that act like detergents and loosen the oil, but the extreme conditions deep within rock formations complicate this simple concept. Such bacteria must be formidable organisms indeed: able to loosen the oil; able to survive high temperatures, pressures, and salt concentrations; and able to live without oxygen—in an environment known as anaerobic.

Several bacteria meet one or another of these requirements, and some bacteria, such as those living near hot vents in the ocean floor, even satisfy several. Putting all the required characteristics into one microorganism would be relatively easy if we knew more about the genetics of these bacteria. Unhappily, we know very little. The gap underscores the importance of basic research to technology.

IN THE LONG TERM, when we have squeezed the planet for its oil and gas, we will need renewable energy sources. Here biotechnology would operate on more familiar ground and could fill a vital niche.

"The green plant," observes Dr. Melvin Calvin of the University of California at Berkeley, "is the best device known for capturing and storing solar energy." Plants already produce the sugars that we have been fermenting to alcohol for millennia. Alcohol mixed with gasoline makes gasohol. We can easily design cars to run on pure alcohol. Unfortunately, in distilling alcohol we expend considerable costly energy.

Imagine instead a veritable petroleum tree: You drive a pipe into its trunk, as in tapping a sugar maple, and out flows fuel. Just such a plant inhabits Dr. Calvin's energy nursery.

The tree, *Copaifera multijuga*, can be

tapped to give about ten gallons per year of a substance remarkably similar to diesel fuel. However, tropical *Copaifera* grows poorly in the temperate U. S. Dr. Calvin suggests a genetic solution.

A cactuslike plant, *Euphorbia lathyris*, is adapted to northern climes and already produces an inferior oil. This plant lacks an enzyme that *Copaifera* relies on to produce its better product. Dr. Calvin hopes someday to identify and transfer the gene (or genes) for this enzyme to *Euphorbia*, allowing it to make a higher-grade oil.

What about our mountains of waste materials—trash, sawdust, cornstalks? Farms in the United States produce about 200 million tons a year of cornstalks. These can be burned for energy, but a more effective use might be to convert them into sugar and thence into alcohol.

These wastes, however, contain cellulose, a chain of sugar molecules linked by chemical bonds that some bacteria cannot break. That is one reason why cellulose in foods such as bran or celery passes through our bodies undigested. Enzymes do exist, however, to do the job. Genetic engineering permits us to transfer these to the proper microorganism for breaking down cellulose to sugar.

Revolutionary new technique fights bone-marrow cancer

BONE-MARROW CANCER *attacks the source of the body's immune system, the marrow that produces cells and antibodies needed to fight all manner of infections and abnormalities. Recently medical science has developed a bold strategy that seeks to destroy the cancer and replace the diseased marrow.*

Here syringes extract samples of diseased marrow **1** *from a patient's larger bones. The marrow is then cleansed* **2** *outside the body, by means of monoclonal antibodies coupled to toxins or radioactive substances that could be dangerous if used in the bloodstream.*

Diseased marrow remaining in the body is then destroyed by high-energy radiation **3**. *At this point the patient is put into a totally sterile environment* **4**, *since without bone marrow there is no immune system to repel even the slightest infection. Then his own cleansed marrow, now free of cancer, is implanted in his bones* **5**. *Growing quickly, it can restore itself and the body's immune system in a few weeks.*

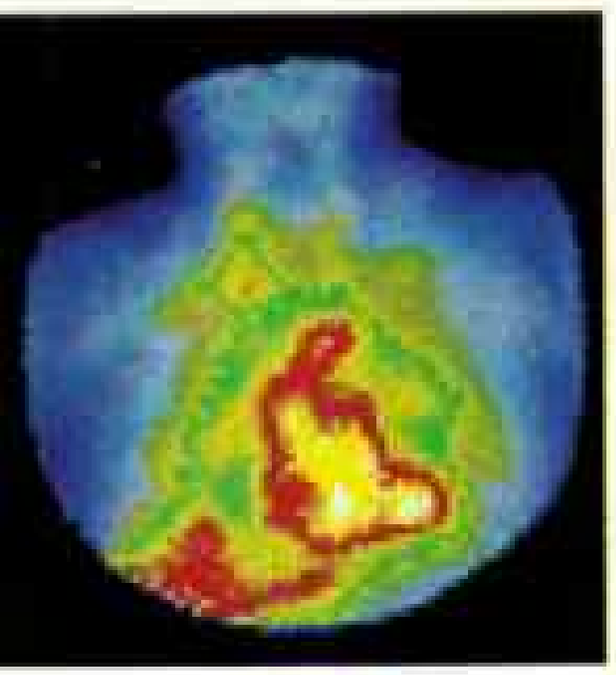
GEORGE KELVIN

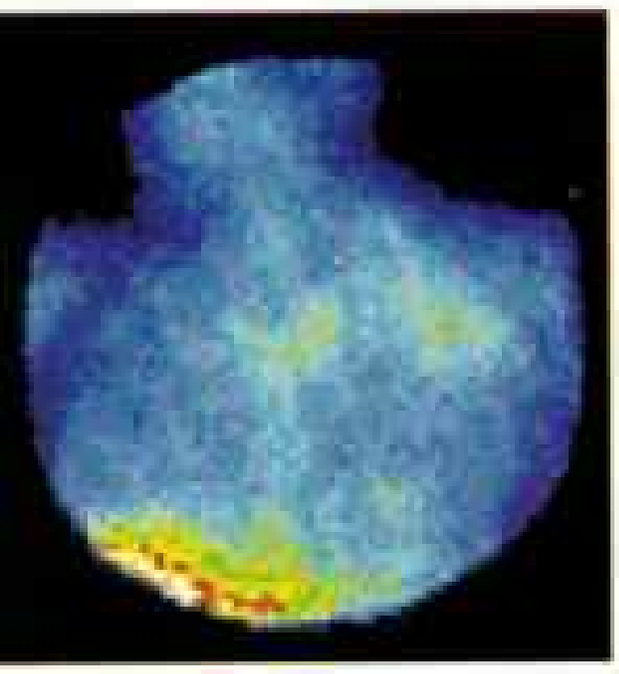
Within a decade we may be able to cost-effectively engineer sugar into methane—natural gas—and other useful chemicals.

A DECADE AGO, at the beginning of the gene-cloning era, many people, including the gene cloners themselves, saw potential danger in their new technology. A major concern was the choice of *E. coli* to carry recombinant DNA.

What if engineered bacteria escaped and set up shop in people's intestines? If the escapees carried novel genes (for cellulose breakdown, for example), could they cause unforeseen problems?

These fears, which led to an 18-month moratorium on recombinant DNA research, probably were groundless. The special strain of *E. coli* that gene cloners use has been so pampered in the laboratory that now it cannot long survive in the human intestine; it fares poorly in competition with other bacteria that inhabit the gut.





Search for cancer cells *scores a win. These scans show radioactive tracers linked by researchers at the National Institutes of Health to monoclonal antibodies that specifically bind to metastatic cancer cells. First scan (**top**), made two hours after the MABs were injected, confirms the entry of seek-and-bind MABs in the heart. Seven days later, in a subsequent scan (**below**), physicians can discern that the yellowish spots at right center are formed by MABs that have found and bound themselves to the sought-for cancer cells.*

The responsible record of molecular biologists has quieted most criticism of the safety of genetic engineering. But a deeper concern persists—uneasiness about where genetic tinkering could finally lead us.

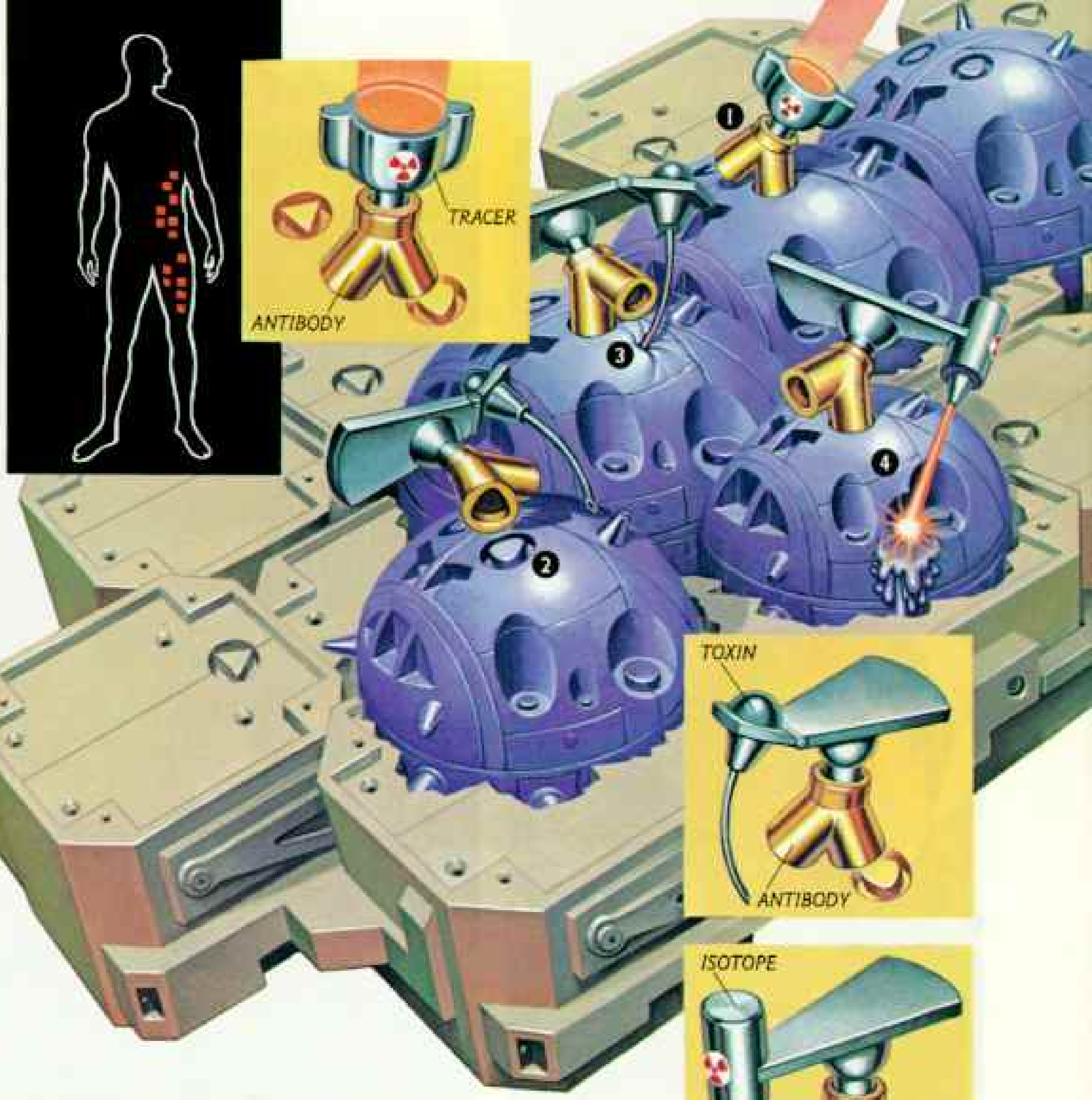
This uneasiness was explored in 1982 by the President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research. Few would object to trying to cure sickle-cell anemia, the commission noted. But the line between good and bad can quickly blur. "What for one person is therapy, is to somebody else fiddling with human characteristics," comments Alexander Capron, then executive director of the commission.

Consider a child with a below-average IQ of 80. If we could raise that child's IQ to 100 by genetic means, should we? And if so, how about raising another child's above-average IQ of 120 to 140? Today such alterations are as unattainable as the questions are difficult, so it may be premature to worry about the line between therapy and tinkering.

More immediate is the question of manipulating the genes of a human embryo. In such a case we would be altering not only the patient but his or her descendants as well. Yet that intervention is theoretically possible. Supermouse demonstrates that we can place new, active genes in mammalian embryos. However, selective breeding techniques applicable to human beings have been available for centuries and people have, by and large, had the good sense not to use them.

Mr. Capron's commission recommended that a permanent federal panel be established to propose regulations and monitor genetic engineering in human beings. Meanwhile, a watchdog group known as the Recombinant DNA Advisory Committee, created by the National Institutes of Health, requires review and approval of "deliberate transfer . . . into human subjects." Violation would mean loss of grant support, a severe penalty for scientists.

OTHER DILEMMAS deeply trouble many researchers. The increasing ties of research to industrial applications create a need for secrecy that casts a pall over what was once a delightfully open field. The amazing pace of research in industry—as well as the vision of riches—is luring away many talented academic scientists. In addition, the increasing percentage of research supported by industry tends to emphasize product development at the expense of expanding fundamental knowledge.



