DOUBLE MAP SUPPLEMENT: ORION/THE HEAVENS

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TEOTIH

ECHOING THE SACRED MOUNTAIN BEYOND, THE PYRAMID OF THE SUN

VISION OF TEOTIHUACAN

CLAIMS A PLACE IN THE ANCIENT COSMOS OF CENTRAL MEXICO.

By GEORGE E. STUART
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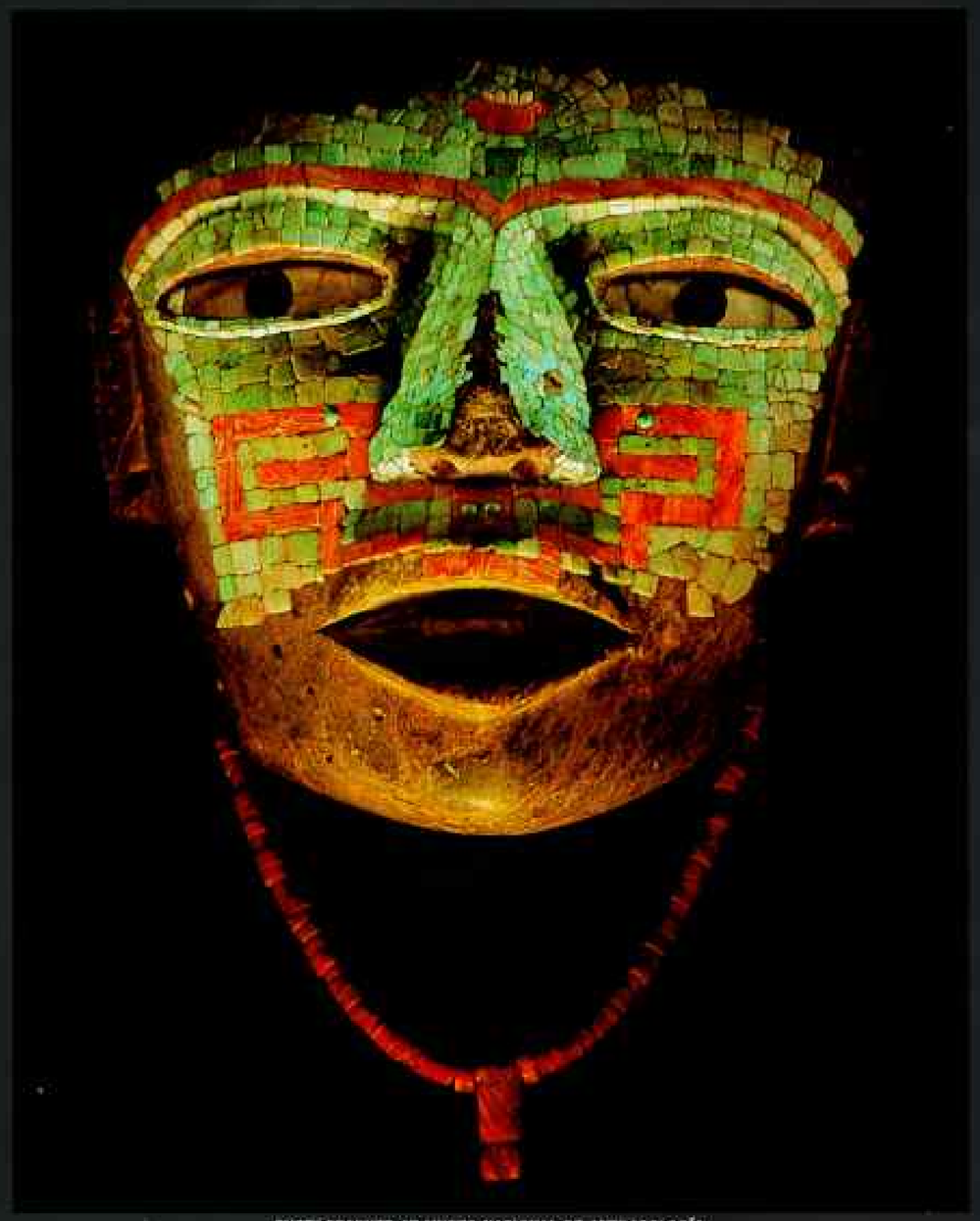
Photographs by KENNETH GARRETT



PHOTOGRAPHED AT MUSEO NACIONAL DE ANTROPOLOGÍA,
INSTITUTO NACIONAL DE ANTROPOLOGÍA E HISTORIA (INAH), MEXICO CITY

MESOAMERICA'S FIRST METROPOLIS, TEOTIHUACAN RIVALED ROME IN SIZE IN THE MID-FIRST MILLENNIUM A.D. RITUAL SITE, MARKETPLACE, AND ART CENTER, IT INFLUENCED REGIONS SUCH AS GUERRERO, TO THE SOUTH, WHERE THIS TEOTIHUACAN-STYLE STONE MASK CAME TO LIGHT. CENTURIES AFTER ITS FALL THE AZTEC CALLED IT THE PLACE OF THE GODS.

Planned on a grand scale, the city covers nearly eight square miles. Much remains unexcavated. "We still don't know what language the Teotihuacanos spoke, where they came from, or what happened to them," notes University of California archaeologist Karl Taube.

WHEN SABURO SUGIYAMA began excavating along the southern edge of the Feathered Serpent Pyramid at the Mexican ruin of Teotihuacan, he realized, as all archaeologists do at such times, that he was crossing the threshold of the unknown. But nothing could have prepared him that summer in 1983 for the macabre discovery at the bottom of a four-foot-deep trench. Seated, arms crossed in back, was the skeleton of a man. Around his neck was a broad collar made of more than 200 shell beads. Suspended from this had once been a tier of upper human jaws carved from now deteriorated wood and decorated with shell teeth.

Sugiyama and colleagues from Mexico's Instituto Nacional de Antropología e Historia (INAH) uncovered 17 other male skeletons in the grave. Their arms too were crossed, and they wore almost identical collars, although two had real human jaws with teeth intact. These men were probably soldiers, for on their lower backs were slate disks—once shiny with pyrite—a standard decoration on ancient Mexican military costumes. Weapons had been buried with them—the grave yielded 169 spearpoints.

"We have no idea how these men died," Sugiyama says. "The bones are unscathed, but we know from radiocarbon dates on some of the organic material that the burial took place around A.D. 200." Sugiyama believes they were sacrifice victims, because the bodies had been carefully positioned in the tomb with their arms tied behind their backs. "It strongly suggests that their killing was part of a ritual that marked the dedication of the structure."

Teotihuacan was the first true urban center in the Western Hemisphere and the greatest metropolis on the landscape of the Americas before the Aztec Empire. It arose around the beginning of the Christian era, witnessed some seven centuries, then passed into legend. At the height of its prosperity, about A.D. 500, it is estimated to have held between 125,000 and 200,000 people—rivaling Shakespeare's London a millennium later. Teotihuacan thrived longer than imperial Rome, its contemporary, and in the more extreme setting of a high arid plateau slaked by a brief rainy season.

It was the elaborate western facade of the Pyramid of the Feathered Serpent that first drew me to the city nearly 30 years ago, when I was still in graduate school. I had taken my family to Teotihuacan as a side trip on our way overland from the United States to Yucatán, where, as a field assistant, I had helped map and excavate Dzibilchaltún and other Maya sites. The Feathered Serpent Pyramid lies on the east side of the huge plaza within the Ciudadela, or Citadel. Named by awed Spaniards in the 16th century, the Citadel was to Teotihuacan what the Forum was to Rome: its physical and spiritual center.

On that memorable afternoon the sun brought the pyramid's

Photographer KENNETH GARRETT "is known by archaeologists all over the world," says author George Stuart. "And they trust him, because he takes time during his work to help document findings important to their research."

Mere inches of clay hold a mystery: the meaning of an austere host figure and its adorned guest. Few such figurines survive at Teotihuacan. Perhaps they symbolized divine protection for a confident and independent people.