Magic bullets battle cancer

DAVID MELTZER

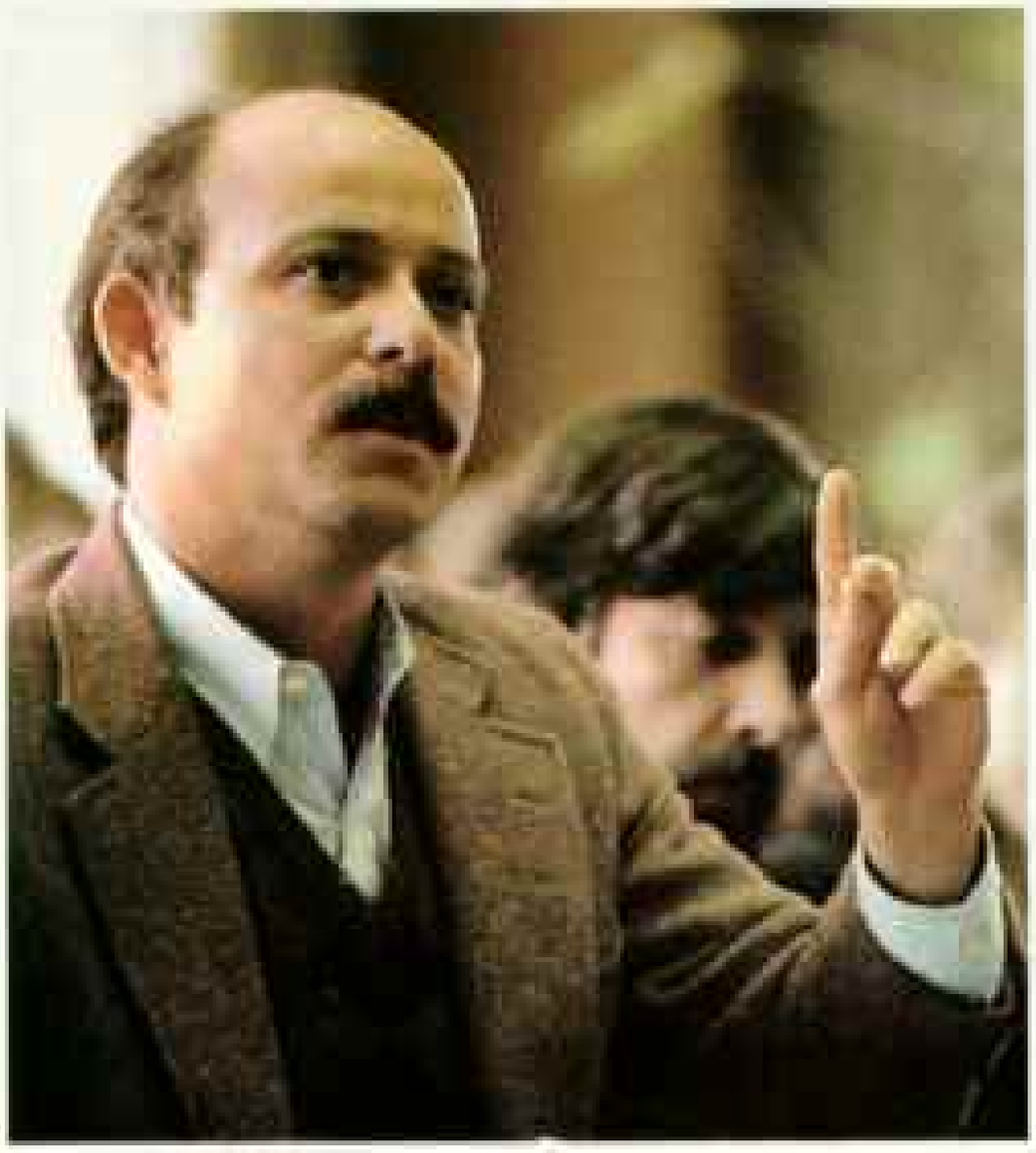
MONOCLONAL antibodies hold potential as precise weapons for the war against cancer. Conventional treatment has involved a "shotgun" approach, treating the whole body with drugs or radiation that attack all high-metabolism cells in an often incomplete attempt to destroy the cancer cells.

This wide poisoning destroys many of the body's healthy cells in hair follicles, intestinal lining, and reproductive organs, causing loss of hair, nausea, and other discouraging side effects.

*With the accuracy of a sniper's rifle, a monoclonal antibody bound to a low-energy radioactive tracer can recognize a cancer cell by the shape of one of its surface proteins, thus pinpointing cancer sites (**top left** and **1**) so the diseased cells can be treated locally.*

*Then, antibodies linked to toxins such as ricin can be dispatched as hunter-killer teams to bind to the cancer cell **2** and destroy it with a dose of poison **3** without affecting healthy cells nearby.*

*In a variation of the same technique, high-energy radioisotopes can accompany a monoclonal antibody on the same mission, destroying the cancer with short-lived radiation **4**.*



To fight frost, *plant pathologist Dr. Steven E. Lindow of the University of California at Berkeley (**above right**) developed a mutant bacterial strain lacking the gene that promotes the formation of ice on plant leaves. Lindow holds a test tube of fluid that simulates the amount of the altered bacteria necessary to spray a newly plowed field in a test authorized by the National Institutes*

Our newfound ability to engineer human genes raises philosophical questions that may be debated for years to come. By altering life-forms to suit our needs, are we playing God? There are those who argue that we have been doing this for centuries by breeding plants and animals. Others counter that gene cloning is so much more efficient and powerful that it is a new and different social force, not just an improvement of existing technology.

A related question has to do with the morality of meddling with the natural course of evolution. Some years ago eminent biochemist Dr. Erwin Chargaff asked: "Have we the right to counteract, irreversibly, the evolutionary wisdom of millions of years?"

This makes nature sound both benign and wise, but Dr. Stanley Cohen of Stanford University, one of the originators of gene cloning, points to nature's darker side: "It is this so-called evolutionary wisdom that

*of Health. Fearing consequences from the release of mutant organisms into the environment, activist Jeremy Rifkin (**bottom left**) filed a lawsuit that delayed the test pending a court decision next year. In a demonstration (**top left**) a citrus leaf freezes in ice-cold water containing the frost-producing bacteria. Another leaf exposed to Lindow's mutant strain does not freeze.*

gave us . . . bubonic plague, smallpox, yellow fever, typhoid, polio, diabetes, and cancer." He reminds us that we have been trying to counteract this "wisdom" since the birth of medicine and in many cases have succeeded. Is this wrong?

Finally, by probing the secrets of the atom we created the threat of global annihilation; are there also biological truths that might better remain hidden? But think of how much meaner our lives would be if it were not for knowledge gathered in this century.

Dr. Paul Berg of Stanford University, one of the pioneers of the gene-splicing era, observes: "In the acquisition of knowledge, I think it would be disastrous to try to anticipate what we don't want to know, what we don't want to learn."

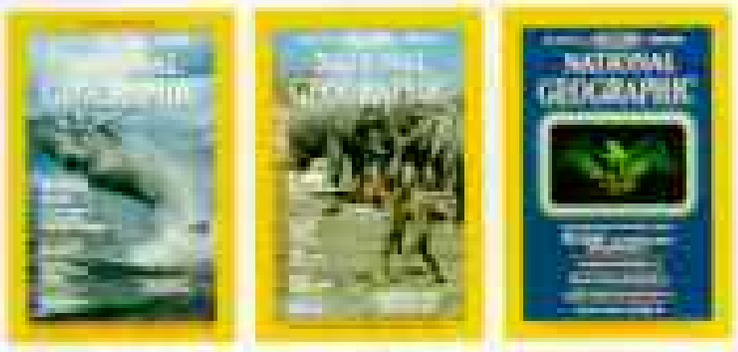
These are the issues we must ponder as we pursue the excitement of scientific discovery and the life-enhancing technologies that lie beyond supermouse. □

Key to '84

Which 1984 issue featured the eagle hologram on the cover, the article on the great gray owl, or the historical map of Japan? Here is a brief key to the past year.

More detailed six-month indexes are free to members upon request to Dept. 4671. The index for the first six months of 1984 (Vol. 165) is now available. That for the last six months (Vol. 166) will be ready in January 1985.

Members with collections spanning a number of years may want to purchase the new 608-page *National Geographic Index 1947-1983*, which includes entries on maps, books, and television specials. This is available from the Society for $13.95.



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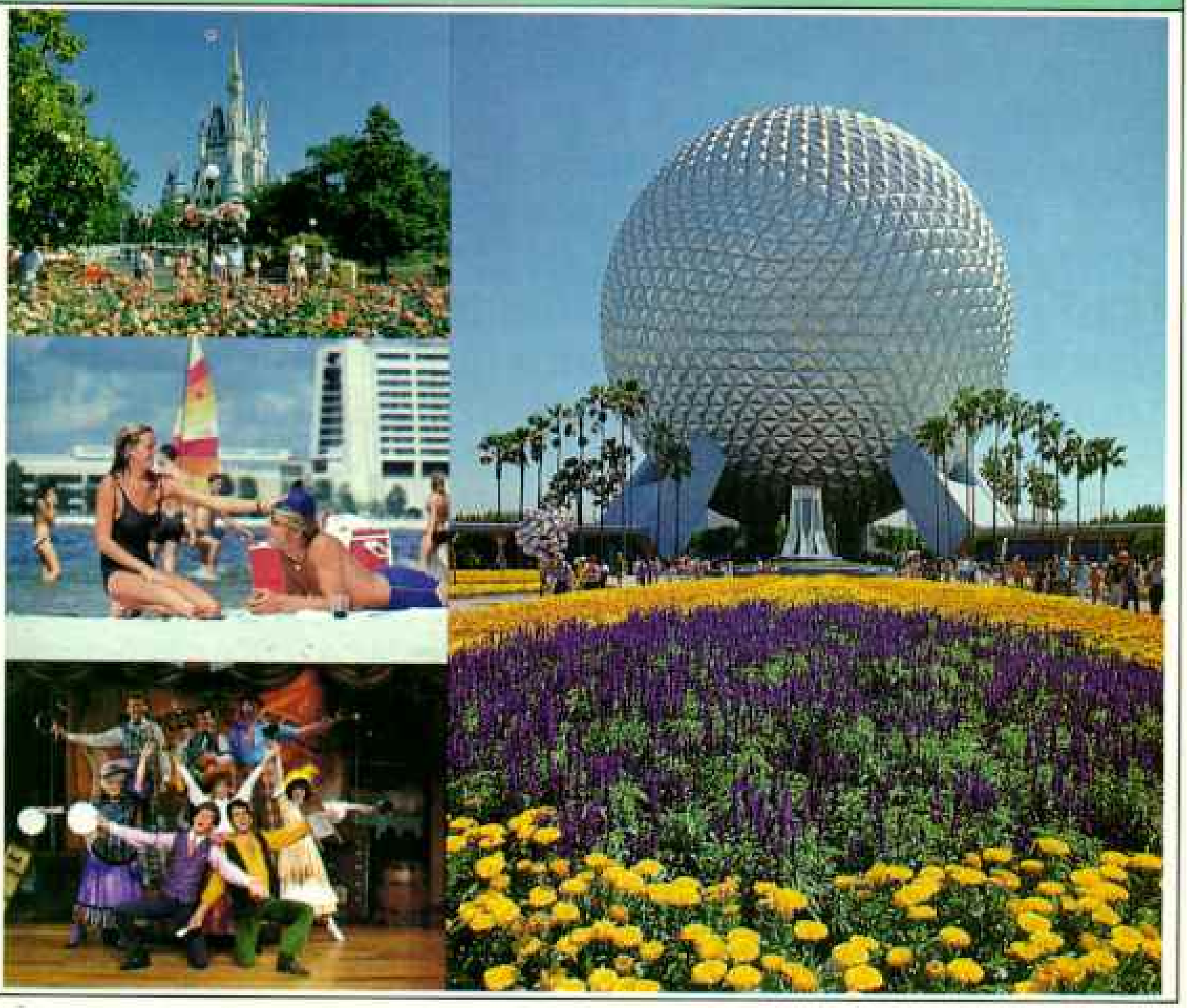

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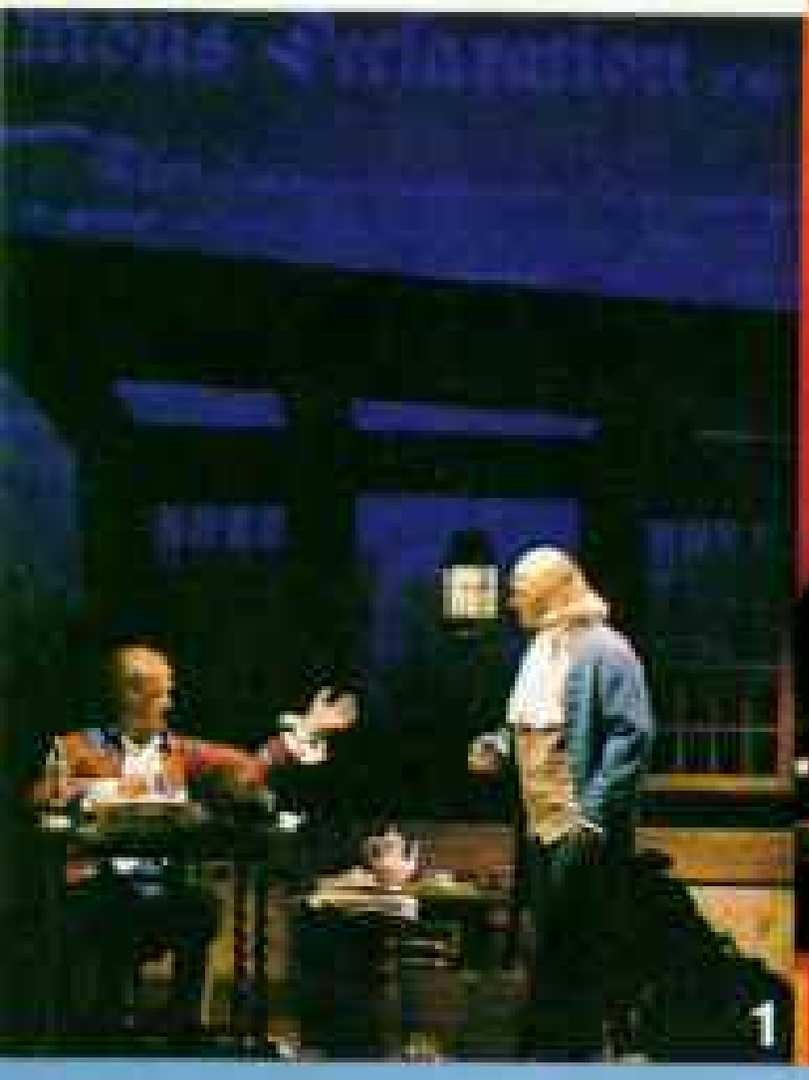

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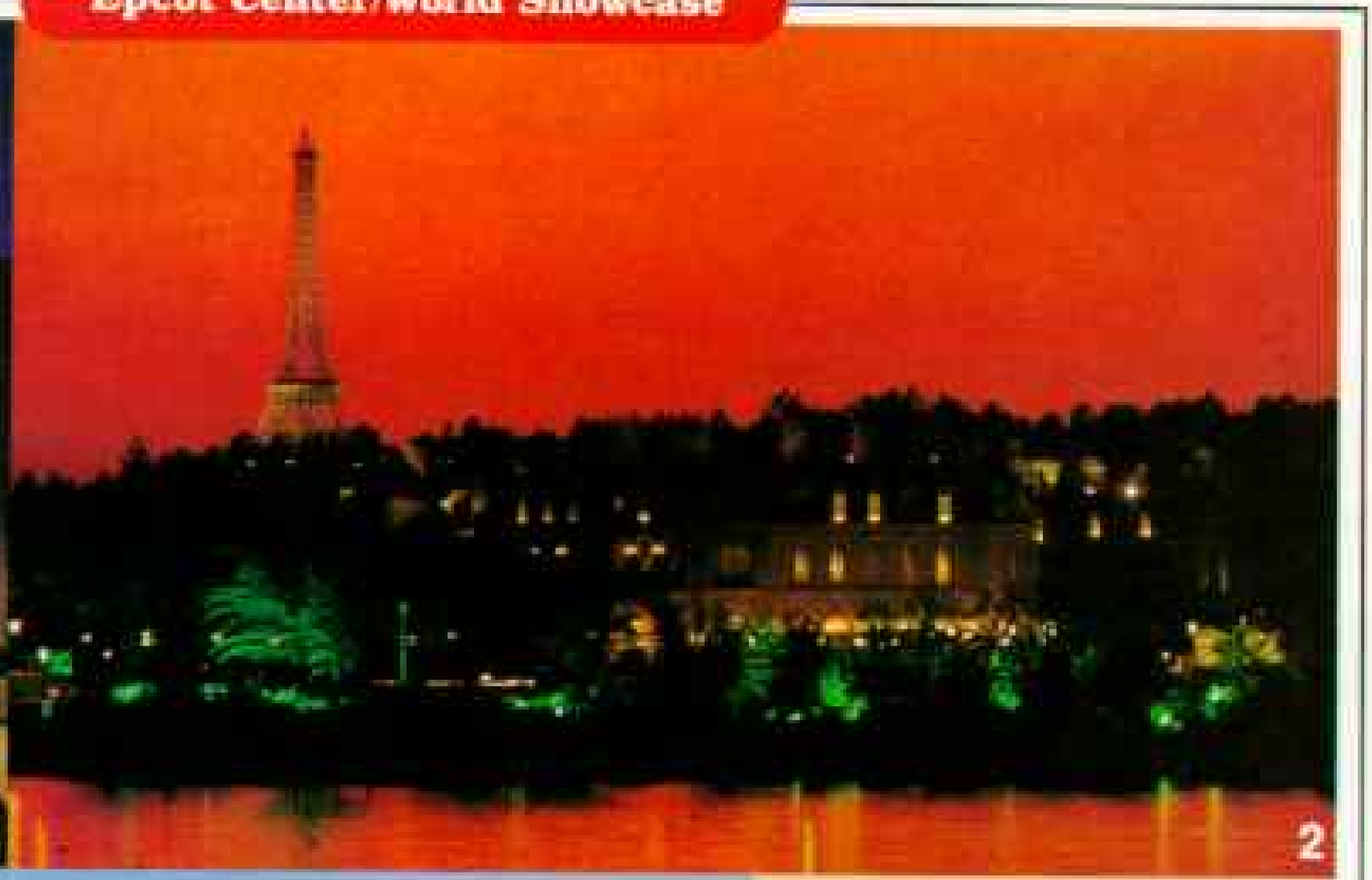

2

3

1. For the first time ever, an Audio-Animatronics figure walks. Ben Franklin climbing the stairs in the ***American Adventure,*** *presented by American Express and Coca-Cola, is enough to raise more than a few eyebrows.*

2. It may look like we moved the Eiffel Tower to Central Florida, but it's actually a very convincing reproduction of Gustav Eiffel's original blueprints.

3. With 222 Moroccan lighting fixtures and native craftsmen laying the intricate tile work, the newest, most exotic country to grace Epcot Center is authentic to the smallest detail.

4. To film footage for the ***Wonders of China*** *movie, a Disney crew had to carry a 300-pound camera up 16,700 stone steps to China's Huangshan Mountains.*

5. Reproducing a scaled-down version of Italy's Campanile Tower meant paying close attention to detail, right down to the hair on the back of the angel's neck and her solid gold-leaf skin.

4

5

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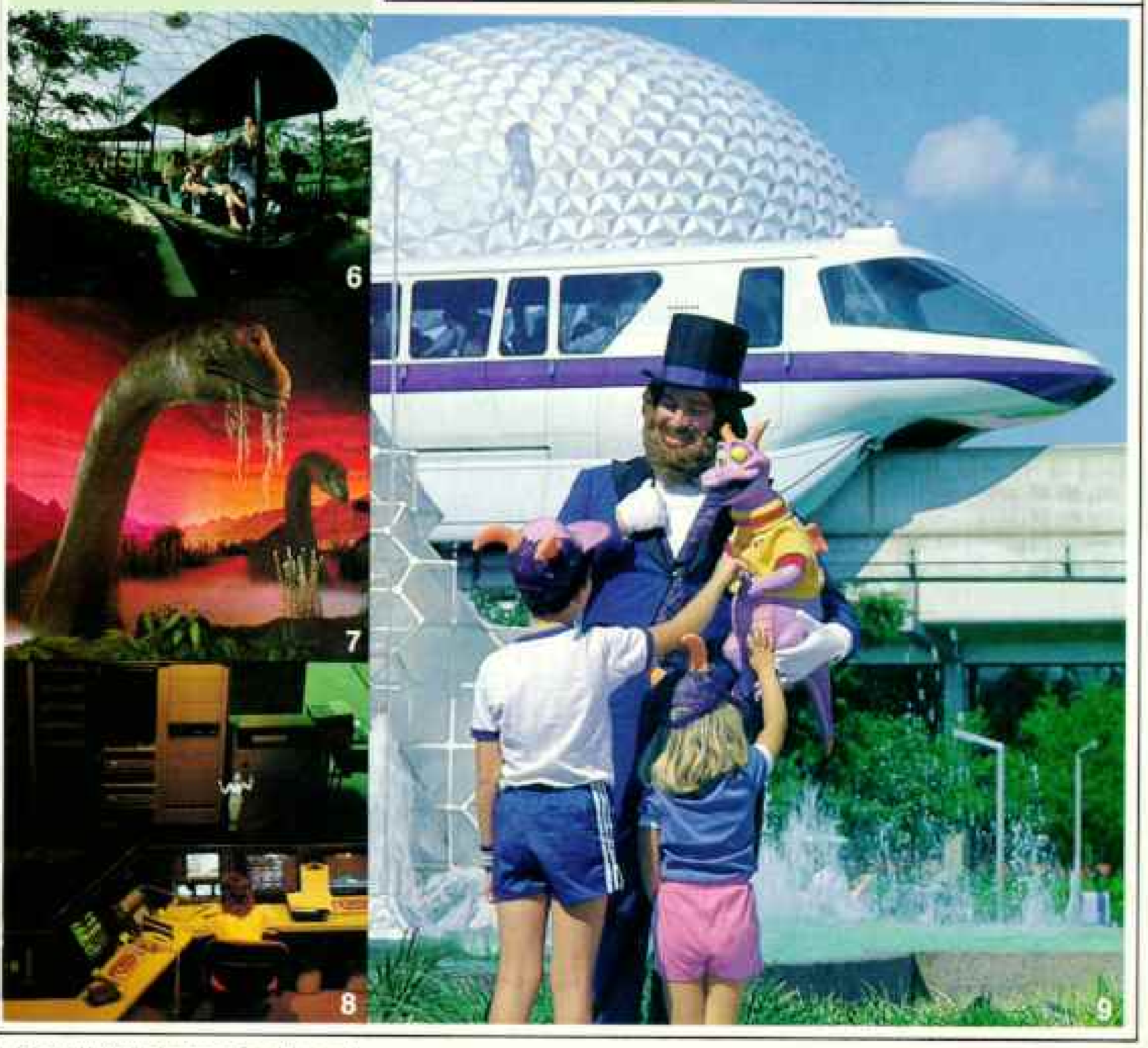
*6. **The Land**, presented by Kraft, covers a vast six acres including three ecological communities, an Audio-Animatronics show, a movie theater and a rotating restaurant.*

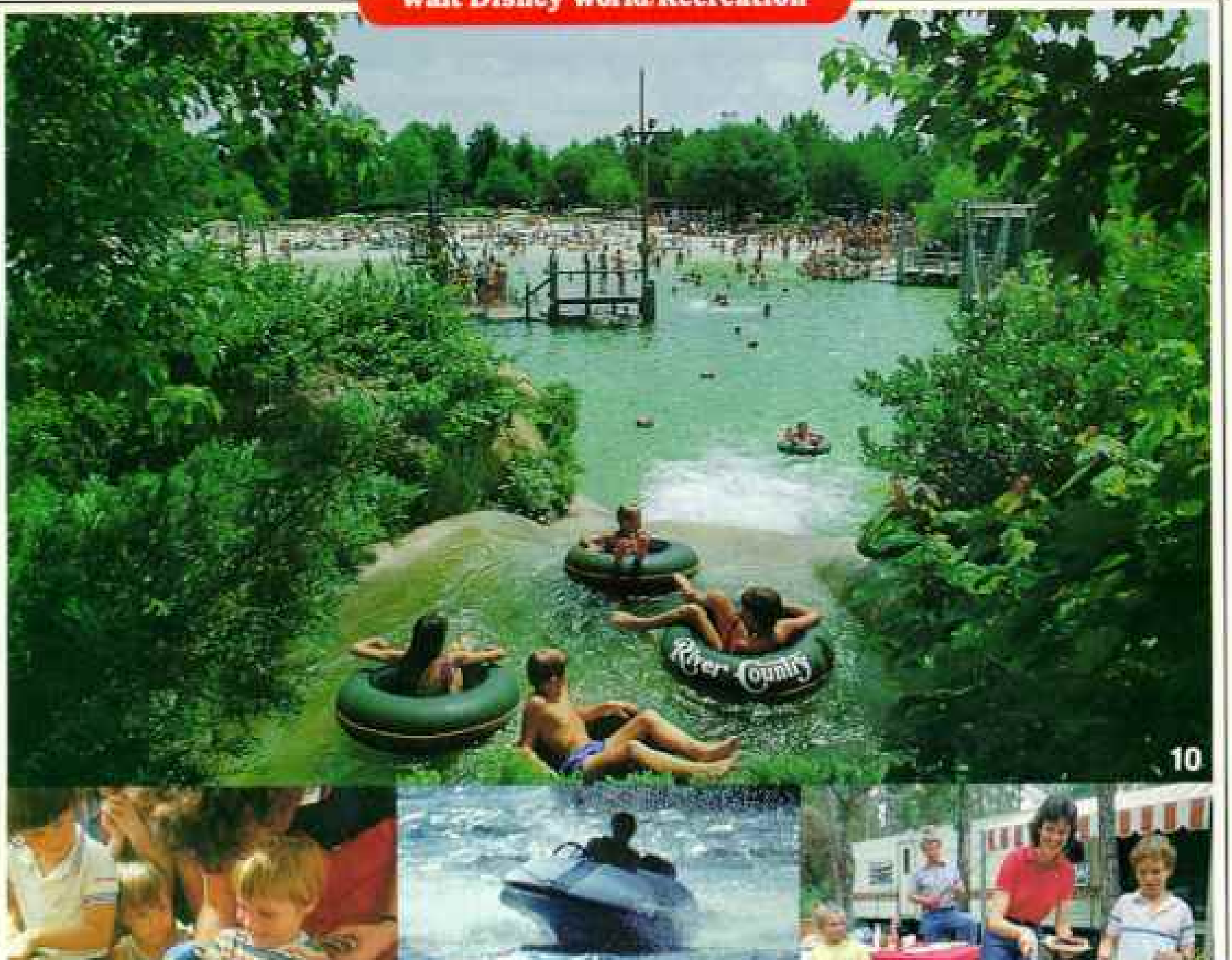
*7. Mobile "theater cars" travel through prehistoric scenes powered by two acres of solar cells on the roof of the **Universe of Energy**, presented by Exxon.*

*8. Did you know there were 12,000 centenarians living in the U.S. today, or that Alaskans have a higher average income than any other state's people? These and other fun facts are at your fingertips in **Epcot Computer Central**, presented by Sperry.*

*9. Hosts of **Journey into Imagination**, presented by Kodak, Figment and Dreamfinder say hello to Future World guests. In the background, **Spaceship Earth**, presented by AT&T, features an outer "skin" with 14,310 aluminum and plastic alloy triangles on its surface.*

TRY THE FUTURE ON FOR SIZE Wondering what the world might be like five years down the road? Ten years? One hundred years? In Epcot Center's Future World, you'll be surrounded by a future that you can see, touch and experience right now! Build and ride your own roller coaster with the aid of a computer. Experience the feeling of traveling at breakneck speeds through special "speedrooms." Conduct a symphony with beams of light and a wave of your hand. Take a trip through the heart of a DNA molelcule. Exercise your artistic side using laser beams and a touch-sensitive television screen. Converse with a robot that can guess your birthday. It's a future beyond your wildest imagination, but you won't need to imagine to experience it.





10. For a fast-paced ride, try ***River Country*** *where water is pumped through two slides and a white water rapids at the rate of 5,000 gallons a minute.*

11. ***Discovery Island*** *covers 11½ acres and is home to 500 exotic birds and 250 species of plants from around the world.*

12. Over 225 sailboats, pontoon boats, mini-speedboats and other pleasure craft make the Vacation Kingdom home to the 5th largest private navy in the world.

13. If you like camping, you'll love Fort Wilderness and its 828 campsites on 650 fun-filled acres.

LEISURE TO PLEASE YA Go ahead, soak your toes in a cool pool, play a round of golf as a matter of course, love tennis or cruise the waters of the world in a splashy, sporty mini-speedboat. The Walt Disney World resort has a wide variety of unique diversions that are sure to please. Watch the birdies and avoid the bogies on three world-class golf courses. Slide and splash through water flumes, white water rapids and the best darn ol' swimmin' hole this side of the Mississippi at River Country. On Discovery Island, rub elbows (or tailfeathers) with birds and beasts of every color and description; caress a cockatoo, pet a parrot and just enjoy nature at its very best. It's leisure, Disney style and it's all here at the vacation destination of the world.