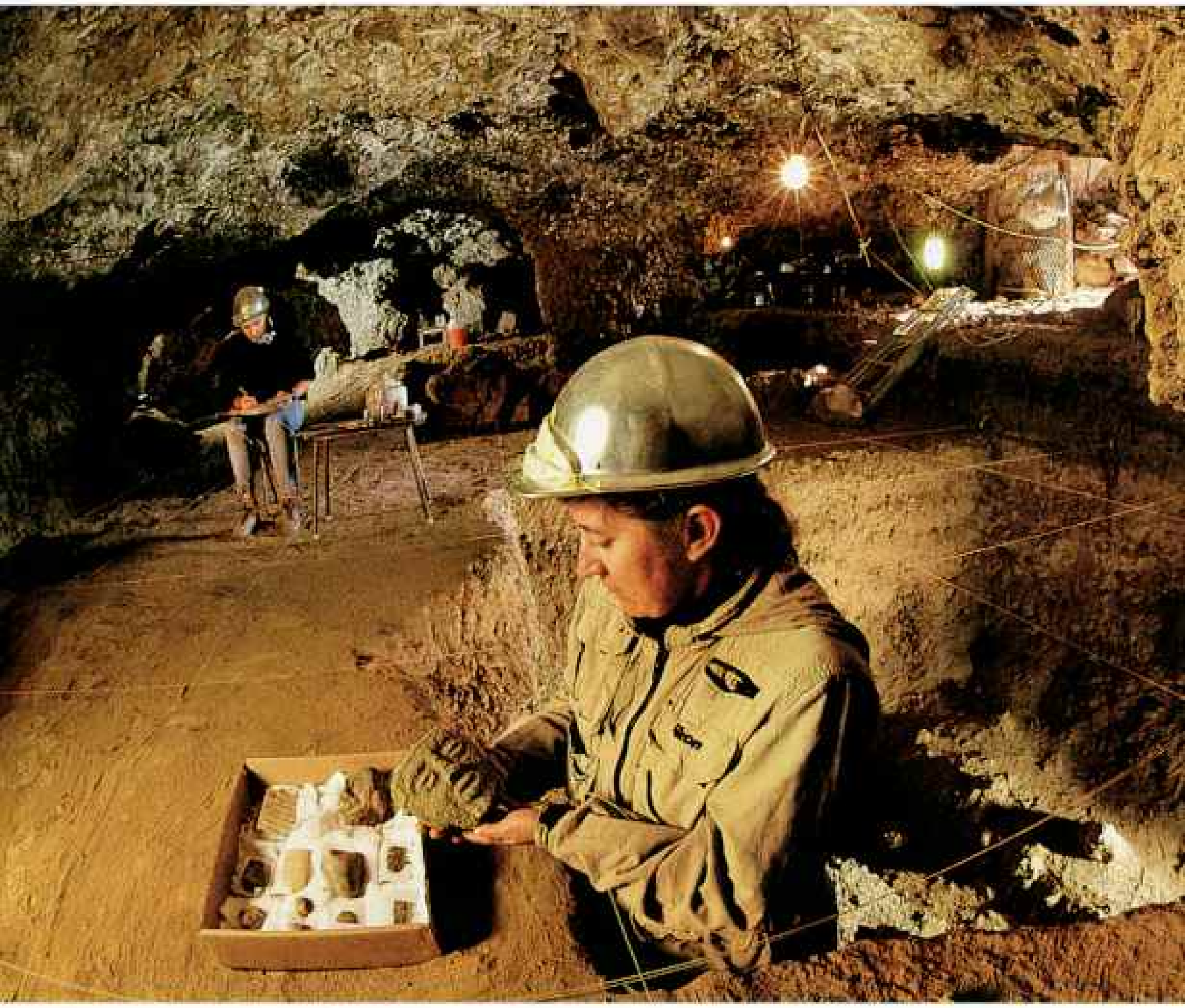
PHOTOGRAPHED AT MUSEO NACIONAL DE ANTROPOLOGÍA, INAH

sculptured facade to life, and it seemed clear that the building was intended to catch—and hold—the attention of the viewer. Four stepped levels looming in front of me held great stone icons, alternating images of the Feathered Serpent—one of the most important supernatural beings in the ancient Mesoamerican pantheon—and enigmatic headdresses. Intricately carved and once brightly painted, they protruded from a backdrop of images of undulating serpent bodies and seashells. All these elements, arranged in geometric harmony, flanked a grand stairway with balustrades punctuated by fanged serpent heads.

Looking beyond the pyramid itself, I was amazed by the sheer sprawl and architectural grace of the Citadel and by the enormity of the Pyramids of the Sun and Moon—Teotihuacan's most celebrated architectural treasures. And yet I knew that all this concentrated grandeur was but a tiny part of the immense city, abandoned and now in ruins, that lay around me.

Since that first visit I have come to know hundreds of sites throughout Mesoamerica as staff archaeologist for the National Geographic Society. I have watched a golden sunrise brighten the pyramids and plazas at Monte Albán in Oaxaca. I have spent the night in the

"There was another life at Teotihuacan, the one underneath," says Mexican archaeologist Linda Manzanilla (below). In one of the many caves east of the Pyramid of the Sun she examines evidence of occupation, which continued in later cultures. She believes the Teotihuacanos themselves created these tunnels as they mined stone to build their city. In doing so they may well have intended them to represent the bottom



level of their universe, an underworld of ancestors and fertility.

"Life and death are related in their cosmology," Manzanilla explains. The incense burner she found in a residential area above ground incorporates both. A funerary offering, it spreads the fruits of the earth—corn, cotton, squash, and flowers—at the feet of its resplendent central figure.

Nunnery Quadrangle at Uxmal, observing the light and shadow as a full moon swept the ornate stone facades. I have stood before an avenue of enormous, evocative pyramids, shrouded in greenery during a brilliant sunset, at Cuajilote in Veracruz. But of all these places, Teotihuacan has lodged itself most tenaciously in my mind.

Founded on what its builders must have regarded as an almost indescribably sacred spot about 30 miles northeast of what is now Mexico City, Teotihuacan once covered nearly eight square miles. Today much of the city is buried under five towns, one of Mexico's largest military bases, numerous farms, commercial centers, and a string of highways. The site also spreads into lonely backcountry, where dust devils stir the gray, talcum-like soil and foothill slopes with impenetrable clusters of prickly pears challenge graying archaeologists.

Teotihuacan was laid out according to a set of alignments that tied it intimately to the movements of the stars and to the mountains on the horizon. To all who knew it as a place of order and power, whose monumentality rivaled nature itself, the city must have seemed a true wonder of the world. The later Aztec knew Teotihuacan as the Place of the Gods. Today's Mexicans speak of the city simply as "the pyramids."

PHOTOGRAPHED AT MUSEO DE TEOTIHUACÁN, 1988

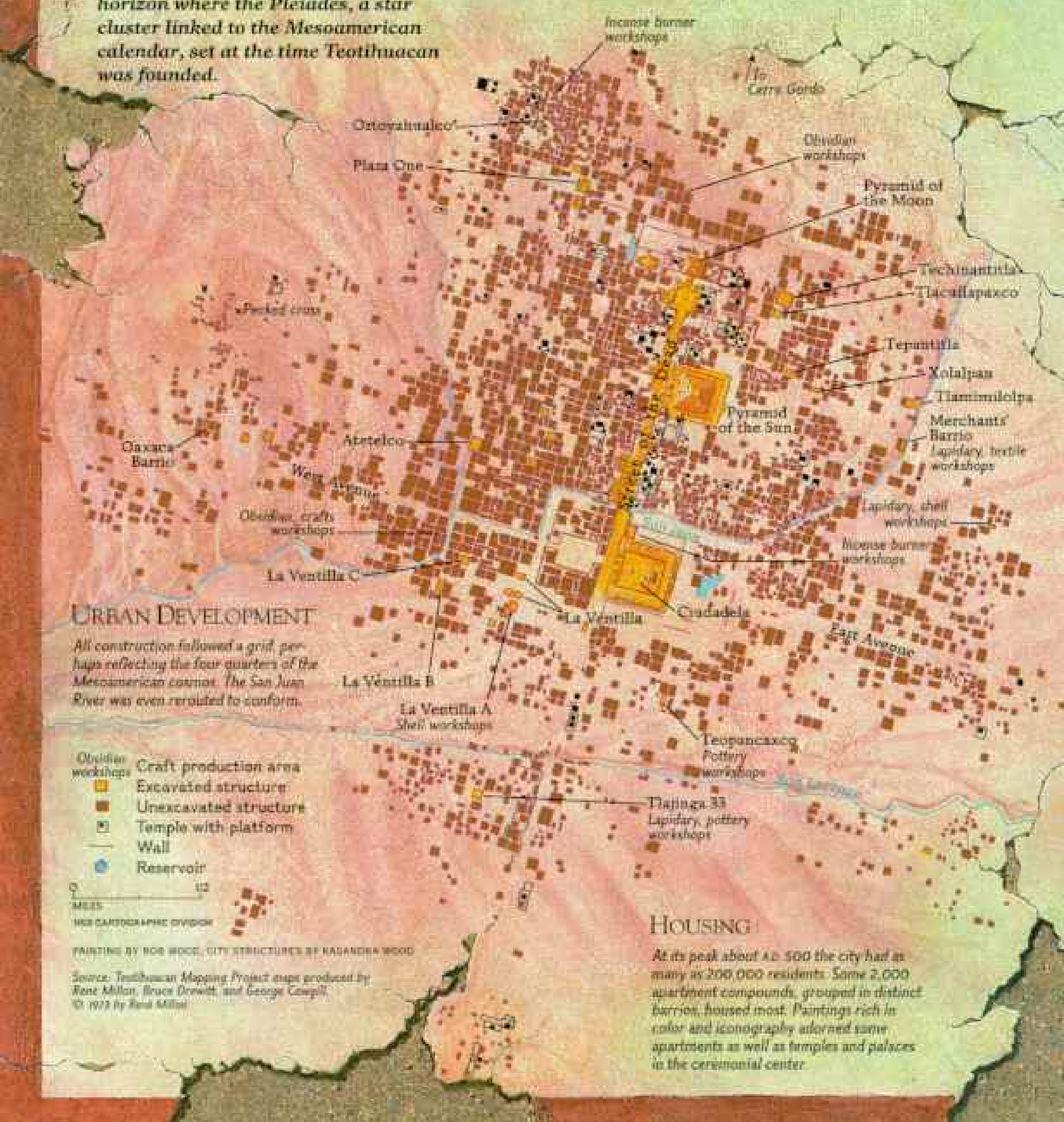
Teotihuacan's Ordered World

In every direction this city was laid out in harmony with the universe as Teotihuacanos understood it. "It's the place where time began," says Colgate University astronomer Anthony Aveni. "Why not have its hour and minute hands set perfectly?"

The Street of the Dead, the main axis, angles east from true north to point toward the sacred peak of Cerro Gordo. The main east-west axis lined up with a point on the western horizon where the Pleiades, a star cluster linked to the Mesoamerican calendar, set at the time Teotihuacan was founded.

Sphere Of Influence

Though it controlled the surrounding central highlands and cultivated wide contacts, Teotihuacan probably had no empire.



Urban Development

All construction followed a grid, perhaps reflecting the four quarters of the Mesoamerican cosmos. The San Juan River was even rerouted to conform.

Obsidian workshops — Craft production area
Excavated structure
Unexcavated structure
Temple with platform
Wall
Reservoir

0 1/2 MILES

HGS CARTOGRAPHIC DIVISION

PAINTING BY BOB BOCE, CITY STRUCTURES BY KASANDRA WOOD

Source: Teotihuacan Mapping Project maps produced by René Millon, Bruce Drewitt, and George Cowgill.

Housing

At its peak about A.D. 500 the city had as many as 200,000 residents. Some 2,000 apartment compounds, grouped in distinct barrios, housed most. Paintings rich in color and iconography adorned some apartments as well as temples and palaces in the ceremonial center.

Ceremonial Center

Domestic altars and local shrines may have served for everyday ritual, but on special religious occasions Teotihuacanos surely came here. Spacious plazas in front of the pyramids could have held tens of thousands. Built to impress, the pyramids climbed toward the sky, the top level of the Teotihuacan universe.

Excavated structure

Modern facility

0 1/8 MILES

The city center (detailed at right) is protected by the Mexican government as the Teotihuacan Archaeological Zone, which also includes several excavated apartment compounds outside the peripheral highway.

Yayahuala

Zacuala Palace

Zacuala Patios

Tetitla

Pyramid Of The Moon

Ascending the Street of the Dead, worshipers would see this structure slowly obscure Cerro Gordo — part of the city's dialogue with space.