DINNERS YOU'LL RELISH So you've just played two full rounds of golf, traveled around the world or met your favorite mouse. Now sit back, relax and enjoy dinner. At Epcot Center, sit down to a hearty portion of Bangers and Mash in the United Kingdom or try the Mole Poblano in Mexico. Then there's the seafood of the Fisherman's Deck, and other restaurants of the Empress Lilly Riverboat in Walt Disney World Shopping Village.

The fabulous dinner shows may find you doing an island dance with a pretty wahine at the Polynesian Revue, humming to the great tunes of the Great White Way at Broadway at the Top, or filling your belly with laughs and barbequed ribs at the Hoop-Dee-Doo Revue. It's a dining paradise, found in the Vacation Kingdom.

14. The popularity of french pastry is evident in Epcot Center's ***Les Chefs de France*** *where 219,000 napoleans were served last year alone.*

15. Just for the fun of it, you should know that this is the only place in the world where you can enjoy breakfast with your favorite Disney characters on the side.

16. The Polynesian Revue, *at the Polynesian Resort, serves up authentic island fare and energetic island dances to the tune of 300,000 guests every year.*

17. The ***Empress Lilly Riverboat,*** *a 220-foot replica of an American stern-wheeler permanently moored in Walt Disney World Shopping Village, is home to three fine restaurants.*

Days Inn® is a better place to stay. For less.

Stay with us on your next trip and you'll see why.

At Days Inn motels, you'll get clean, quiet accommodations with two double beds, color TV, direct dial phone, plus, a well lighted and appointed bathroom with separate dressing area. You'll also enjoy great food and friendly, quick service in our restaurants.

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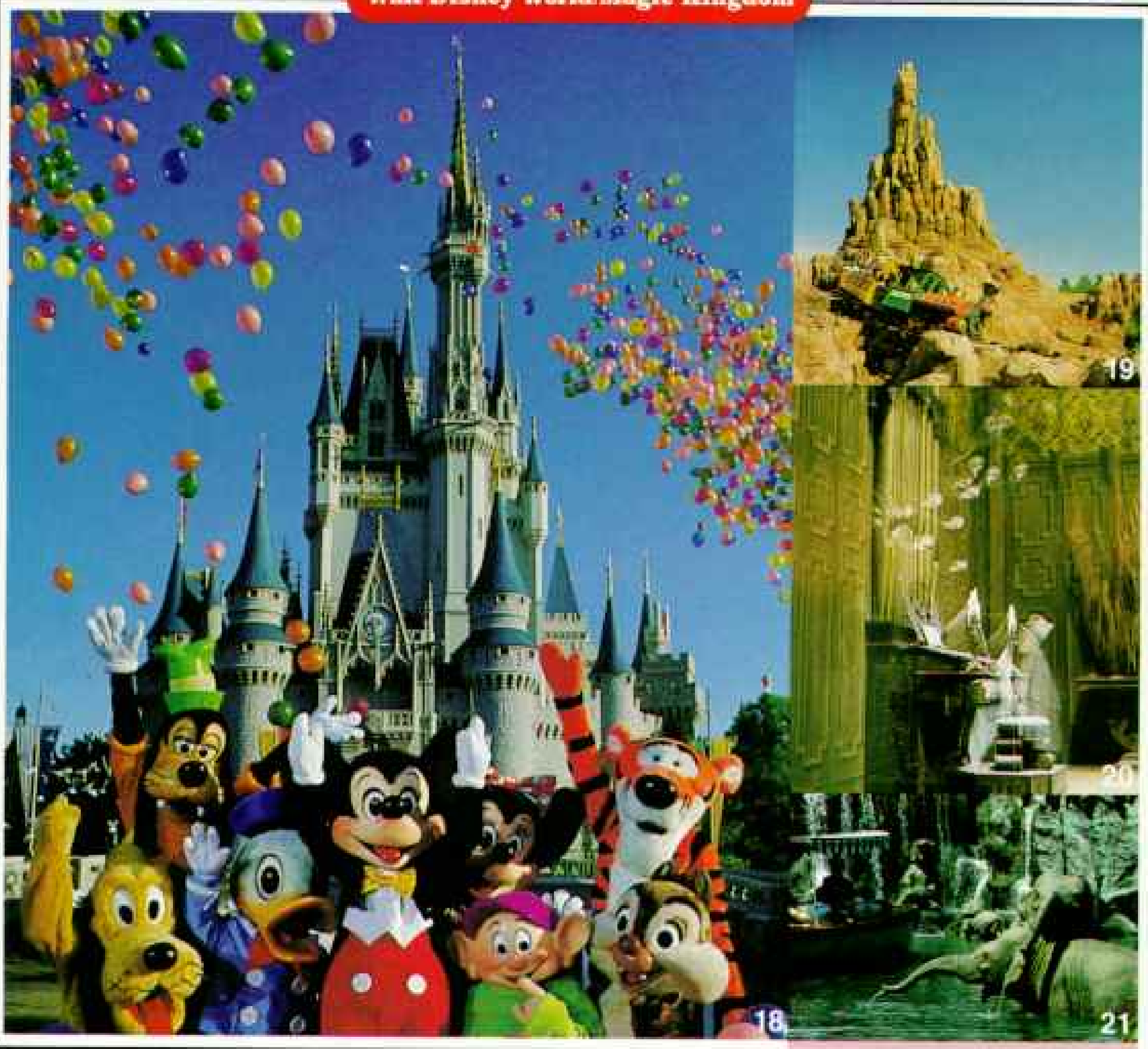
Walt Disney World/Magic Kingdom



LOTSA MICKEY, LOADSA MAGIC! When was the last time you shook hands with a five foot mouse or were serenaded by a troupe of singing bears? If you're hard-pressed for an answer, come visit the Magic Kingdom. Here you'll ride a runaway mine train through Big Thunder Mountain, pick-up a hitchhiking ghost and blast off to a pulse pounding flight through Space Mountain. The magic's here. And it's waiting for you!

There you have it. Mom gets the world, Dad gets his golf and the kids meet the mouse. But more than that, everyone has a vacation of non-stop fun and a lifetime of unforgettable memories at the Walt Disney World Vacation Kingdom. So come visit!

For more information on a Walt Disney World vacation and accommodations write to: Walt Disney World Co., Dept. US (NG), P.O. Box 40, Lake Buena Vista, FL 32830

*18. **Cinderella Castle,** the most recognizable symbol of the Magic Kingdom, boasts five panels of mosaics, each 15 feet high by 10 feet wide and featuring hundreds of thousands of individual ties, real silver and gold leaf.*

*19. For the first time, a mountain dominates the landscape of Florida, thanks to **Big Thunder Mountain Railroad.***

*20. Keeping the **Haunted Mansion** haunted requires spreading dust by the pound. Since opening enough dust has been used to bury the entire building.*

*21. Because one jungle wasn't enough, the **Jungle Cruise** features flora and fauna from diverse landscapes including the Southeast Asian jungle, the Nile valley, the African veldt and the Amazon rain forest.*

F L O R I D A

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To find out how good, send for our 128-page, full-color Florida Vacation Guide. Then see your travel agent.

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Florida Division of Tourism, Visitor Inquiry Section, Dept. NG, 126 Van Buren Street, Tallahassee, FL 32301. Enclosed is $2.50 for your Vacation Guide.

(No cash please, check or money order only, payable to Florida Department of Commerce.) Allow 3-4 weeks for delivery.

Is it too much to ask for space behind the seat so you don't feel cramped? So your tools or sports gear won't need the passenger seat?

The Toyota SR5 XTRACAB doesn't think so. That's why there's extra space behind the seat and, up front, more leg room than in any small truck.

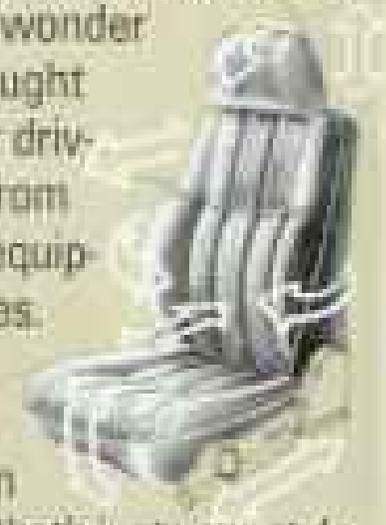
The XTRACAB also has full, rich carpeting, reclining bucket seats and options you wouldn't expect to find in a tough truck. Like an AM/FM/MPX sound system with electronic tuning, cassette and 7-band graphic equalizer that puts others to shame. Like a 4-speed automatic overdrive transmission. Like a 7-way adjustable driver's Sport Seat to indulge you even more if this is the kind of equipment you've been looking for in a truck, read on.

XTRACAB's 2.4 liter engine with 116 hp is the *most powerful* ever built for a truck in its class. And its all-new computer-controlled Electronic Fuel Injection system provides the most power while never taking its eye off economy.

These are more of the special extras you'll find here that make driving there as easy as possible.

OH WHAT A FEELING! TOYOTA

Once you test glide the easy ride of an XTRACAB, you'll wonder why you always thought trucks were only for drivers delivering logs from the mountains and equipment to building sites.

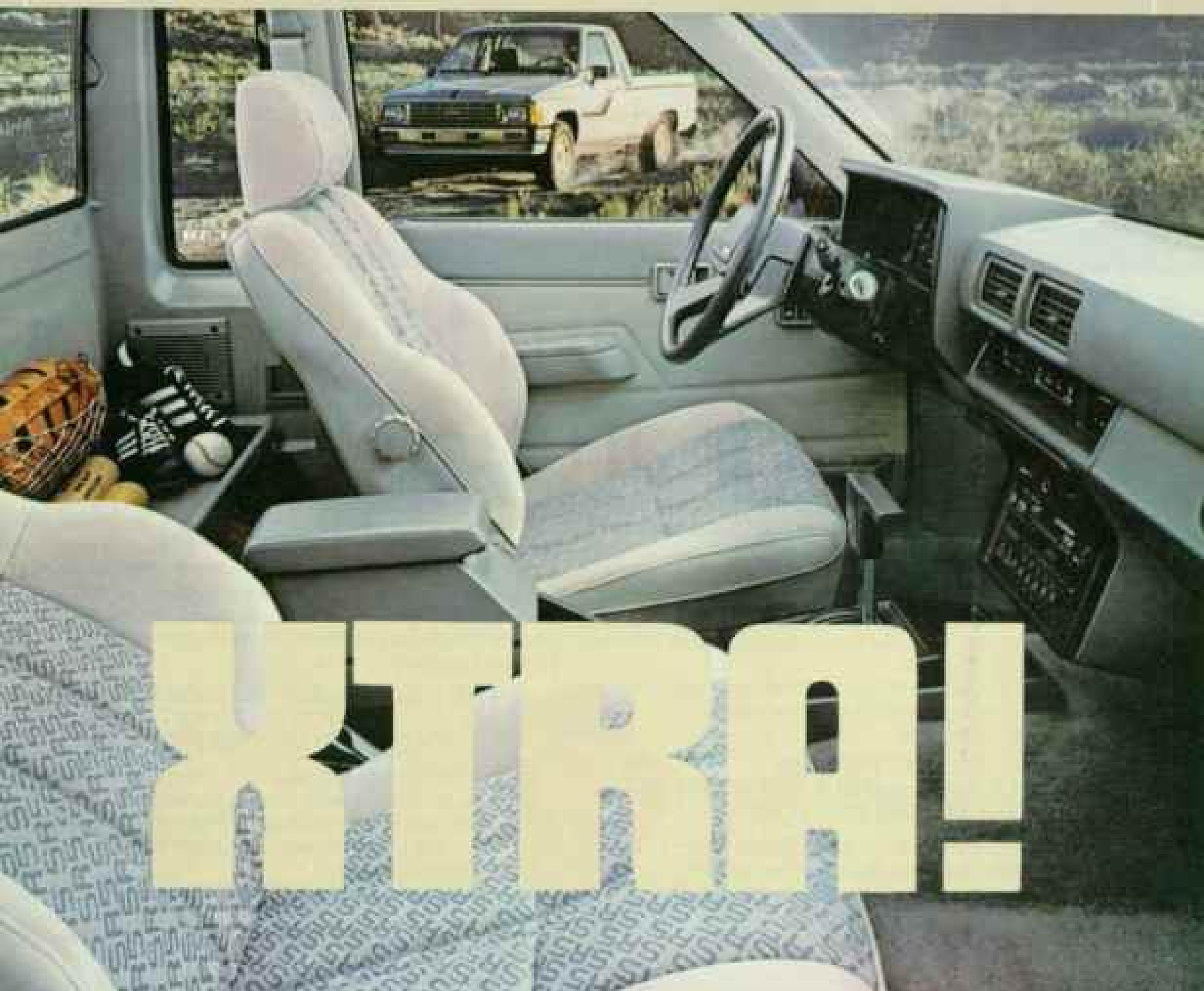


Climb into the world of XTRACAB.

There's extra fun waiting for you here that's just your style.

TOYOTA TRUCKS. MOST POWERFUL EVER!

THE 1985 TOYOTA SR5 XTRACAB. BECAUSE YOU SHOULDN'T HAVE YOUR BACK UP AGAINST THE WALL.



XTRA!

The new 8mm Kodavision
Its features were desi

Everything Kodak's learned about people and what makes them click has gone into our extraordinary new video system.

It's called the Kodavision series 2000 video system—with an extraordinary new camcorder adapted to you and the way you like to shoot. It's so remarkably light and portable, you can take it anywhere. And so uncomplicated, you'll want to.

How did Kodak do it? By pioneering a big breakthrough in home video with the new, smaller format 8mm video tape.

8MM. IT PUTS AS LITTLE AS POSSIBLE BETWEEN YOU AND THE ENJOYMENT.

Want a video format with a brilliant future? Our 8mm video tape has the excellent quality of ½" tape, and more importantly, gives you all the picture sharpness, vivid color and sound clarity you've come to expect from Kodak. Yet a 30-, 60- or 90-minute cassette takes up no more room than a regular audio cassette. That's what allowed us to create a small, single-piece camera and recorder. With no separate recorder unit. No messy wires or cords. So instead of getting tangled up in the equipment, you can get wrapped up in the action.

THE *KODAVISION* CAMCORDER 2400. DESIGNED TO LET YOU FOCUS ON THE MOMENT.

Worried about missing a great shot because you're fiddling with a lot of gizmos? Don't. With the Kodavision camcorder, you simply drop in a video cassette, set a few controls and you're ready to go.

But don't think that just because it's not com-

1. Can't wait to get home and see what you've shot? Well, we see eye-to-eye with you. With the Kodavision camcorder, you can review the results instantly because the monitor is built right into the eyepiece.

2. You hardly have to lift a finger to operate the Kodavision camcorder. We put all the important shooting controls within easy reach.

3. The Kodavision camcorder is light enough, compact enough to be carried in one hand. So naturally you'll want to carry it more places.

4. The Kodavision camcorder is designed to let you keep your mind on what you're recording. It remembers to focus the shot and adjust the color balance and exposure—continuously and automatically—so you don't have to.

5. The smaller the tape, the smaller we can make the camera and recorder. In fact, they're all in one piece, so you don't have to shoulder the burden of a separate recorder unit.

6. Smile! With the Kodavision video system, you never have to worry about compatibility with your current video equipment. It hooks up easily to any TV set and lets you dub recordings to either VHS or Beta format.

camcorder from Kodak. gned to match yours.

plicated, it's not sophisticated. The newest video technology provides beautiful pictures time after time. The latest Newvicon tube. A 6X power zoom lens. And a highly sensitive automatic iris and color balance that instantly know when to adjust themselves—even before you do. Which means the Kodavision camcorder can go anywhere the great pictures are. From the dazzling brightness of a ski slope to the low light of a grade-school violin recital.

NOW, RELIVING THE MOMENTS IS AS EASY AS CREATING THEM.

Want a camera that lets you see what you've just shot? Then look into the Kodavision camcorder. Whether you're at home or away, you can review right in the camcorder because the electric viewfinder is also a miniature black-and-white monitor. Then replay your special moments on the nearest TV, using the Kodavision converter/charger. Or use the Kodavision series 2000 cradle with tuner/timer as a fully functioning VCR. However, if you do want to edit or transfer a tape, you can do so on any existing VCR. The Kodavision system is completely compatible with both VHS and Beta systems.

All of which adds up to a video system that will spend its time collecting wonderful memories instead of dust. So why not visit your nearest dealer in Kodak video products and ask to experience the extraordinary new Kodavision series 2000 video system firsthand?

If you want truly enjoyable home video, you'll find the new Kodavision camcorder from Kodak matches what you're looking for.

Kodak

Everything we do grows from the membership

WHAT IMPORTANCE do we attach to the membership of the National Geographic Society? Simply put, members are all-important. Collectively, you enable the Society to support research, to publish periodicals and books, to produce TV programs for public broadcast and other educational materials for use in schools.

At nearly 10.5 million members, our size (I emphasize *our*) is enormously helpful in realizing these projects. Yet that same size may leave many members without a strong personal feeling of their partnership role in the Society's enterprises.

PHOTOGRAPH BY MARY G. SMITH, NATIONAL GEOGRAPHIC STAFF

Society President Gilbert M. Grosvenor *and Mrs. Grosvenor, at left, and Dr. Frank C. Whitmore, Jr., listen to American archaeologist Dr. John Camp explain how a second-century travel guide to ancient Greece aids his investigations of the Agora, or marketplace, of Athens' classical period.*

There are, I think, two other factors that contribute to this situation. First, the Society does not try to build member solidarity by advocating causes—no matter how good they might seem to be. We do not lobby for legislation, nor do we urge members to support or attack special interests or doctrines.

Another factor that may dilute the sense of membership is what might appear to be a short list of benefits. The principal membership benefit is, of course, the monthly arrival of NATIONAL GEOGRAPHIC. Less obvious is member access to other Society periodicals and books at low cost for value received.

We are now considering what additional benefits we might realistically offer Society members, yet we are proceeding cautiously. Any future benefits must be useful, must be available to all members, and must be in harmony with our fundamental purpose.

I began these columns last January with an account of the Society's founding, and I have reported on such Society activities as a new building, two new periodicals, and help for gifted children in New York City schools. While this is a season for annual reports, I hope that members will excuse me if I forgo a roundup of the past year—properly done, that would take dozens of pages—and instead continue to share with you the Society's progress on a monthly basis.

Many current and deserving projects await mention. Others are imminent or are in the development or planning stages. Some are dreams. I hope to discuss these as they move into the testing ground of reality.

Everything we do grows from the membership. Nothing the Society has done, is doing, or will do is apart from Society members.

Instead of sending you bumper stickers or manifestos, the Society supports exploration and research. I hope that you the members will take personal satisfaction in the Society's work to advance knowledge.

Together, we have become the world's largest scientific and educational organization—an everyman's university. That is a major accomplishment, and I commend you all.

Gilbert M. Grosvenor

PRESIDENT, NATIONAL GEOGRAPHIC SOCIETY

Is there a coffee made with those incredible tasting gourmet store beans?

Yes. Taster's Choice.

The costliest, most flavorful coffee beans found in gourmet coffee stores, Arabica beans, are the very same beans used to make Taster's Choice a superior coffee. Only Taster's Choice uses this gourmet blend, Arabica Supreme.

The more you know about coffee, the more you'll know why the choice for taste is Taster's Choice.

The choice for taste is...Taster's Choice.

The 1985 Turbo New Yorker. Once you

Chrysler introduces the new technology of driving: Turbopower* in its most advanced luxury sedan.

Here is the confidence of front-wheel drive, the security of advanced electronics and the quiet, smooth, comfortable ride you expect in a distinctive luxury car.

And here are the luxuries you demand. Automatic transmission, power windows, power steering, power brakes, power remote mirrors and individual pillow-style reclining seats are all standard.

And finally, here is the new technology of turbopower. More power to move you. More power to accelerate. To pass. To cruise in serene comfort...yet with remarkable mileage.

*Turbo is optional. **Use these EPA ests. to compare. Actual mpg will vary with options, driving conditions and habits and Dealer has details. †1 Lowest percent of NHTSA safety recalls for '82 and '83 cars designed

drive it, you'll never go back to a V-8 again.

23 hwy. est. mpg [20] city est. mpg.**

Turbo New Yorker merits careful consideration by every luxury car owner, from Cadillac to Mercedes. It is backed by a 5-year/50,000-mile Protection Plan covering drivetrain, turbo and outer body rust-through.†

The new technology of driving must be experienced. So Chrysler invites you: test drive Turbo New Yorker. Once you drive it, you'll never go back to a V-8 again.

Purchase or lease your 1985 Turbo New Yorker at your local Chrysler-Plymouth dealer.

Buckle up for safety.

Chrysler

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vehicle condition, CA ests. lower. †Whichever comes first. Limited warranty. Deductible applies. Excludes fleet/leases and built in North America. Best backed based on warranty comparison of competitive vehicles.

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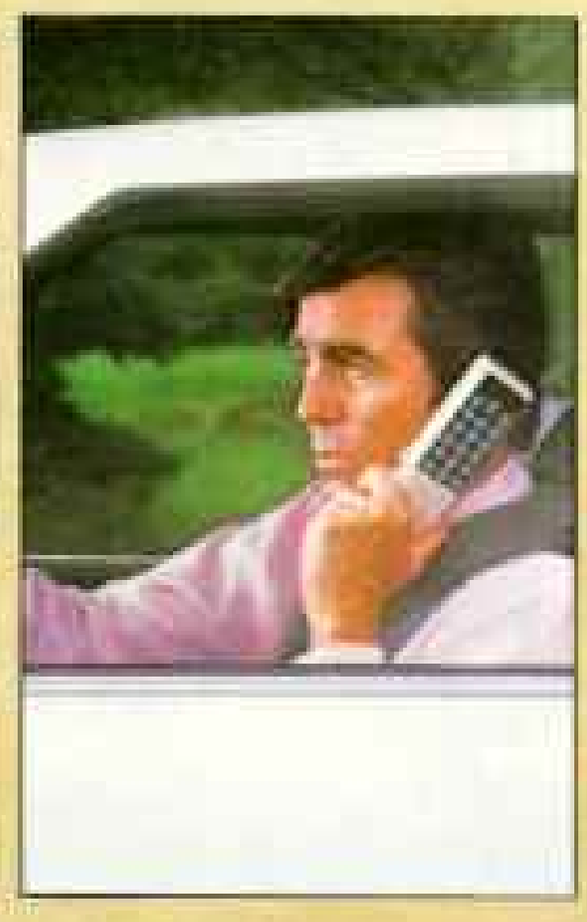

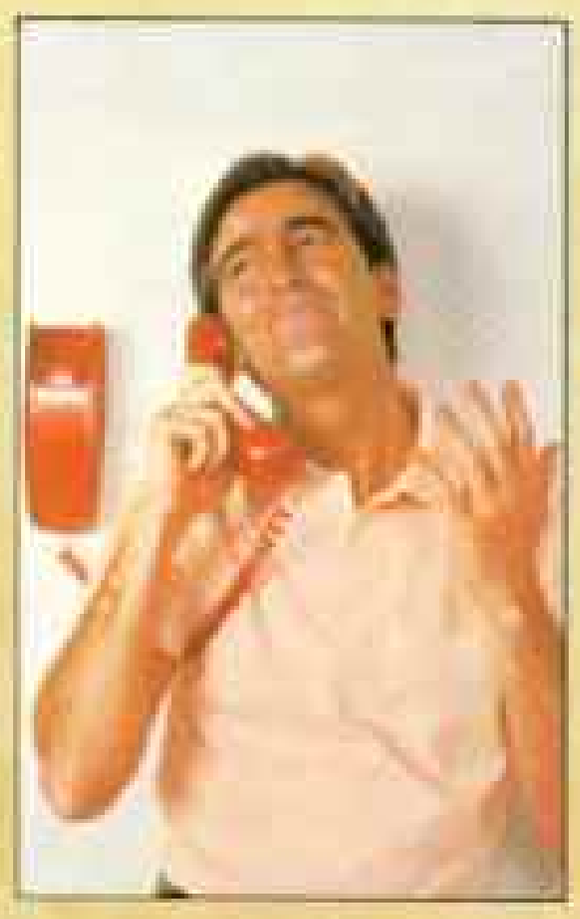

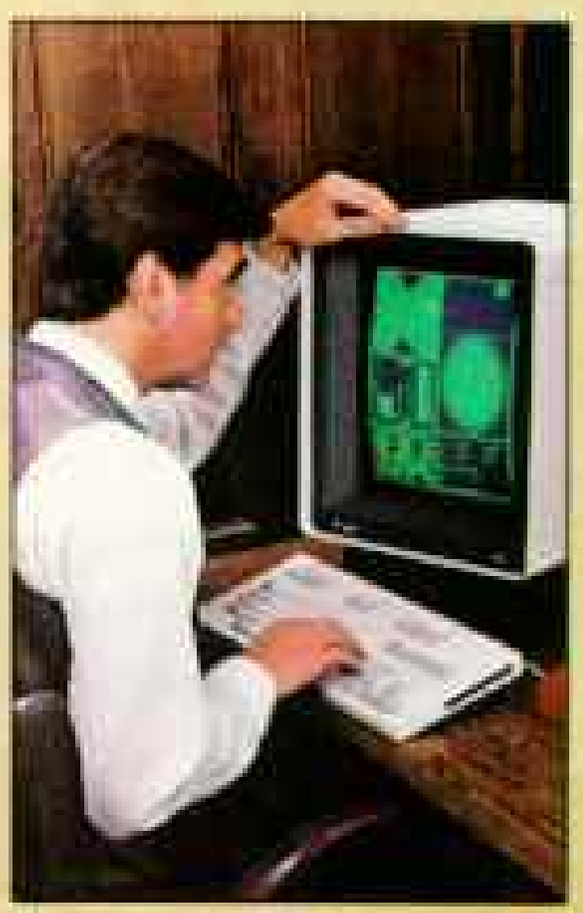

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OUR INFORMATION SYSTEMS MAKE YOUR WORK LESS WORK.

We designed our information systems for business by putting ourselves in your place. Systems that grow when you grow, change when you change. Complete with digital technology that'll integrate communications with everything from temperature control, to electronic mail, to security. Or data communications terminals, modems, teleconferencing equipment and more.

For customers who only want phones in their offices, we are constantly improving Centrex services to satisfy many of these same sophisticated voice and data needs.

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Not only do we have customized systems that monitor themselves, we also have a service that keeps tabs on them 24 hours a day. Plus the industry's largest and most experienced service force at your beck and call.

So your lines stay up.

Not to mention your productivity.

A GLOBAL NETWORK THAT OFFERS A WORLD OF DEPENDABILITY.

Whether it's a home phone, information

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Information coming in. Information going out. Voice, video and data.

It can all get pretty pressure-packed.

Which is where AT&T comes in.

We'll help you cope with this new world of information management.

Something we've been doing for 108 years with the best telephone system in the world.

And what we did for telephone communications, we're now doing for all kinds of information.

Making it easily available and easy to use.

PHONES THAT SAVE EVERYTHING FROM TIME TO LIVES.

We've designed our phones to make your life a lot easier. And a little safer, too.

Phones that will dial and redial busy and unanswered numbers, so there's no aggravation. And phones that will answer the phone for you.