Five Prime Pyramid Group

PERIPHERAL HIGHWAY

Pyramid of the Moon

Patio of the Jaguars

Gate 3

Building of the Altars

Plaza of the Moon

Palace of Quetzalpapalotl

Temple of Agriculture

Temple of Mythological Animals

Amanalco (Barrio of the Looted Murals)

Puma Mural Group

Palace of the Sun

Patio of the Four Small Temples

Great platforms of the Pyramid of the Sun Complex

Gate 4

Tepantitla

Gate 2

Plaza of the Sun

Cave entrance

Pyramid of the Sun

Street of the Dead

Pecked cross

House of the Priests

Museum

Cave entrances

Pecked crosses

West Plaza Complex

Viking Group

Gate 5

Gamio Center

Superimposed Buildings Complex

Street of the Dead Complex

San Juan

Pyramid Of The Sun

Twenty stories tall, this was the largest Mesoamerican pyramid of the time. As with the Pyramid of the Moon, it retains the name used by the Aztec, who made pilgrimages to the city.

North Quadrangle

To Mexico City

Great Gate 1

Shops and restaurant

Compound

Administrative offices

La Ventilla

Pyramid of the Feathered Serpent

Ciudadela (Citadel)

The South End

Some two centuries of monumental building came to an end about A.D. 250 with the completion of the Great Compound — probably the main market — and the 39-acre Ciudadela, a civic and religious complex.

PERIPHERAL HIGHWAY

When Sugiyama unearthed the mass grave at the Pyramid of the Feathered Serpent, he was working under the supervision of Rubén Cabrera Castro of INAH, as part of a team investigating the Citadel. The find spurred a collaborative investigation of the entire pyramid by scientists from Mexico, led by Cabrera, and the United States, under George Cowgill of Arizona State University in Tempe. Eventually the team tallied 133 skeletons in 21 separate graves along the edges, at the corners, and in the heart of the pyramid, and members suspect there are as many as 200. "We began to see a pattern in the placement of the burials," Cabrera told me. "It saved us lots of tunneling."

The corpses, females as well as males, were arranged in segregated groups of 4, 8, 9, 18, or 20—key numbers in the Mesoamerican calendar and cosmology. They had been placed in various positions: seated, on their backs, and on their sides. Those on the periphery faced outward, as if to guard the pyramid.

The archaeologists made one final discovery, which suggests that the Feathered Serpent Pyramid may have been the tomb of one of Teotihuacan's most powerful rulers. Tunneling deep into its core, Sugiyama encountered 20 male skeletons surrounded by a plethora of offerings, including objects of jade, shell, slate, wood, and flaked obsidian. It is the richest burial ever found at Teotihuacan.

Nearby was a tunnel, presumably dug by ancient looters, which skirted the mass grave. The tunnel led to a deep broad pit with a few skeletal remains and scattered fragments of its once rich contents. "It's exasperating," says Cowgill. "The main tomb may have been there, but we will never know for sure."

THE MASS SACRIFICE at the Feathered Serpent Pyramid—and this hint of a royal burial—are examples of recent gains in our understanding of Teotihuacan. Modern investigation of the site began in 1918 when Mexican archaeologist Manuel Gamio conducted the first systematic excavations around the Feathered Serpent Pyramid, which he also partly restored. Gamio's analysis earned him the title "father of Teotihuacan archaeology." Archaeologists who followed concentrated initially on the pyramids, palaces, and plazas that give the city its public image.

Now we are beginning to learn about the lives of the Teotihuacanos—what kind of food they ate, how they used the rooms in their houses, and what kind of work they did. We have found out that the metropolis attracted immigrants from far afield and that it was the center of a vast trading network. We may even have the first tantalizing evidence of a writing system. (For me, the apparent lack of one has been Teotihuacan's greatest mystery.)

Yet despite these scholarly advances, more than 1,200 years after its fall Teotihuacan remains a paradox: We speak of it with awe, as we do the pyramids of Egypt, but we still know next to nothing about the origins of the Teotihuacanos, what language they spoke, how their society was organized, and what caused their decline.

Central to what we do know, however, is an atlas compiled in the 1960s by René Millon of the University of Rochester in collaboration with George Cowgill and Bruce Drewitt of the University of Toronto. The Teotihuacan Mapping Project, which Millon himself characterizes as "a staggering undertaking," surely ranks among the greatest achievements in archaeological surveying.

From a combination of meticulous ground surveying and aerial

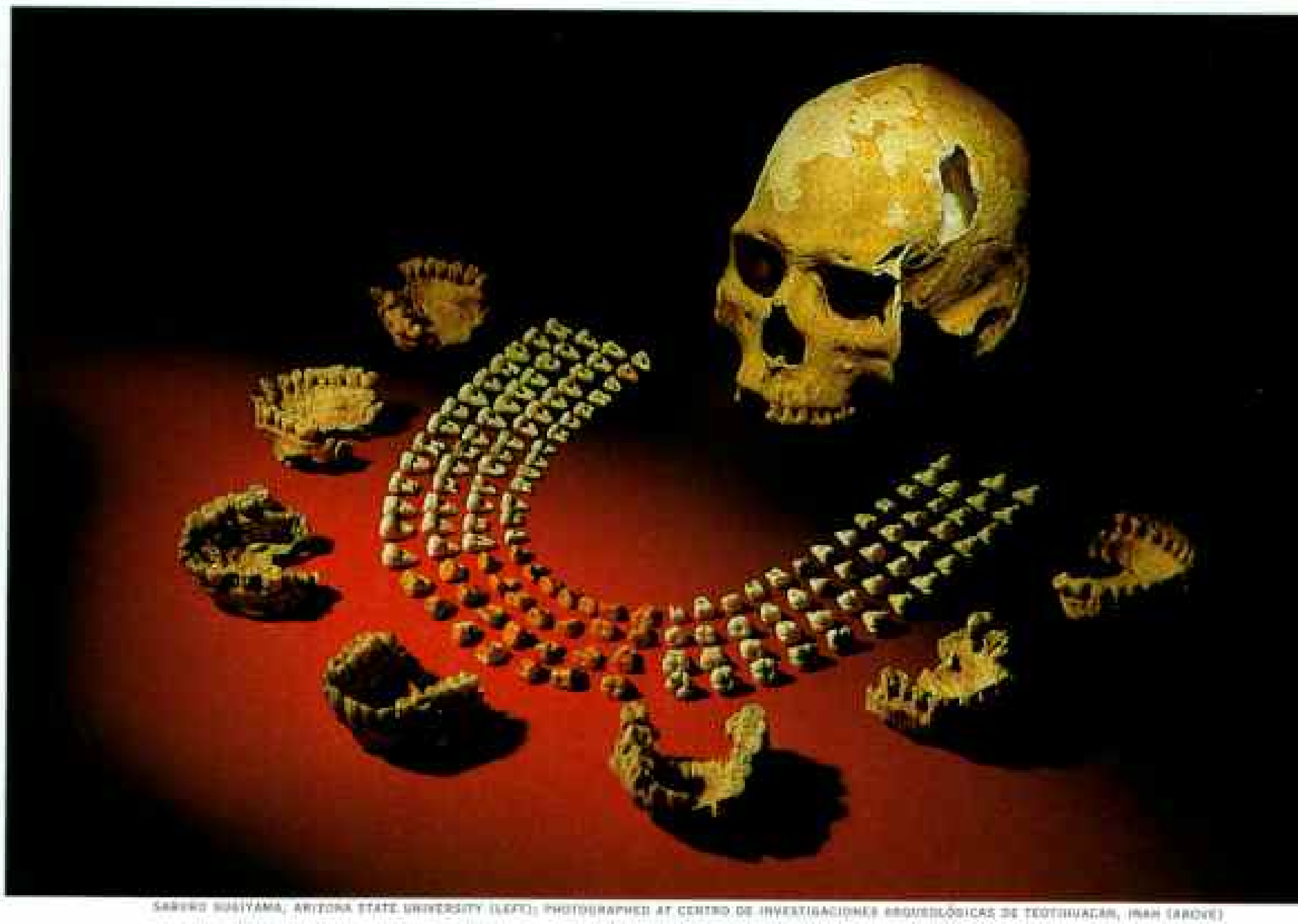
A dramatic sky matches the mood of the Pyramid of the Feathered Serpent, god of the dawn, war, water, and agriculture. "This building was ideologically very important," says archaeologist George Cowgill of Arizona State University. "It was intended to be very visible—like the Lincoln Memorial."

The modern world puzzles over what such a monument said to the Teotihuacanos; serpent

images once appeared hundreds of times on all four pyramid walls. One thing is certain: Residents ultimately obscured the front of this pyramid with a platform and showed the Feathered Serpent under attack in murals around the city. Perhaps the supernatural being, and the institutions it represented, had lost favor.

photography, Millon and his team produced exquisitely detailed maps of the site that included, as reference points, the exact positions of modern buildings, roads, bridges, and other features. The surveyors and archaeologists plotted the ancient floors and walls on these base maps. Broken pots, figurines, and other artifacts at the surface helped them determine both the outermost limits of the city and the changing patterns of its growth.

The map of Teotihuacan reveals an urban grid as deliberate as Pierre L'Enfant's plan for Washington, D. C. The grid used two principal, almost perpendicular, alignments. The east-west axis led from a spot near the Pyramid of the Sun to a point of great significance on the western horizon. Astronomer-anthropologist Anthony Aveni of Colgate University explains that on the day that the sun passes directly overhead in the spring, about May 18, the revered Pleiades star cluster makes its first annual predawn appearance. It was at this point on the western horizon that the Pleiades set. A second theory notes that the sun also sets here on August 12—the anniversary of the beginning of the last great Mesoamerican calendar cycle—reckoned by many scholars to have begun on August 12, 3114 B.C. Whatever the astronomical



SABURO SUGIYAMA, ARIZONA STATE UNIVERSITY (LEFT); PHOTOGRAPHED AT CENTRO DE INVESTIGACIONES ARQUEOLÓGICAS DE TEOTIHUACÁN, INAH (ABOVE)

No signs of struggle disturb figures sacrificed with perhaps 200 others at the dedication of the Pyramid of the Feathered Serpent. Collars of human jaws and teeth carved from shell (arranged as worn, above) were likely war trophies. Such newly uncovered remains reveal a commanding military presence in a society once thought to be a peaceful theocracy.

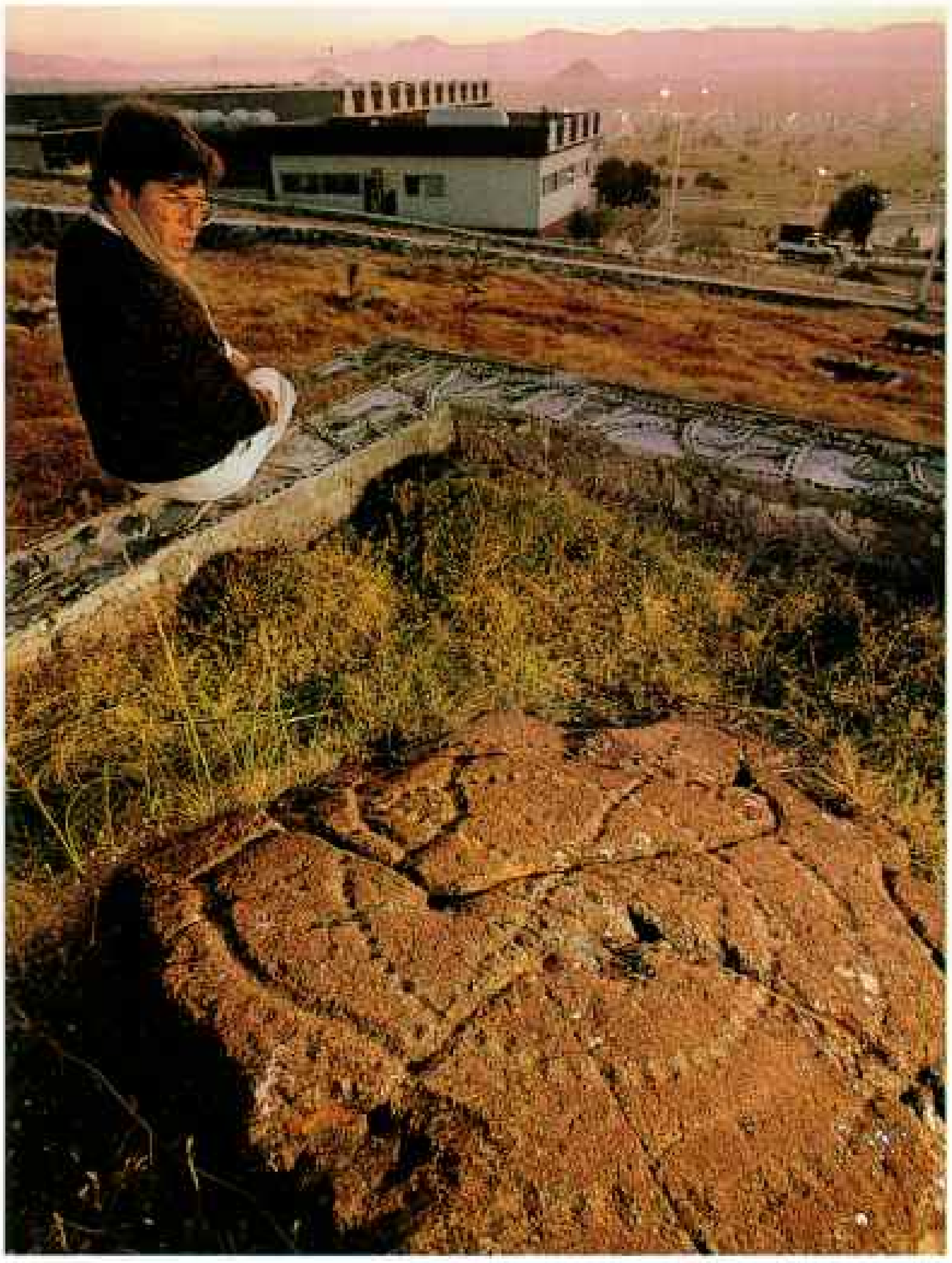
motive for the axis, it was considered so important that the channel of the San Juan River, which crossed the center of the site, was rerouted to align with it.

The north-south axis is Teotihuacan's main avenue, which the Aztec named the Street of the Dead, possibly because they believed that the mounds along it held the tombs of ancient kings. This axis also produced a remarkable juxtaposition: It led the Street of the Dead directly toward the hulk of a hallowed mountain called Cerro Gordo. At the northern end of the street, in front of Cerro Gordo, the Teotihuacanos built the Pyramid of the Moon.

The planners of Teotihuacan thus achieved harmony among themselves, their landscape, the heavens, and the cadence of time itself. In the centuries to follow, the layout of the growing city never deviated from this grand and sacred scheme.

LATE ON A RAW OCTOBER DAY I made my pilgrimage to the 140-foot-high summit of the Pyramid of the Moon, as I do every time I visit Teotihuacan. In prehistory, only three structures in the Americas were larger: its near neighbor, the Pyramid of the Sun; a massive mound completed 500 years later by the inhabitants of Cholula, some 60 miles to the southeast; and the great adobe mound of the Huaca del Sol, built by the Moche people on the north coast of Peru.

I have been privileged to gaze upon the Pyramids of Giza and the Athenian Acropolis, but the view of Teotihuacan from the Pyramid of the Moon seems to me the most memorable archaeological panorama on earth. And what a sight it must have been before time robbed the



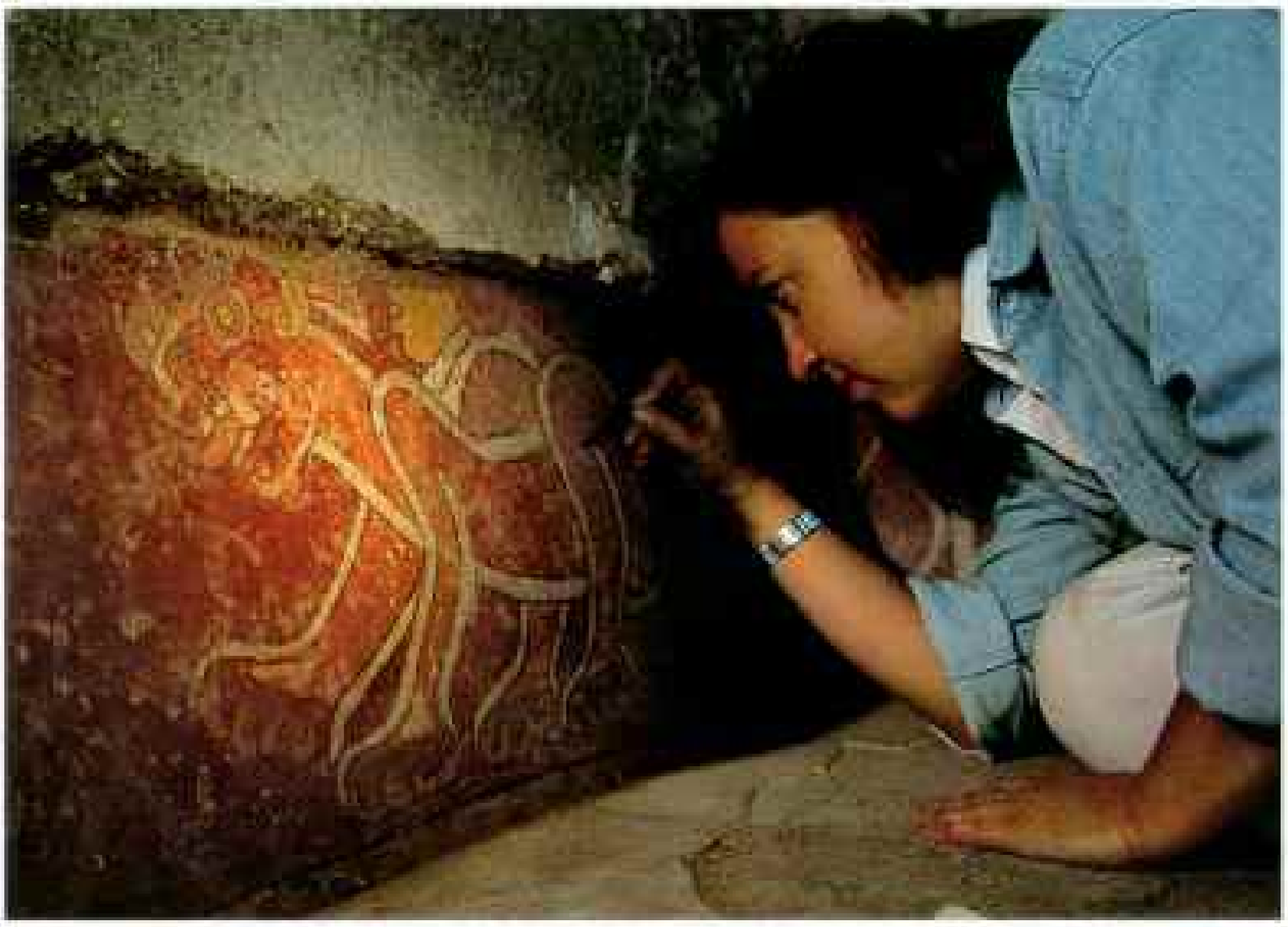
city of its finishing touches—especially the gleaming stucco, which, as we know from the excavations done so far, covered almost every visible surface.

Standing on the summit, now an irregular dome of packed rubble, I imagined myself in the doorway of a temple. With my back to the gently curving heights of Cerro Gordo and with my line of sight coinciding with the center line of the Street of the Dead, I contemplated the scene. The street—no less than 50 yards wide—and the platforms, pyramids, and staircases that line it with unwavering geometric regularity all converge toward the volcanic ranges of the far southern horizon. The whole is a masterpiece of architectural and natural harmony.

From my viewing point the combination of light and shadow played to full advantage on the stark platforms and pyramids. The scene was unified by the *talud y tablero*, the Spanish term for the distinctive building style of generations of master architects at Teotihuacan. Platforms and pyramids had slanted walls (taludes), which were capped with overhanging vertical stone panels (tableros).

To my left loomed the Pyramid of the Sun, the largest known ancient structure in the Americas, after the Cholula mound. It rises 212

Pecked carefully into stone, concentric circles around a cross lie two miles from the pyramids. "This was the western edge of the city," says Mexican archaeologist Rodolfo Cid, who is excavating in this area. Teotihuacanos may have used such circles—found in and around the city—as surveyors' marks for orienting the site, calendrical counters, or bases for the Parcheesi-like game of patolli.



A mural comes clean under the scalpel of conservator Zinna Rudman Pier in an apartment in the barrio of La Ventilla (above). Surrounding fields were recently used for farming. "Imagine a tractor on top of this painting!" says Rudman Pier. Archaeologists found such a wealth of artifacts, including debris from a stone carvers' workshop, that an excavation planned for two months lasted two years.

Social Structures

Block after block of one-story stuccoed stone apartment compounds made up most of the city's real estate. "There's no other civilization in Mesoamerica that has these multifamily houses," notes Linda Manzanilla. "Maybe it was a state decision to control the labor force, but we don't know."