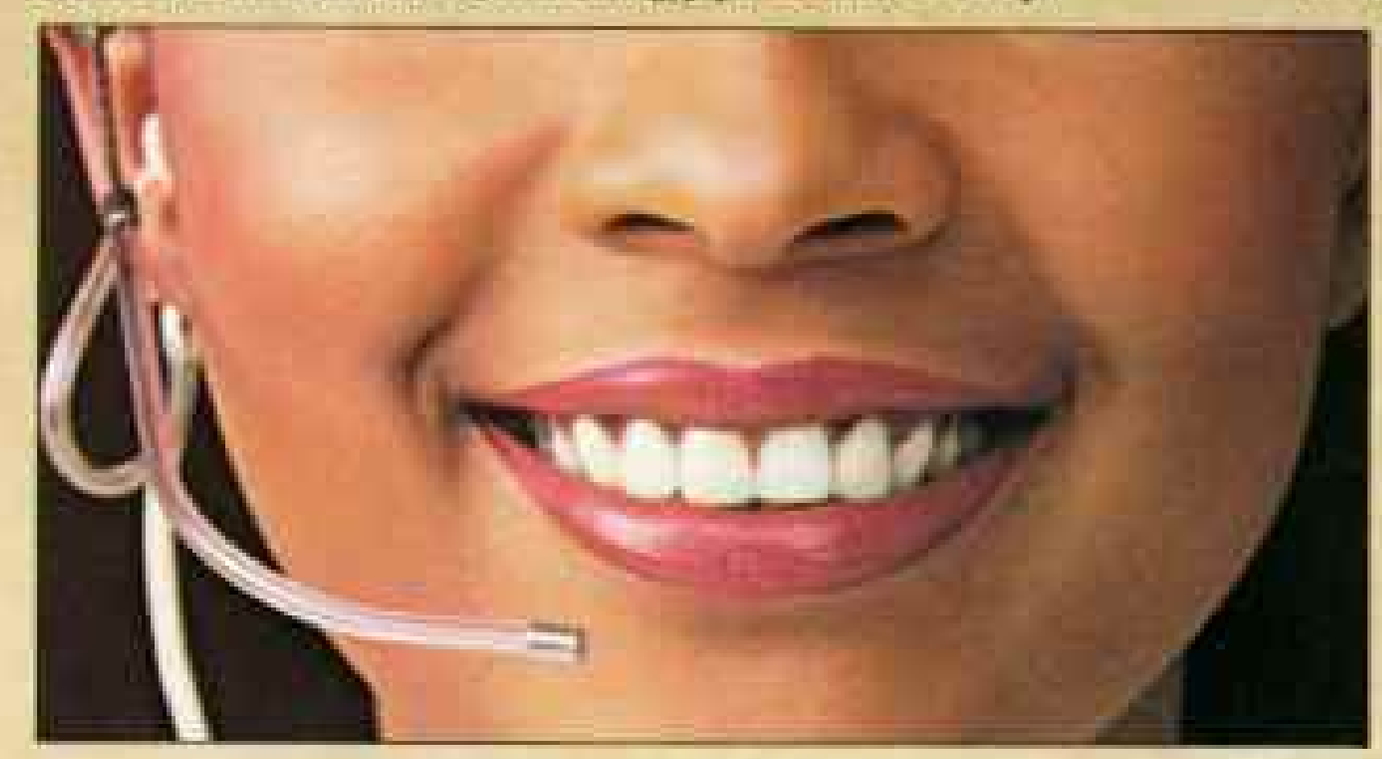
Cordless phones that'll go the distance with clearer and more secure frequencies.

Cellular mobile car phones that go farther, so you're never out of touch even when you're driving.

A phone that automatically calls not one, but two preprogrammed numbers in case of fire or other emergencies. All

system, or computer, AT&T lets you reach out and touch any place in the world.

With an incredible computerized network that takes you from Tokyo to Kokomo, from Cairo, Illinois, to Cairo, Egypt. And every-



where in between.

So you can send and receive voice, video, or data across the country or around the world. Or meet face to face through teleconferencing, so you don't have to worry about time and travel costs. Or even have unlimited access and budget control through our 800 numbers and WATS lines.

An intelligent network that's not only the most reliable in the world, but the most flexible.

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Our switching systems are second to none, with built-in computer intelligence.

We can handle the telecommunications needs of any size city, town, or village.

In fact, our switches are used by countries and companies all over the world.

Our lightwave technology is now bringing the world closer, faster—by moving millions of bits of video, voice, or data thousands of miles in a split second.

All on a hair-thin strand of glass fiber. Across the country or under the sea.

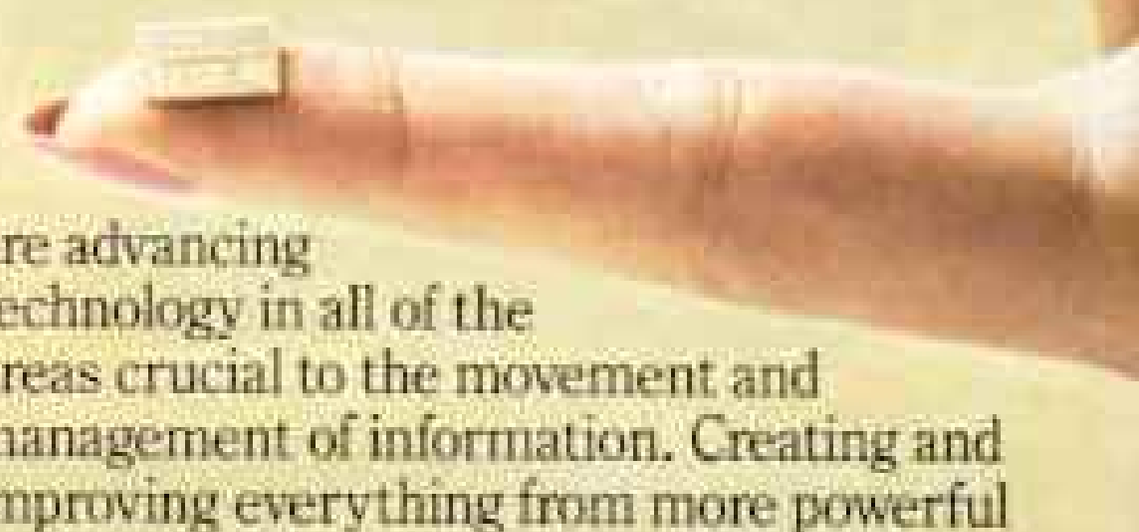
AT&T Bell Laboratories is developing new advanced systems of even higher levels of communication and information control.

Systems that utilize conventional phone lines for data access—lowering the cost of data calls.

Systems for the home and business that let you know who's calling even before you pick up the receiver.

But that's just a sample.

Today our scientists and engineers



are advancing technology in all of the areas crucial to the movement and management of information. Creating and improving everything from more powerful computer chips to software applications.

Which all comes down to a future where the Age of Information will be available to more people in more places than ever before.

THE MOST EXTENSIVE COMPUTER ENTRY EVER MADE.

Legally, we couldn't sell our computers before. But now we can.

In fact, we've already introduced the broadest initial product line in the history of information processing.

Computers ranging in size from desk-top super micros, to super minis.

Along with our new personal computer that can handle everything from financial analysis, forecasting, and budgeting to word processing and inventory.

User-friendly computers that'll take the complexity out of information movement and management.

Computers capable of working with other equipment you may already have.

To give you the most flexible information systems in the world.

And that's not all. Our UNIX™ System V operating system is already becoming the industry standard for multi-user, multi-tasking machines.

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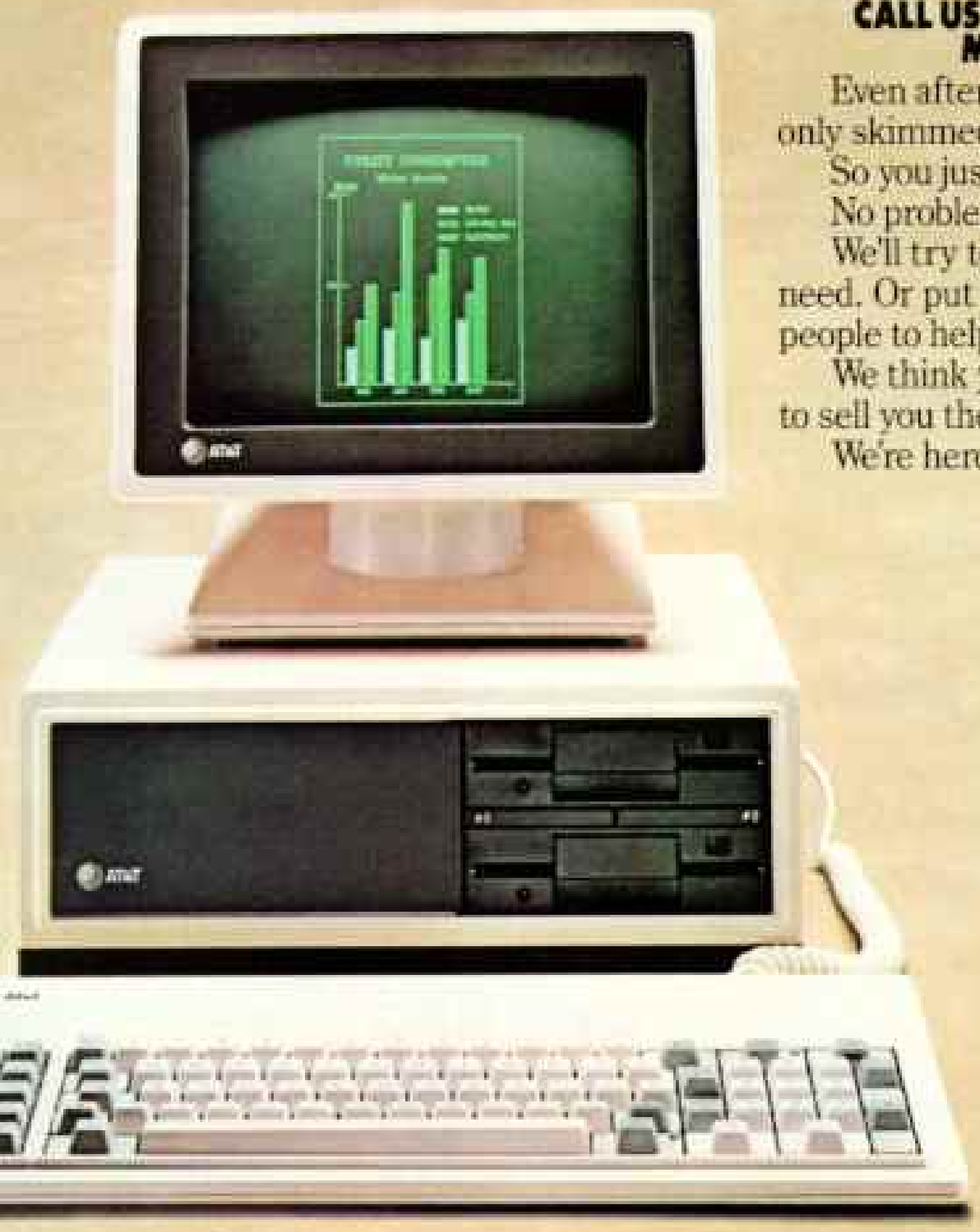
We think you'll be impressed with our full line of computers.

Even some of the toughest people in the world to impress are impressed.

The Japanese.

Japan's Nippon Telephone and Telegraph Public Corporation has bought 60 of our 3B20S super minicomputers.

So you're going to be hearing more and more about AT&T computers.



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Even after reading these pages, you've only skimmed our surface.

So you just might have a few questions.

No problem, just call us at 1 800 247-1212.

We'll try to give you the information you need. Or put you in touch with the right people to help you.

We think you'll see that we're not just here to sell you the Information Age.

We're here to help you cope with it.

AT&T

THE BOLD LOOK
OF **KOHLER**

In the world of Kohler form and function emerge triumphant. Here, a Kohler Faucet in cast brass. For a complete, full-color catalog of imaginative Kohler concepts for the kitchen, bath, powder room and spa, contact your Kohler dealer listed in the Yellow Pages or send two dollars to Kohler Co., Department AXD, Kohler, Wisconsin 53044.

How Mitsubishi Eliminates A Problem That Starts 93,000,000 Miles Away.

Until now, watching television has always been a matter of give-and-take.

In order for a television to give you the kind of picture you've wanted, you've had to take away the existing sunlight. Most often, by closing the blinds or pointing the set away from any incoming light.

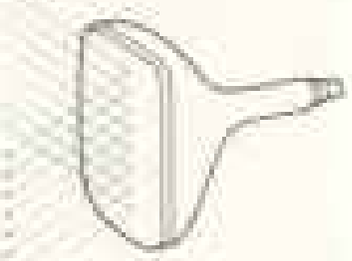
For sunlight is the Achilles' heel of most televisions, producing a glare that can wash out an otherwise superb picture.

SUNGLASSES FOR YOUR SCREEN.

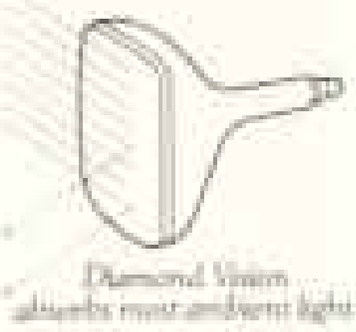
Recognizing that certain chemicals absorb certain colors in the light spectrum, we added those chemicals to the glass of our television screen to absorb the offending light. And we called this patented process, Diamond Vision.™

Diamond Vision not only creates a picture relatively unaffected by sunlight, the picture is greatly improved even when there's no sunlight present.

Compared with conventional television tubes, in fact, the range of colors that can be reproduced by Diamond Vision is 15% to 40% wider—depending on the amount of ambient light. So that colors like sky blue and crimson rose are reproduced more exactly.



Conventional screen reflects most ambient light.



Diamond Vision absorbs most ambient light.

And because the colors are reproduced more exactly, the various shades are differentiated as well. Which means that instead of watching a picture that just sort of sits on the screen, you can watch a picture with infinitely more depth and clarity.

But perhaps the most attractive feature of all is simply this. Diamond Vision isn't limited to just our more expensive televisions. It's built into virtually every color television we make. Whether it's a thirteen inch portable, nineteen inch component or twenty-five inch console.

Because if sunlight can find its way into your home, so should our televisions.

MITSUBISHI

Mitsubishi Electric Sales America, Inc., 3030 E. Victoria St., Rancho Dominguez, CA 90221

The new Typestar personal electronic typewriter from Canon.

It's small. It's light. It's brilliant.

You can hold it in the palm of your hand. Or carry it in a briefcase or rest it on your lap.

The new Typestar™ personal electronic typewriter from Canon.

But don't let its smallness fool you. It has a complete professional keyboard and all the features you'd expect from an electronic typewriter three times its size. Typestar 6, for instance, has a full-page memory, 32-character display for easy correction, automatic centering and underlining and the ability to print in double width. Plus a choice of five typestyles.