In the barrio of Oztoyahualco she uncovered a three-family compound. Small clay figurines like these (below) littered the site. "You find them in the thousands and thousands and thousands wherever

you excavate at Teotihuacan," she says. Some may have represented the residents themselves in domestic ceremonies.

Three related families occupied separate, multi-room quarters here. Some members were plasterers, judging from their tools (A). Others left behind bones of the rabbits they raised and, on a ritual patio, a rabbit sculpture (B)—the embodiment, perhaps, of a patron deity. People were often buried with offerings under floors (C).

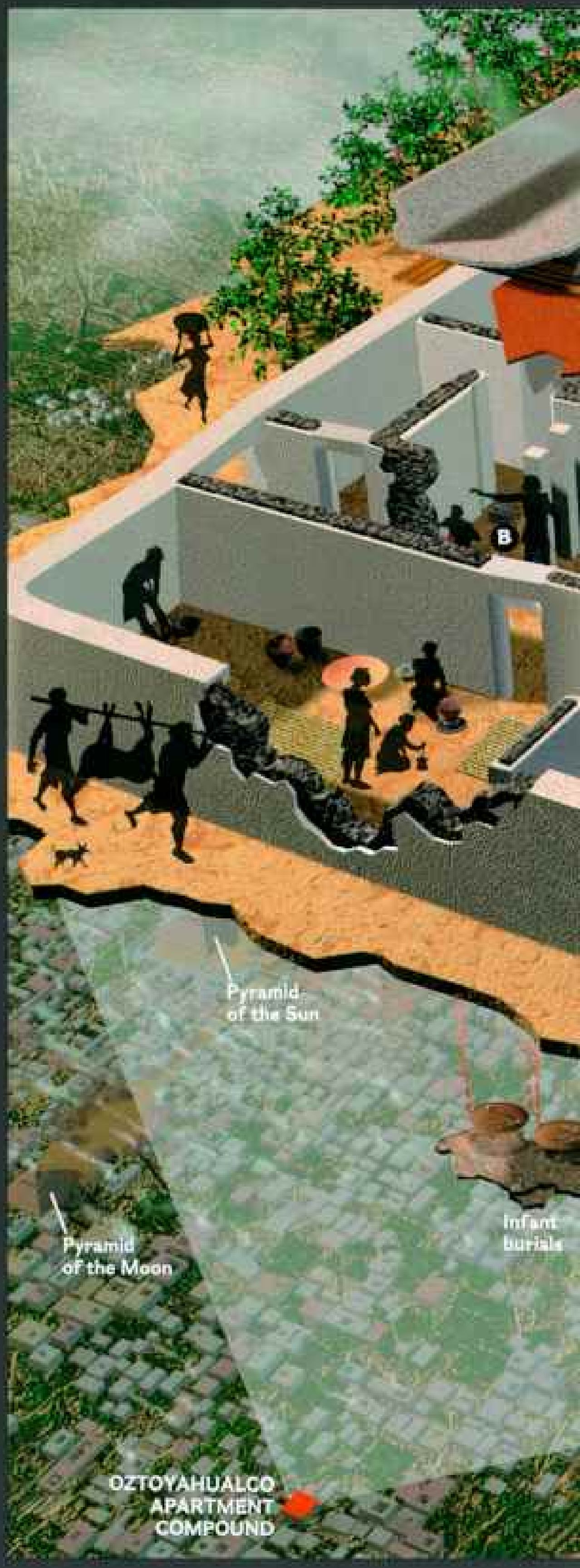


ILLUSTRATION BY CHUCK CARTER

feet, and its base—more than 700 feet to a side—nearly matches that of the Great Pyramid of Giza. But such impressive statistics seem beside the point when you see the Pyramid of the Sun. My eyes were drawn to a ribbon of color in the radiant light—the clothes of a multitude of visitors toiling up the more than 240 steps from the Street of the Dead.

The Pyramid of the Sun is slightly less of a monument than it originally was. In a hasty restoration attempt to celebrate the 1910 centennial of Mexico's Independence Day, most of its original facing stones were stripped away.

WALKING AROUND the Pyramid of the Sun to its east side, I found an excavation in progress. Leading it was my old friend Eduardo Matos Moctezuma of INAH, the archaeologist who in the 1970s uncovered the foundations of the Great Temple of the Aztec and other remains of their capital beneath Mexico City. Since 1991 Matos has had the daunting task of managing all archaeological activities within the heart of Teotihuacan—protected as a national park and separated by a road and fence from the bulk of the site, which lies on privately owned lands.

"We're finding the original plaza level here—a sunken space surrounding three sides of the base of the pyramid," he told me. "Its location and privacy suggest that it may have been one of the most sacred spots in the city, although we can't yet say what happened here. We've got the stucco floor, though, and it's easy to see precisely how it curves up onto the original surface of the pyramid itself. This will help immensely in rectifying the old errors in restoration—at least on paper."

Hidden below the Pyramid of the Sun lies a mysterious cave. It extends 330 feet from its mouth near the base of the pyramid stairway to a point near the center of the pyramid. The Teotihuacanos must have used the cave for something, because its walls were reshaped and in some places reroofed.

Its entrance may have been the initial sighting point for the east-west alignment that was so crucial in the city plan. The cave, therefore, may have been the holiest of holies—the very place where Teotihuacanos believed the world was born. Some archaeologists speculate, based on contemporary as well as ancient indigenous religious practices in Mesoamerica, that the cave was an oracle or meeting place for secret cults.

Linda Manzanilla, an archaeologist at the National Autonomous University of Mexico (UNAM), has a theory about the city's numerous other caves. "There are a lot more than we ever thought," she said, as we embarked on a tour of a labyrinth of underground passageways east of the Pyramid of the Sun. "I think these chambers and tunnels are the source of virtually all the volcanic stone used to build Teotihuacan."

Wearing hard hats and equipped with flashlights, we climbed down a wooden ladder to a dark entrance under the brow of a cactus-covered embankment. Inside, a string of bulbs lit by a generator on the surface gave dim form to a system of low, wide chambers. Stooping, we entered the largest chamber, which was 165 feet long and 60 feet wide. In every corner a grid of measuring string crisscrossed the dirt floor. Coated with gray dust, a dozen hard-hatted students from Manzanilla's graduate program at UNAM were excavating sections of the grid, recording every detail on clipboards.

"Based on the character of their walls, I developed the idea that these caves are all artificial, dug to get stone for the buildings," Manzanilla said. After ten years of work, she has determined that the

Billboards of their day, art and architecture spoke in an instant. "People communicated in a public way with this very complex iconography," explains Karl Taube. Everyone understood symbols such as the Goddess, seen on a Tetitla apartment mural (right), and the jaguar serpents on a once buried stairway at the Street of the Dead Complex (above). Modern experts, however, have yet to penetrate the many layers of meaning.

volume of stone taken from the caves is equivalent to the volume of stone used to build the city's residential compounds. (The pyramids in the ceremonial center are largely volcanic rubble with stone veneers.) Another Teotihuacan mystery may have been solved.

Remnants of large ceramic vessels in the caves point to their use as storage areas. They were also burial sites. In a lower corner of the main chamber, a student was brushing dirt, slowly exposing the skeleton of one of the city's later Toltec occupants. Manzanilla expects to find Teotihuacano burials as well. People may have believed that the caves provided a direct link to the underworld, where, according to Mesoamerican belief, life not only ended but also began a resurrection journey, symbolized by the daily passage of the sun.

TO APPRECIATE Teotihuacan as a living city, one must look beyond the monuments along the Street of the Dead to the outlying districts. There René Millon's mapping team found surface traces of the walls of some 2,000 groups of dwellings—the places where Teotihuacanos lived, worked, loved, worshiped, and died.

Teotihuacan archaeologists refer to these as apartment compounds. Each compound probably housed a single kin group, related families and their closest relatives. Within a compound's exterior wall were a varying number of apartments, each consisting of clusters of rooms with different functions. Seen from the gargantuan downtown structures, the flat rooftops of the apartment compounds would have stretched, like tiles on a floor, to all horizons. Beyond lay cornfields and a lattice of irrigation ditches.

Compounds varied in size, with the largest covering more than 35,000 square feet—enough room for a hundred or more people. At roughly 7,000 square feet, the smallest compounds may have held 20 people or so. Each compound occupied a rectangular block and was separated from its neighbors by straight streets—12 feet wide on average—and narrow alleyways, all paved with stucco. To the street the apartments presented windowless walls of stuccoed stone one story high and about two feet thick, relieved by a single doorway.

Atetelco is a medium-size compound, grandly called a palace, about a half-mile walk west of the Street of the Dead. As always, I was pleased to find that an old acquaintance, Raul Roldán Cortéz, a curator at Teotihuacan for 35 years whom I had not seen in more than a decade, was still there, watching over the exposed ruins and explaining them to visitors. Distinguished in his crisp official khakis, he looked grayer than before—but no less genial.

"You know," he said, as we passed through what had once been a maze of rooms and hallways, "I've been here so long that I often feel this is my real home."

Atetelco would have made a fine home for Raul or anyone else around A.D. 400, when it was built for members of the upper middle class. Designed for maximum privacy, most of the chambers are fairly small, measuring at most 10 by 15 feet, with doorways that may have been covered by cloth curtains. Many of the tall interior walls were painted, at least along their base and around the doorway. Judging from material excavated from collapsed rooms, the flat roofs of the apartment compounds were made of thin poles laid across beams and coated with stucco.

Most rooms enclose sunken courtyards or patios open to the sky.

Crop-sustaining, life-giving rain was the gift of the Storm God (right), who wields his lightning bolt on this stucco-covered pot from a La Ventilla burial. "He's clearly one of the major deities," says George Cowgill. "He's all over the place." Under his influence summer cloudbursts watered volcanic soil to put corn, beans, hot peppers, squash, and amaranth in Teotihuacan kitchens.

Family ceremonies, religious rituals, and other shared activities no doubt took place in these spaces, which had the added benefit of catching sunlight and precious rainfall. Throughout the compound, carefully graded stucco floors funneled water to hidden reservoirs. An intricate drainage system below the floor led excess water to the street.

Raul and I stopped in one of Atetelco's two main courtyards to admire the unusually elaborate altar at its center—a miniature pyramid carved from gray volcanic stone, featuring a tiny staircase and surmounted by a small temple.

The courtyard is bounded by three large squarish rooms on platforms with front stairways and wide columned porticoes. Each room has been restored to its original height of about 20 feet. Painted on the walls in various shades of red are themes of war and sacrifice, suggesting to some archaeologists that Atetelco was the headquarters for a local military order. A superbly rendered procession of coyotes with feather headdresses fills one wall. On another, soldiers carry knives with human hearts impaled on them.

Such paintings, rarely preserved so well as they are at Teotihuacan, appear sometimes in even the smallest compounds and are for me the

GEORGE R. STUART, NGS (TOP); PHOTOGRAPHED AT MUSEO DE TEOTIHUACAN, INAH

Ethnic Neighborhoods

Like immigrants everywhere, foreigners drawn to this great commercial center didn't always fit in. Zapotec who settled in a barrio of standard housing near the city limits treasured this funerary urn (below), brought from their home in Oaxaca. Many more of their customs and belongings also marked them as different. Teotihuacanos probably tolerated such strangers for generations because of their economic importance as traders.

In Merchants' Barrio, also on the outskirts, immigrants from the Veracruz

area built the familiar adobe houses of their native Gulf Coast (right). "We certainly didn't expect round structures," says Evelyn Rattray, an archaeologist at Mexico's National University. "People even accused me of making them up for a while." Distinctive mass burials (A) and abundant foreign pottery (B) stand out as well. In addition to processing fibers and weaving (C), this community probably traded in tropical luxuries such as cacao, rubber, and quetzal feathers.

URN PHOTOGRAPHED AT MUSEO NACIONAL DE ANTROPOLOGÍA, INAH; ILLUSTRATION BY CHUCK CARTER

Original Expressions

Whatever the medium, simple forms and anonymous faces distinguish much of the sculpture that endures. Stone objects such as this mask (above) and torso (right) probably belonged to the elite. Popular with the people, clay took on shapes that include a pot bearer with a slot in his head—possibly for hair—a jointed doll with large

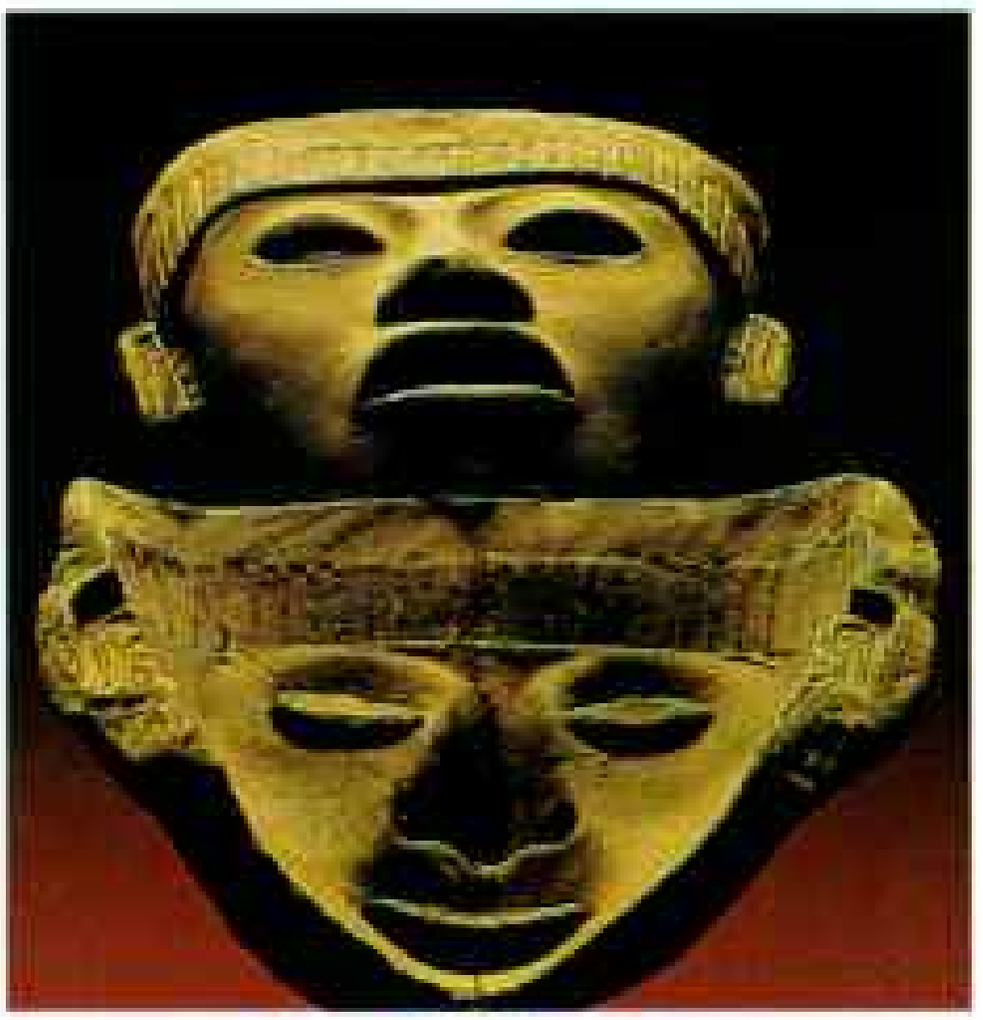
PHOTOGRAPHED AT MUSEO NACIONAL DE ANTROPOLOGÍA, INAH (BOTTOM RIGHT); OTHERS AT MUSEO DE TEOTIHUACAN, INAH

earrings (above), and a mold—here with a modern mask created from it (right).

"This art style comes all of a sudden out of nothing," says Karl Taube. "It seems to be an intentional statement of Teotihuacan as a very special place."

most revealing of Teotihuacan's surviving treasures. This was truly a painted city, many of its walls adorned with images of gods, people, and animals; representations of mountains, trees, flowers, and water; depictions of the insignia of war; motifs of blood and sacrifice; and pictures of divine hands and ornate headdresses.

Images of the Goddess and the male Storm God are so common in the city that these supernatural figures were probably the supreme beings of the official religion. In her studies of art and iconography over the past 20 years, Esther Pasztory of Columbia University has clarified the nature of the gods of Teotihuacan. The many guises of the Goddess—sometimes she seems beneficent, sometimes fierce—show her intimate relation to nature in the form of mountains, which were sacred, and as the capricious provider of water. Her male counterpart, the fanged, goggle-eyed Storm God, also represents water, but the lightning bolt he wields symbolizes war as well. So the murals speak not only of the sacred and secular life of Teotihuacan but also of the inextricable relationship between them.



NOT FAR FROM ATETELCO, also on the west side of the city, is a neighborhood called La Ventilla, which encompasses several compounds of varying size and character. This neighborhood is of great interest to Rubén Cabrera. "The most important thing about La Ventilla," Cabrera told me, "is the opportunity to study social relationships within the city. The rooms and compounds here had functions that must have been as different as the people who lived in them and, after all, that is what Teotihuacan was all about."

A compound on one block is finely built, with precise masonry, painted patios, and numerous rooms, some designed for high ceremonial activity. A place across the street, by contrast, is shabby—a virtual slum. It yielded undistinguished ceramics and a grave with a disproportionate number of infants. Presumably malnutrition or disease had afflicted the people who lived there.

Among Cabrera's other finds at La Ventilla is a 35-foot-deep stone-lined well—uncommon in excavations so far—that supplied one compound. His team also excavated numerous ceramics, sculptures, and a wealth of murals—grist for iconographers and art historians.

The stucco on the stairways and floors in the patio of one apartment has retained its gleaming white finish and brilliant red borders. As the archaeologists cleaned away the dust, they exposed what looked like large hieroglyphs, some standing alone and others arranged in groups: human faces, animal heads, circles, and other symbols.

For me, this is one of the most important discoveries to come to light in many years. Previously, Teotihuacan had yielded only isolated

New Age crowds, many clad in white, swarm the Pyramid of the Sun at the spring equinox. Arriving before dawn, these modern pilgrims wait outside the park until it opens. A steep climb and a turn to the east ready them to receive the structure's ancient sacred power with the sun full on their faces.

symbols of uncertain meaning. Bar-and-dot numbers, the customary calendrical notation in ancient Mesoamerica, have been found here only rarely, such as on two stucco-covered conch shells, and no system of hieroglyphic writing such as was used by the Maya has surfaced. Could these few intriguing symbols be evidence at last of Teotihuacano writing? Unfortunately the sample is far too small to make interpretation possible—especially since we have no clear idea what language the Teotihuacanos spoke.

AT OZTOYAHUALCO, a modest barrio near the northwestern edge of the city, Linda Manzanilla has accomplished what seems a miracle of interpretation: In the almost total absence of artifacts and other remains, she has revealed facets of the daily lives of the people there by analyzing the chemical composition of apartment floors.

"We knew the stucco floors were swept clean by the original inhabitants," Manzanilla told me, "so we planned a strategy that took into consideration chemical traces of human activity. For example, areas high in phosphates show where organic refuse was abundant—areas where food was consumed." Because lime was used to prepare tortillas—as much a dietary staple then as now—Manzanilla concluded that high concentrations of carbonate pointed to either a kitchen or a place where stucco had been processed.

With the knowledge that alkalinity levels are high where fires burn and that high iron concentrations indicate likely butchering areas, she plotted her findings on the floor plan. In the end she had enough information to pinpoint the places where a ceramic cooking stove stood, where food was stored, and where meals were eaten.

Teotihuacanos apparently enjoyed a varied diet of plants and meat. Aside from the expected corn, beans, squash, and chili peppers, there were traces of cactuses, hawthorns, and cherries. Among the bones in

refuse piles were those of rabbits, deer, dogs, and turkeys, along with ducks and fish.

The picture emerges of three families living in three separate apartments within this Oztoyahualco compound—no more than about 30 people in all. "Each apartment," Manzanilla explained, "included rooms for eating, sleeping, and storage, patios for cult activity, and funerary areas." She also found stone-smoothing tools that may have been used by plaster polishers to finish temples in the neighborhood.

The specialists at Oztoyahualco had counterparts throughout the city. At Tetitla, a compound near Atetelco, excavation has found numerous small flaked stone scrapers of a kind used to extract pulp from the fibrous leaves of the agave plant: Tetitla may have been devoted to the production of *pulque*, an alcoholic drink taken at ritual ceremonies. In other compounds skilled Teotihuacanos wove cloth, molded and painted pottery vessels, carved stone masks and figurines, and worked obsidian into fine blades.