Typestar 5 has a 15-character display and a host of equally impressive features. But most important, they both give superior letter quality typing wherever and whenever you need it.

Because Typestar runs on simple batteries or AC.

So why not reach up now and hold your very own star. Typestar. From Canon.

Reach for a star. Typestar.

Canon

Never has so little done so much.

Canon U.S.A., Inc., One Canon Plaza, Lake Success, NY 11042

IT WON'T TAKE "NO" FOR AN ANSWER.

NOW THERE'S A GE PHONE THAT AUTOMATICALLY CALLS BACK BUSY NUMBERS EVERY 30 SECONDS.

And now, General Electric gives you a very good reason to replace your main phone. Because with the GE Auto Busy Redial Phone, you may never have to suffer the aggravation of a busy signal again.

If the number you call is busy, you simply press the Auto Redial button. The phone automatically redials the busy number up to 15 times and rings you back when it gets through. It can also remember 3 emergency numbers, plus 13 other numbers you call most often. It even gives you the convenience of hands-free, on-hook dialing.

All with the reassurance of GE quality. Its rugged construction has been rigorously tested. Its high-grade components assure years of reliable performance. And it's backed by a full two-year warranty and the support of the GE Answer Center,℠ there to help 24 hours a day. (800) 626-2000.

The new GE MAINFONE™ SERIES. The quality rings true.

We bring good things to life.

GE

ELECTRIC

DURACELL. WHEN YOU WANT TO BE SURE NOT TO MISS THE BOAT.

With most of today's cameras, if the batteries don't work, neither does the camera.

Which is why you need batteries that are long-lasting and reliable. DURACELL.®

Our alkaline batteries, for instance—long-lasting batteries to begin with—have been improved. So now they'll last up to 20% longer than the ones we made just three years ago.

Our biggest-selling silver button cell is so long-lasting, each one will give you more than a thousand shots.

Our amazing, long-lasting lithium batteries perform beautifully, even when the weather isn't. Deliver nearly 100% of their original power after an incredible five years in storage. Yet cost less than most silver cells.

And DURACELL® photo batteries are all factory-tested. So no matter what type or size you need, you can depend on them to work. Shot after shot after shot.

Or, for that matter, boat after boat after boat.

DURACELL

When it comes to making them last longer, we never stop.

Our Space Program.

Most people think of countries having space programs. At RCA, we have a bigger one than most countries.

Since 1958, we've built more than 80 satellites and been involved in 70 other space missions. With over 40 more satellites planned for launch during the next five years.

In our space program, RCA-built satellites have monitored weather patterns so accurately that no major storm has gone undetected for the past 18 years. Which just reflects our strength and reliability in the development of meteorological satellites.

Aboard the Space Shuttle, RCA is also a pioneer. It was our cameras and video equipment that sent back the dramatic, live television pictures of every shuttle mission. And we'll continue to do so over the next decade.

In communications, where RCA has built more than 75 satellites and sub-systems for ourselves, NASA, and many other major corporations, we're continuing to break new ground by building the first commercial Direct Broadcast Satellite, scheduled for launch in 1986.

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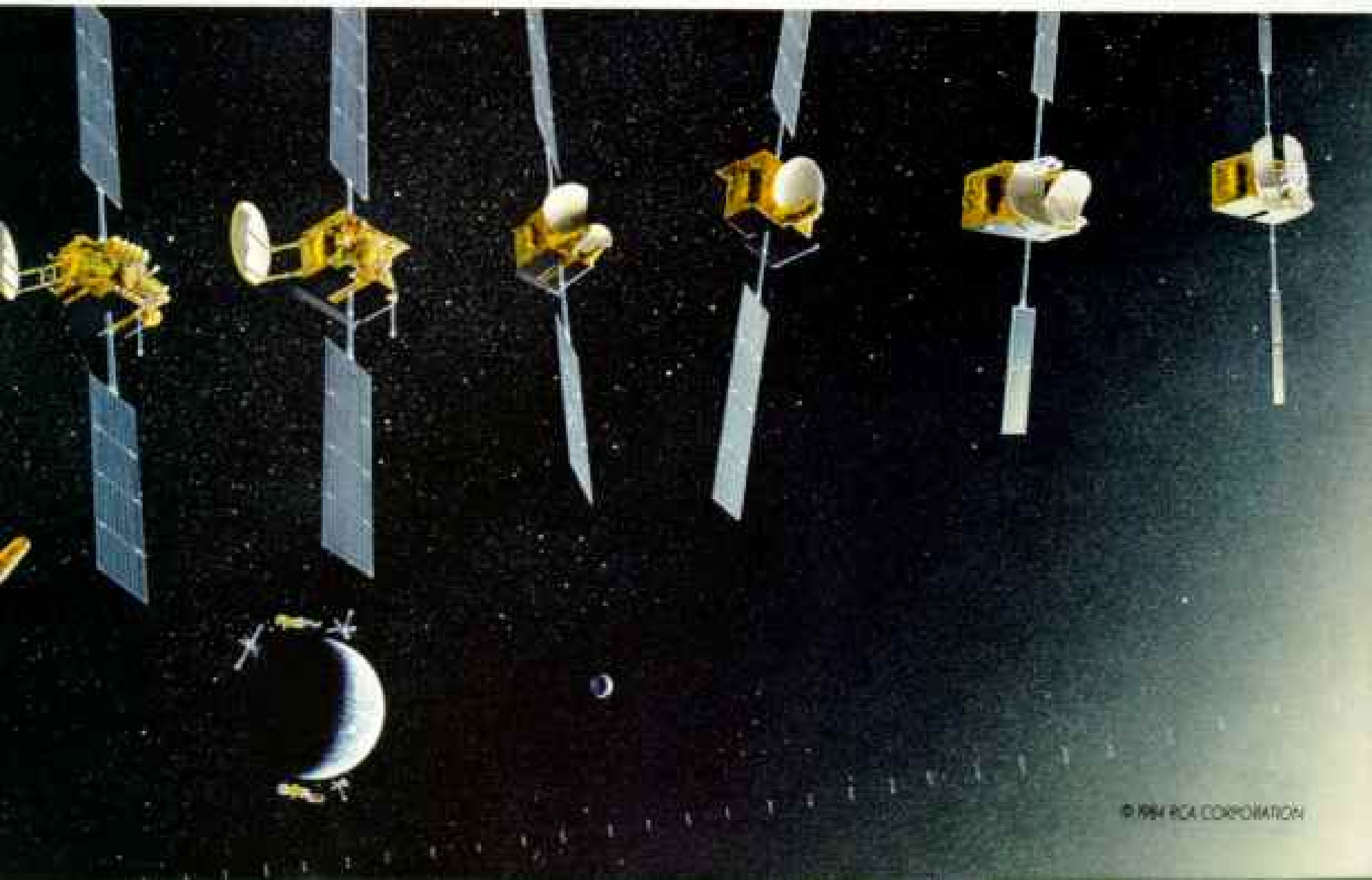
ONE OF A KIND

Now if all this surprises you, be prepared for a few more. In fact, if you'd like to learn more about RCA as a corporation, an investment or as a place to work, write for "This is RCA," P.O. Box 91404, Indianapolis, Ind. 46291.

After you read it, you'll know why in communications, electronics and entertainment, RCA is one of a kind.

Below, just a few of the satellites that RCA has built or is currently building. (Left to right) RCA Satcom III & IV, Spacenet, GSTAR, RCA Satcom V, STC-DBS, ACTS (Center), USSB, Rainbow, ASC, RCA Americom Ku, Anik-B, RCA Satcom I & II. (Orbiting the globe, read clockwise from upper left) Dynamics Explorer, TIROS-N, Nova, Navsat, DMSP.



"The pioneer spirit that pushed the railroads across America drives many of today's emerging growth companies."

Robert E. Brennan, President, First Jersey Securities

Only 150 years ago much of this country was still rugged frontier. Enterprising men and women seeking opportunity could travel by wagon and canal boat, but the trip required courage and took months.

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Populations and cities boomed. In ten years Kansas gained 432,000 inhabitants. Commerce exploded. Huge markets in cattle and grain were created. By 1900, U.S. trains carried nearly half the world's freight.

Today that same pioneer spirit that built the railroads inspired hundreds of small to midsize companies whose new ideas, new jobs and new technologies will push back today's frontiers.

First Jersey Securities is a nationwide investment firm providing capital for such emerging growth companies. If you are an investor with vision and want to discuss current investment opportunities, please contact us.

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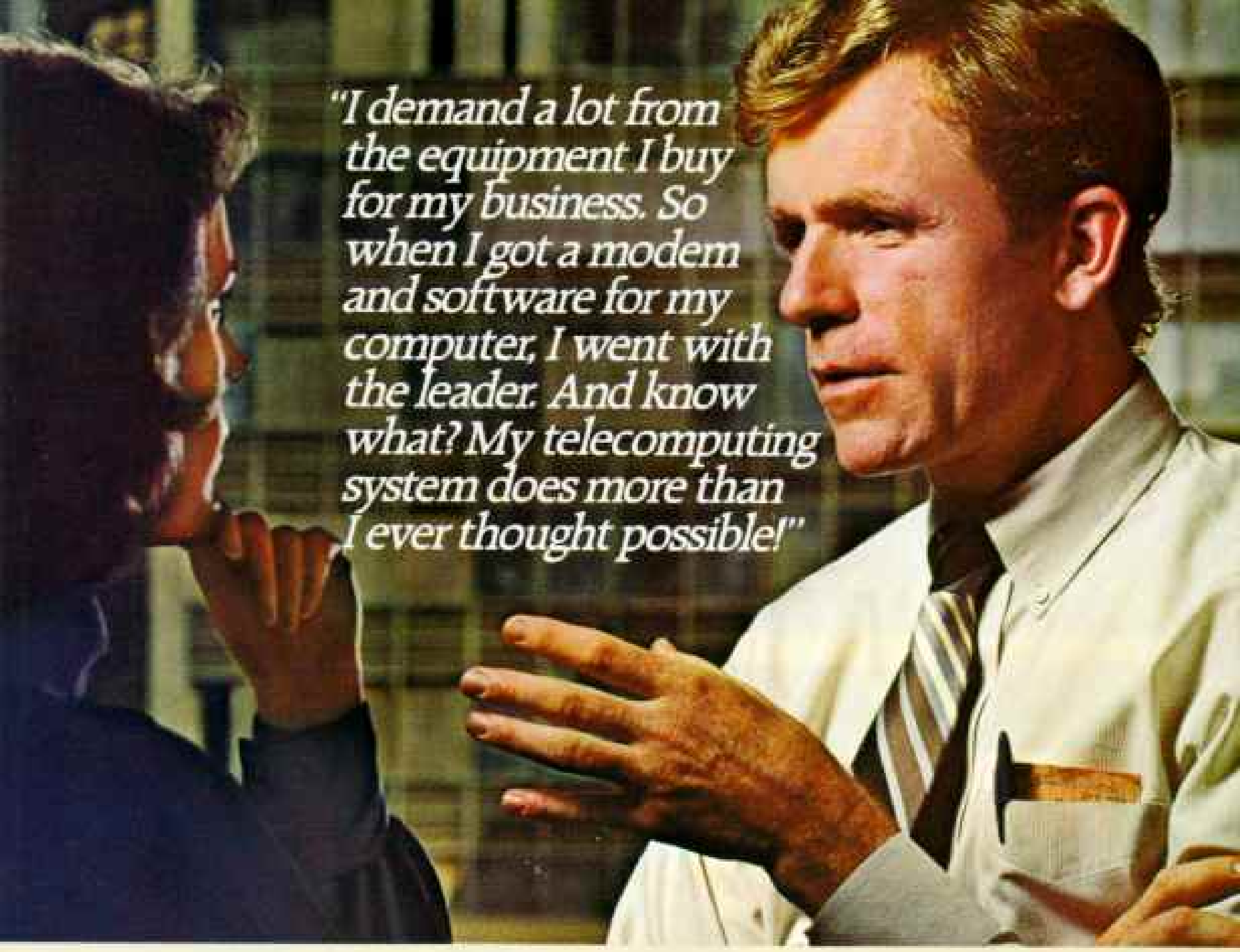

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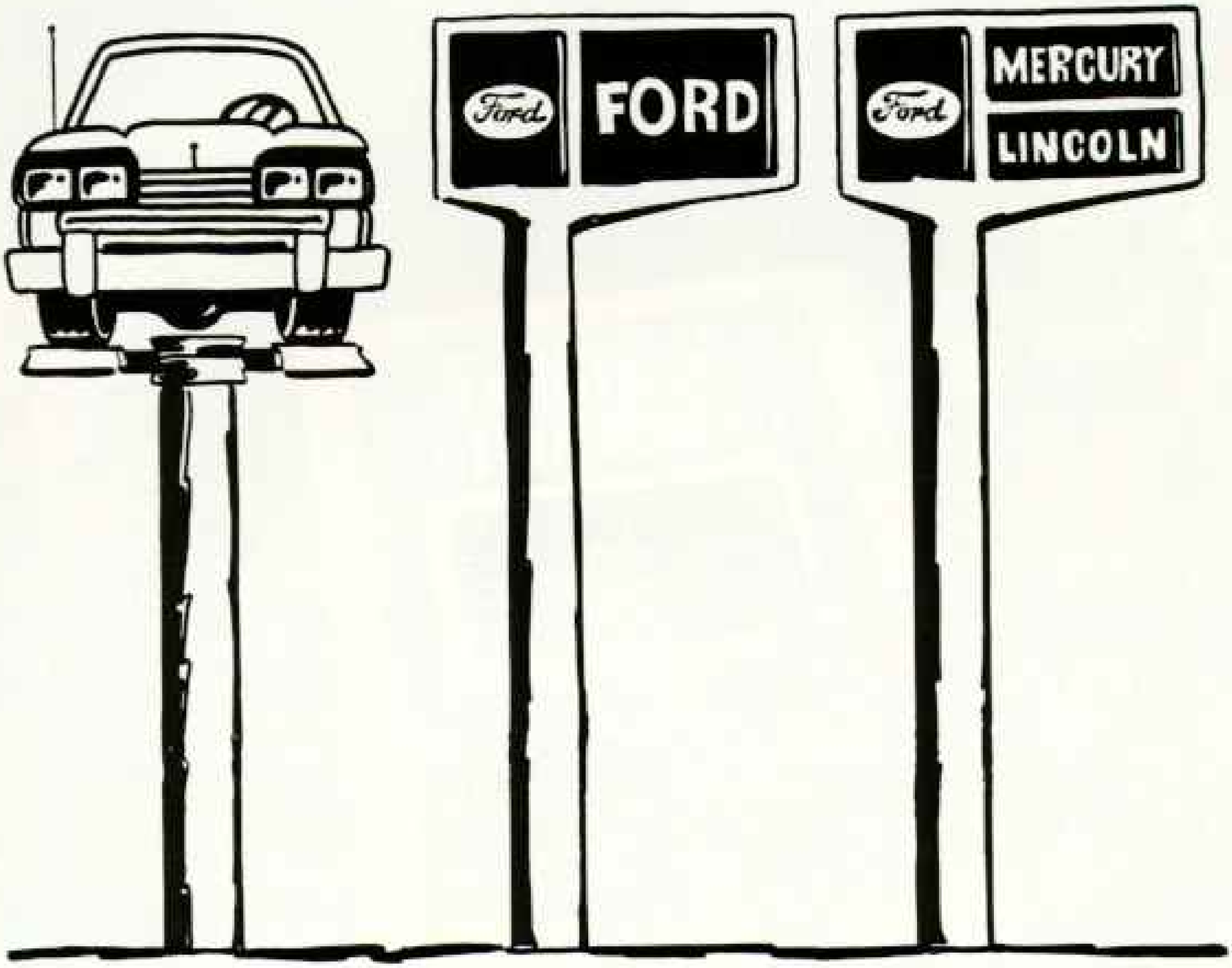