The remains of the obsidian mines that contributed to the city's economic success lie 35 miles north of Teotihuacan at Cerro de las

PHOTOGRAPHED AT MUSEO DE TEOTIHUACAN, IRAN

Debris is a bonanza for archaeologists studying Teotihuacan's source of green obsidian: Cerro de las Navajas, or Mountain of the Knives. Workers chipped these chunks to lighten valuable cores for transport to the city, 35 miles away. The elite sent crafted obsidian to powerful contacts across Mesoamerica, keeping for themselves lithic gems such as these blades buried at the Pyramid of the Feathered Serpent.

Navajas—Mountain of the Knives. Obsidian, a fragile natural glass that can be made into a blade sharper than a surgeon's steel scalpel, was prized throughout Mesoamerica for household knives, scrapers, and saws. Hunters venturing into the countryside around Teotihuacan carried obsidian spears and skinning tools; soldiers in Teotihuacan's prestigious military companies used it to tip their lances; artisans chipped the green stone into a dazzling variety of shapes for use in religious ceremonies or as luxury items for elite consumers; priests used obsidian knives in human sacrifice.

I can envision porters on the trails from Cerro de las Navajas, bent beneath the weight of obsidian-bearing rocks as they trudged toward the city. The raw obsidian was sold, possibly in a central market, to craft specialists from the different compounds. From the volume of obsidian debris found, it seems that blades and tools were made in dozens of apartment compounds—for sale locally and through much of central Mexico and for export as gifts and symbols of Teotihuacan to the elite of more distant points in Mesoamerica.

Teotihuacan grew so prosperous during its golden period from about A.D. 200 to 500 that it became a magnet for foreigners. The newcomers

tended to stay together, much as immigrants to the great cities of North America do today.

Evelyn Rattray, a UNAM archaeologist who excavated a neighborhood east of the city center, found that house styles and some of the pottery closely resembled those at sites in the Veracruz area, 100 miles to the east, and in the Maya region, 300 miles beyond that. When René Millon mapped Teotihuacan in the 1960s, he named this enclave Merchants' Barrio, because the array of ceramics suggested its occupants were traders. Rattray's work confirms the presence of immigrants.

"We couldn't figure it out at first," she recalled when we talked in her university laboratory in Mexico City. "I thought surely I was digging somewhere else." Some of the pottery in the barrio was obviously Maya, she said, handing me a wide-mouthed jar decorated with the orange, brown, and cream anthropomorphic designs characteristic of Maya ceramic art. "Even the houses were different—circular with thatched roofs," Rattray said. The immigrants had persisted in using the architectural style of their lowland homeland.

Michael Spence of the University of Western Ontario has excavated another such enclave that Millon found, the Oaxaca Barrio, near the

The grim stone image of a skull evoked death and darkness near the Pyramid of the Sun. In the place that was the seat of power for centuries, it foreshadowed the end.

Most likely economic problems and political tension sent the city into a slump sometime after the year 500. The ceremonial center was attacked. Fire swept temples and palaces. Sculpture was smashed and public buildings ruined.

PHOTOGRAPHED AT MUSEO NACIONAL DE ANTROPOLOGÍA, 1968

Eventually most people left their apartments, though the site was never completely abandoned.

Where did everyone go? Did they bring down their own government? Or did another people wreak this destruction?

The answers rest somewhere amid the monumental legacy of the city.

western edge of the city. It was home to Zapotec families from the area of the famed site of Monte Albán, some 250 miles south of Teotihuacan. These people, probably also traders, imported their own funerary customs. Spence's team found walk-in tombs of carved stone identical to those that lie beneath Monte Albán and other Zapotec sites.

As people converged on Teotihuacan, ideas and customs as well as goods flowed out, bringing what archaeologists call "Teotihuacan influence" to the farthest reaches of Mesoamerica. We are still uncertain how this happened, but most likely it was through trade or military conquest or a combination of both.

The unmistakable impact of Teotihuacan can be seen in the ceramics, iconography, and architecture at many Maya sites in the early centuries A.D. And at Oaxacan as well as at Maya sites, hieroglyphs refer to Teotihuacan in contexts suggesting great reverence for it as the Place of the Reeds: In the traditional histories of Mesoamerica, this was the legendary place of origin of civilization itself.

Teotihuacan-style rectangular shields adorned with the Storm God and other insignia of the city appear prominently in the military garb of the fourth- and fifth-century rulers of the Maya sites of Tikal and Copán. In one burial at Copán, a noble actually wears the cutout shell goggles that allowed him the honor of identifying with the Storm God. At Tikal, 600 miles from Teotihuacan and deep in the rain forest of northern Guatemala, one building is so reminiscent of Teotihuacan that archaeologists half-jokingly call it the Teotihuacan Embassy.

INEXPLICABLY, sometime after A.D. 500, half a millennium after its first flowering as a sacred and secular power, Teotihuacan went into a terminal decline. By A.D. 750 the Place of the Gods had collapsed. The sheer volume of people finally may have exceeded the ability of the surrounding land to sustain them. Lack of sanitation may have been involved, with fatal diseases spreading as sewage and waste accumulated. Other possibilities are that a widening gap between the elite and Teotihuacanos of low status sparked a revolt or that political infighting crippled the bureaucracy.

Archaeologists working in the vicinity of the Street of the Dead have come across many piles of burned debris, evidence that a systematic burning of public buildings—possibly the culmination of an organized rebellion—brought Teotihuacan to its end. If so, there would be an irony in that event—a kind of ritual obliteration of the ideals embodied in the ceremony of sacrifice and renewal that had marked the dedication of the Feathered Serpent Pyramid long before.

The cataclysmic fall of Teotihuacan must have sent shock waves throughout Mesoamerica, disrupting trade networks and affecting people in settlements from Oaxaca to the frontiers of the Maya realm. For students of Mesoamerican prehistory, the end of Teotihuacan marks the beginning of the end of the Classic period, which the city had helped define.

As I left the silent ruins, I reflected on how my reaction to Teotihuacan has changed. At the time of my first visit in 1968, the scene from the Pyramid of the Moon was a sublime vista of monumental architecture in a monumental landscape. But there was no connection with human beings. Today, thanks to the continuing work of archaeologists and their collaborators in many sciences, we have begun to populate that vista with the householders, nobles, farmers, merchants, priests, and others who took part in this grand urban experiment. □

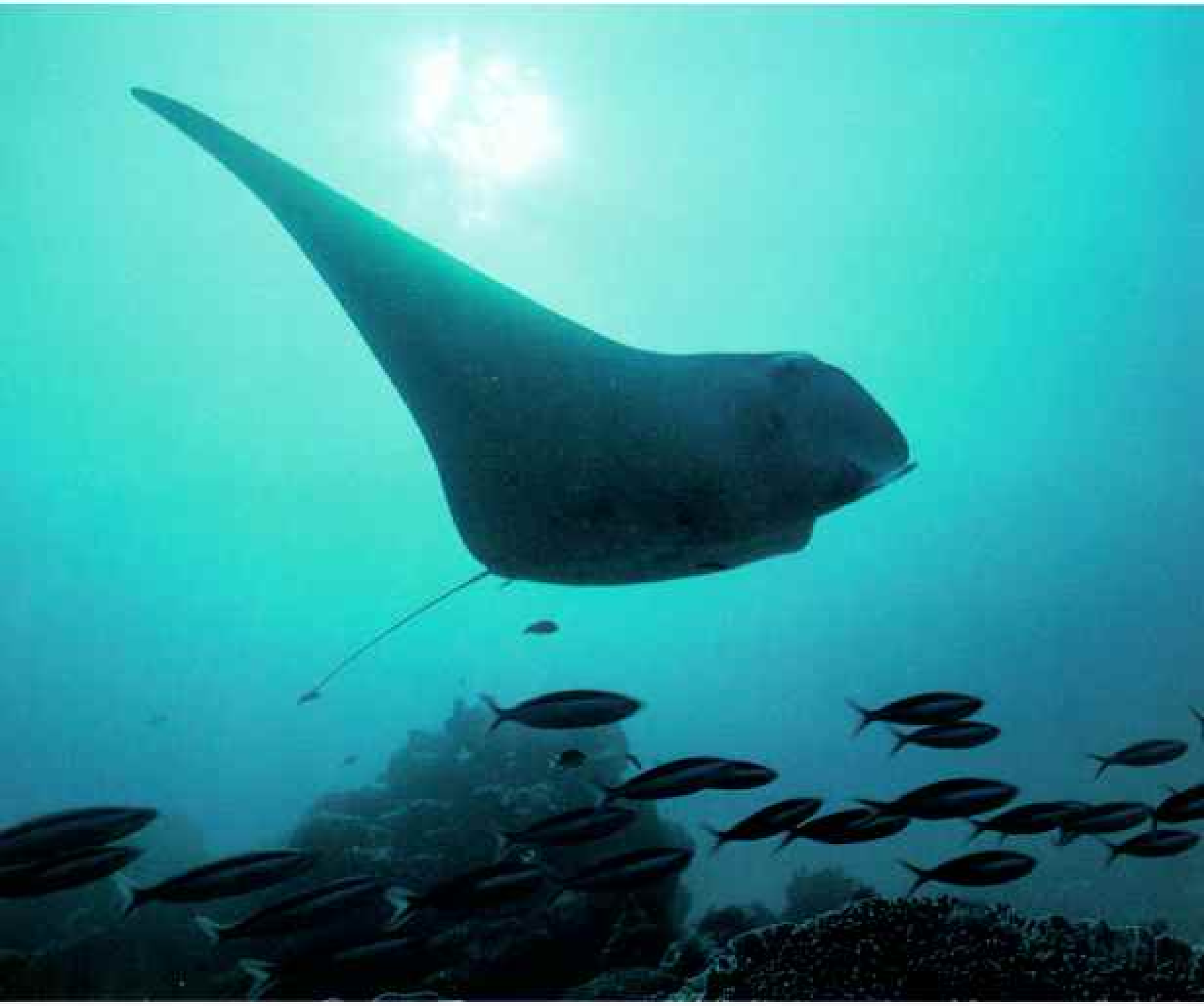
Once known by the nightmare name of devilfish, these huge distant cousins of sharks seem dream-like—as elusive and harmless as shadows in the sea.

Article and photographs by DAVID DOUBILET

MAN

T A !

In a midnight tableau off the Kona coast, on the island of Hawaii, clouds of tiny plankton swarm toward the light surrounding diver James Watt. Plankton in turn attract a giant manta ray that arches into their midst with gills flared and mouth open for feeding. With a wingspan that can exceed 20 feet, mantas depend on multitudes of these smallest of sea creatures.