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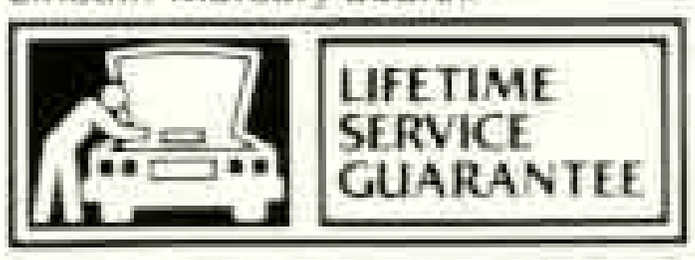

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Members Forum

Topsoil

I have just read your article on soil (September 1984). As in the U. S., we have people in Canada who don't understand soil conservation. They continue to bulldoze our trees and drain our sloughs. And when the fall and spring winds blow away the topsoil, they blame it on everyone but themselves. When the water table drops, do they stop to consider that, had they left the slough where it was, none of this would have happened? A number of farmers have gone to zero tilling, which seems to stem the snow from drifting off the fields in the winter. The last thing we need now is another drought. But unless the farmer changes his ways, it will soon be on us.

Doug L. Brown
Rivers, Manitoba

Thanks for the stirring article "Do We Treat Our Soil Like Dirt?" To quote an old Texas farmer on the soil he has farmed for 25 years, "It used to be we could just plant the peanuts, and when the soil got wore out, we'd just move on. Now we're running out of places to move on to."

Nature is resilient. With proper management we will be able to renew one of our most precious resources, the soil.

Elizabeth Jewell
Conway, Arkansas

In January 1977 we had a very dirty snow in Joliet. In some places in our yard the dirty layer was more than eight inches thick. I recognized it for what it was—the cream of someone's farm—and in midwinter got out my wheelbarrow and shovel and put the snow from my driveway on my garden. That growing season its output was 50 percent greater than before.

Thank you, farmers of Colorado, for my backyard bonus. However, I hope my grandchildren don't go hungry because of you. Anytime one sees a dust storm, he is seeing the future of our country's agricultural productivity disappearing before his eyes.

John J. Balek
Joliet, Illinois

Colorado

References to shale "oil" in your "Colorado Dreaming" article (August 1984) lack some basic facts. Kerogen is a very low-quality hydrocarbon and must be upgraded with energy inputs to make anything close to gasoline. Current shale processing is a net energy loss system, and thus the demand for multibillion-dollar subsidies and price guarantees at $44 to $92 per barrel while high-grade crude is at $28. No surprise then that the only customer in sight for shale oil is the Pentagon. Environmental effects of shale operations would create severe air, land, and water degradation here in Colorado.

Chester McQueary
Parachute, Colorado

It's obvious that one of the things Mike Edwards likes most about Colorado is its mining industry. He prefers Leadville as a "lusty, loud, miner's daughter." Maybe we should also add a "polluting, environmentally irresponsible, miner's daughter." Is he fond of the hideous open gash hundreds of feet across that runs from Leadville to Climax? Or perhaps all those colorful mine tailings that spangle the surrounding mountains?

It could be that Mr. Edwards is simply captivated by romantic notions of Colorado's old gold-rush days, but his treatment of modern uranium mining is another matter. He tells us that the presence of radioactive tailings is "provoking debate," as if it weren't dangerous. These aren't obscure little piles; we're talking about *mountains* of the stuff. Nothing will grow on them, nothing can live around them. Of all the evils of the nuclear power game, uranium mining is the most insidious.

Richard Bruhn
Austin, Texas

Japan Alps

It was with great pleasure and surprise that I opened the August 1984 issue to see the photo of Tateyama. In the summer of 1968, as a twenty-year-old, I climbed Tateyama, and it was with a great deal of endurance and pride that I reached the top. As I stood on the summit, sweating and tired, I glanced around to find an elderly monk dispensing blessings to a group of 20 smiling, cheerful ten-year-olds.

John Oliver
Hartsville, Tennessee

Mexico City

Congratulations to Bart McDowell and Stephanie Maze for the excellent article (August 1984). A large metropolis develops its character and personality from its geologic location. I think you captured the feeling of this great city.

Dr. Luis Roberto Ocón
León, Mexico

"Mexico City: An Alarming Giant" was read with consternation and disapproval by those

who, like me, have spent 30 or more years in this exuberant, fascinating, delightful, majestic, ever growing, sometimes shabby, sometimes unruly, but always beloved city we call home. The emphasis of your story is overwhelmingly on the underprivileged population of the inner city, which is very similar to the ghettos of New York, Chicago, or any other large, aging city. In only a very partial sense does such a focus truly reflect the character of the city as a whole or accurately describe its form or substance.

Juan Wortman
Mexico, D.F.

Forty years ago my uncle Lavoisier Lamar, a worldwide consulting engineer, was in Mexico and was asked his opinion of Mexico City. He said, "When a large group of people ignoring geography, climate, politics, and reason decide to live in a community, they live, largely, off each other. The money flies around, changing hands; most of it stays there. The clever siphon some away. It means little. The more people, the more confidence, the more growth. That is Mexico City today."

William H. Lamar
San Antonio, Texas

Population Bomb

In an otherwise excellent article (August 1984) you got the central point backward. On page 184 you state "primitive farming methods limit crop yield—and profit." The truth is that the lack of profit in modern farming forces farmers to continue primitive farming methods.

Gilles Stockton
Grassrange, Montana

Whales

For the past two weeks I have been attending a class on marine mammals at Scripps Institution of Oceanography in La Jolla, California. In "The Whales Called 'Killer' " (August 1984) a caption states the eye gel is for protection when the whale comes out of the water. According to my teacher at Scripps, the eye gel of the killer whale is used for protection underwater. Please confirm which is correct.

Bobby D. Highfill
Spring Valley, California

Most scientists think the glandular secretion protects the orcas' eyes both above and below water. Orcas are among the few cetaceans to deliberately lift their heads above water in search of prey.

Scotland

Rowe Findley's fine article on Scotland's "ghosts" might have included more on Sir William Wallace (1270-1305), who more than any

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other fired the national instincts of the clans and brought unity and independence to his people. His defeat of King Edward's forces at Stirling rallied the Scots, and that fervor never died. So enshrined is Wallace's heroism in Scottish hearts that his statue stands to the right as you enter Edinburgh Castle. To the left is Robert Bruce.

William Wallace
Fraser, New York

Great Gray Owl

Michael Quinton, in his article on the great gray owl (July 1984), mentioned the American Birding Association's list of Most Wanted Birds. I'd never heard of it. Now that I have, I'd sure like to know their "top ten."

Tommy DeMarco
Eatonia, Saskatchewan

They are as follows: Bachman's warbler, California condor, ivory-billed woodpecker, great gray owl, black rail, gyrfalcon, boreal owl, yellow rail, aplomado falcon, and Eskimo curlew.

Mr. Quinton's story of the great gray owl was absolutely marvelous. His report showed me what an incredible creature the great gray is. One question still lingers in my mind, though—is the great gray considered endangered?

Peter Bilden
Zionsville, Indiana

The great gray owl is not on the U. S. endangered species list. In Canada—its basic range—it is considered "rare," a ranking below "threatened."

Cover

Thank you so much for the March 1984 issue and the article on lasers. The cover alone must have attracted world comment. Last evening I took that issue to school for the evening study period for our Grade Sevens, all local kids of the Lunda-Ndembu tribe. Most of them tilted the cover at various angles, exclaimed on the different color effects, and then went on with their studies. But one more curious than the rest took the magazine to a quiet corner of the room, studied the cover very carefully from different angles, and four different times cautiously opened the magazine to see where the rest of the bird was!

Brother Joseph Weissling
Mwinilunga, Zambia

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

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*1984 6-passenger model comparisons: lowest base and comparably equipped sticker prices; highest mileage—28 EPA est. mpg, used for comparison, actual mpg varied depending on speed, distance and weather; longest warranty—5 years/50,000 miles, whichever came first. Limited warranty on powertrain and outer body rust-through, excluded leases, deductible applied. Dealer supplied details.

**Aries LE savings based on sticker prices of package items if purchased separately. Ask for details.

BUCKLE UP FOR SAFETY.

On Assignment

SAILING THE INDIAN OCEAN off the coasts of India and Sri Lanka may seem like a delightful adventure, but if your schedule is dictated by the erratic movements of sperm whales, the glamor quickly fades.

"It sounds exotic, but it's actually quite exhausting, because we follow them day and night," says zoologist ***Hal Whitehead***. Here, aboard the sloop *Tulip* (***below***), which served as the project's research vessel, he stands watch flanked by crew members Caroline Smythe and Philip Gilligan.

FLIP NICKLIN

A native of Derby, England, Whitehead learned to sail in the United States during boyhood summers spent at his maternal grandmother's house on Maine's Isleboro Island. He holds a Ph.D. in zoology from Cambridge University and has studied whales off the coasts of Greenland and Newfoundland and in the West Indies. Though his fondness for the giants is unshakable, he says, "The whales had no idea what anguish they caused us when they suddenly changed direction or crossed in front of a passing ship."

"I've worked with a lot of whales before," says photographer ***Flip Nicklin*** (***below***), "but the sperm whale is special. It's like diving with Moby Dick." For this assignment Nicklin put his scuba gear aside and used only a snorkel, since sperm whales shy away from bubbles produced by air tanks.

A veteran diver, the San Diego native has photographed articles on three other whale species—humpbacks, rights, and killer whales—for NATIONAL GEOGRAPHIC, and another on krill, a favorite whale food. "We're just getting beyond the survey years in whale photography," says Nicklin. "Eventually we'll see pictures that will really knock your socks off." And Nicklin hopes to be the one who trips the shutter.

FLIP NICKLIN

Photographed by Luiz Claudio Marigo. *Seven-colored Tanager:* *Genus: Tangara* *Species: fastuosa*
Adult size: *Average length, 14cm* ***Adult weight:*** *Unknown*
Habitat: *Tropical coastal forests of northeastern Brazil* ***Surviving number:*** *Unknown*

Wildlife as Canon sees it: A photographic heritage for all generations.

Once abundant in the tropical forests of Brazil, the stunningly beautiful seven-colored tanager has seriously declined in the past 30 years. Continually sought after as a cage bird because of its fanciful plumage and threatened with the loss of its habitat, this species of tanager today faces an uncertain future.

Nothing could bring the seven-colored tanager back should it vanish completely. And while photography can record it for posterity, more importantly photography can help save it and the rest of wildlife.

Photography is an invaluable research tool that can assist in efforts to save the seven-colored tanager. Continued protection from the pet trade and the preservation of its natural habitat are needed to ensure the survival of the species. Also through photography, one can better appreciate and understand this exotic and fabulous denizen of tropical forests.

And understanding is perhaps the single most important factor in saving the seven-colored tanager and all of wildlife.

Canon
Images for all time

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1. Full-size interior with enough room to seat six full-size adults.
2. Reclining front seat with finely woven cloth seating surfaces.
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4. AM/FM stereo radio with 4 speakers for full, rich sound reproduction (may be deleted for credit).
5. An electric clock with the precise accuracy of quartz movement.
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14. New gas-filled shock absorbers for the smoothest riding LTD Crown Victoria to date.

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15. Standard, steel-belted radial, whitewall tires, for sure-footed traction and low-rolling resistance.
16. An optional automatic load leveling suspension that with the trailer towing package keeps LTD Crown Victoria riding smooth and level whether you're towing 5,000 pounds, or just carrying luggage.
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All because our scientists and engineers have perfected several photographic and chemical processes.

They've made important changes inside the film for a significant difference in quality. And Polaroid pictures have never looked better.

The colors are now much richer and brighter. So true to life their effect is dazzling. Even the images themselves appear sharper and crisper. Our film gives your pictures a reality, a sense of "being there", as never before. The improvements are so noticeable, if you haven't seen Polaroid pictures lately, it's as if you've never seen them at all.

The micro-thin layers of Polaroid film have been ingeniously improved to produce pictures that are now more colorful than ever and as thin as ever – only .0013 of an inch.

Of course, some things we didn't change.

Polaroid pictures still develop in seconds, dry and durable. With lasting colors.

And every pack comes with a fresh battery, for powerful flash you can count on.

Shoot a pack, you'll see the improvement. Or, buy a money-saving two or three pack.

With Polaroid pictures your imagination can express itself in a brilliant array of colors.

600

Bright
rich
colors
Polaroid

Polaroid