Range of giant manta ray

MARK N. SPENCER (RIGHT)

Out of blue gloom, a manta materializes at dawn with a company of fusilier fish parading the Goofnuw inlet in the Yap Islands. My diving partner, Bill Acker, and I hold our breath so that exhaust bubbles won't disturb the giant. As the inlet begins to fill with the rush of a rising tide and growing light, three more mantas beat by us on silent wings.

These are creatures seen along the edges of reefs, where ebbing tides pump rivers of eggs, larvae, and tiny crustaceans into the open sea. The rays follow the tides, feeding nonstop.

Found worldwide across the equatorial belt, mantas are seen regularly by divers in the Yap Islands, off the Kona coast of Hawaii, and at San Benedicto, one of the Revillagigedo Islands, 250 miles south of Mexico's Baja California.

Much about giant mantas—their breeding, birthing, and life span—remains poorly understood. Even the number of species is under review.

"When in doubt I always use the oldest classification, *Manta birostris*, which was first described in 1798," says ichthyologist Jack Randall of Hawaii's Bishop Museum.

Smaller mantas are classified in nine species of the genus *Mobula*. Off the coast of Australia some swim together, looking like stealth bombers in formation (right).

For all their placid ways, giant mantas were a threat in the days when divers wore helmets with air hoses connected to shipboard pumps. Yashinori Maeda, one of the last hard-hat pearl divers in Australia told me this story:

"I was collecting oysters 70 feet down when a giant manta snagged my air hose and safety line. Then it must have panicked. It was so strong that it pulled my helmet off the breastplate, breaking the screw threads.

"Wearing lead shoes and a lead belt, I could not swim to the surface. I was drowning when my tender saw I was in trouble and pulled me up."

Manta!

Flying easily within enormous Pacific swells, mantas come to the Boiler, a rock formation flanking San Benedicto Island, where orange clarion angelfish clean the rays' skin of parasites and marine growth. Trailing remoras, mantas return to open ocean.

On its daily commute through the inlets and channels around the Yap Islands, a manta pauses over certain rocks and hangs, barely fluttering, to balance in the current.

Suddenly wrasses about three inches long dart from the coral below and head for the manta (bottom). The creature then opens its enormous mouth, and a wrasse enters the white cave, picking between the gill arches that support the gills (left).

I also watch a jack swimming with a manta as it slowly unfurls its "horns," or cephalic fins (far left). The extended fins no longer resemble horns but have become soft and pliable. The jack appears to be riding the giant's invisible body wave like an underwater surfer. It picks at bits of loose manta skin or uses the bulk of its companion as cover before making quick raids into the reefs for prey.

For mantas, being cleaned is more than just a soothing act of grooming; it may be critical to life itself. Excessive marine growth such as algae can start a chain reaction of infection that could ultimately lead to death. Sometimes manta rays will leap entirely out of the water, possibly to clear themselves of parasites.

Adult mantas face few natural predators: perhaps only large sharks and killer whales.

Like barnstorming pilots who never tire, mantas make endless slow loops in a shaft of light. Rising almost to the surface in a broth of plankton, they wheel over, descend, and begin again.

Stargrazer In a nebula of plankton, a feeding ray seems to be all cephalic fins, outer mouth parts, and gill arches—and all are engineered to concentrate and control the entering stream of food.

On calm nights off the Kona coast, where lights from a hotel balcony attract swarms of plankton, it is possible to bring dive boats close in to the rocky shore, slip over the side, and swim with feeding mantas.

We mounted a powerful 6,000-watt light to divers Jim and Julie Robinson's boat and aimed it into dark water. They also placed a "manta catcher" on the bottom, two 100-watt lights powered by batteries. Encased in a movie camera's underwater housing, they glowed dimly but attracted a cloud of plankton. I put my hand over the light, and it was surrounded by a wriggling mass (top right).

The light moved and turned with the mild ocean swell, and the mantas came to feed. Biologist Pauline Fiene-Severns went into the sea with her

plankton net to take samples. Under a microscope, she identified most as mysids; hundreds of the shrimplike animals swam in a drop of water (center).

She also found thumbnail-size larval fish, octopuses (bottom), and lobsters that were clear as crystal. The mantas were eating them all.

DAVID DOUBILET AND JOSEPH S. STARCAMPIANO, NGS STAFF (ABOVE AND CENTER)

Late on a gray, rainy day we swam with a giant manta as it moved away from the Boiler off San Benedicto. As it turned over on its back, remoras attached to each side of the ray's head curved outward like old-fashioned mustachios. While diver Pam LaFon stroked its stomach, the creature fell down into the ocean's dark like a leaf. When Pam broke away at 120 feet, the manta turned over and glided into Pacific oblivion. □

BY ALICE J. HALL
ASSISTANT EDITOR

PHOTOGRAPHS BY IRA BLOCK

New Face for a Desert Mission

■ Mission San Xavier del Bac rises from the windy sweep of an Arizona Indian reservation, secure from the spread of Tucson beyond. Visitors and worshipers alike flock to this sanctuary, one of the few Spanish colonial missions in the United States still serving the native peoples it was designed for.

To prepare for its bicentennial in 1997, the Tohono O'odham (formerly known as the Papago) and a local volunteer group called Patronato San Xavier have embarked on a $2,000,000 restoration.

High on the domed roof, mason and congregant Danny Morales is resetting fired brick with a traditional mortar of sand, slaked lime, and sticky cactus juice. "We went back to the old formula," he says. "We put out a call for cactus, and everyone in Tucson pruned his yard and brought us tons."

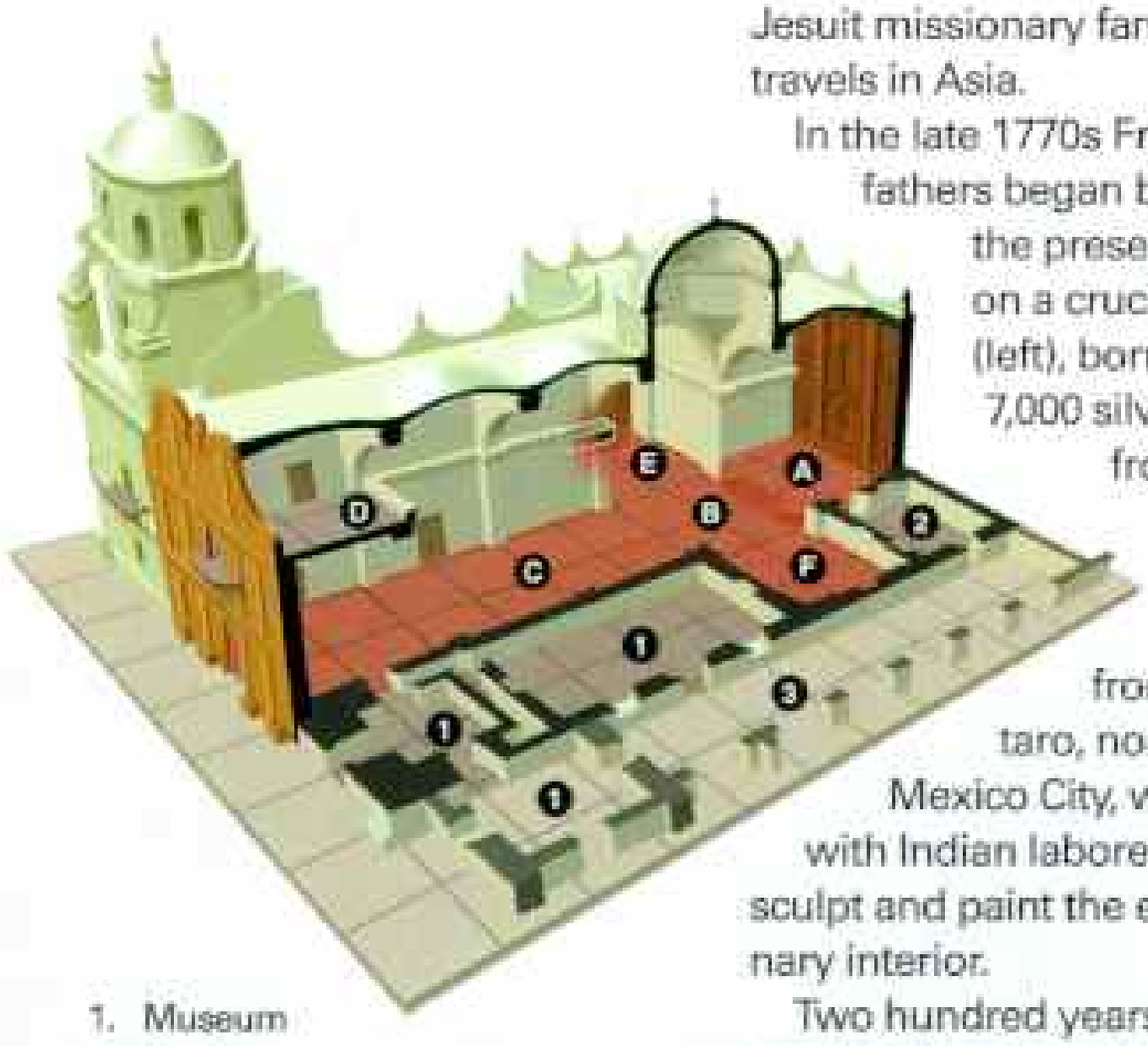
Inside the church, conservators from the U. S., Italy, and Turkey have converged each winter since 1992. With four O'odham apprentices they are saving a happy profusion of saints, dancing angels, gilded ornaments, and star-studded ceilings long obscured by dust, candle soot, wasp nests, bird droppings, and water damage.

This angel (left), high on the altarpiece, shows a face-lift in progress. Its right side bears the crackling and grime of age; its left, cleaned and repaired but not repainted, reveals an angelic complexion.

New York-based photographer IRA BLOCK has long been fascinated by the history and peoples of the Southwest.

Highly decorated areas with dates of restoration

A. Sanctuary with altarpiece (1995-96)
B. Crossing with dome (1994)
C. Nave with oval vaults (1995-96)
D. Choir loft (1995-97)
E. West chapel (1993)
F. East chapel (1992)



1. Museum
2. Sacristy
3. Cloister

■ In 1692, when southern Arizona lay along the northern rim of New Spain, Eusebio Kino, a Jesuit missionary-explorer, arrived at the Indian farming village of Bac. The people seemed open to conversion, so Father Kino founded a mission that he named for San Francisco Xavier, an earlier Jesuit missionary famed for travels in Asia.

In the late 1770s Franciscan fathers began building the present church on a cruciform plan (left), borrowing 7,000 silver pesos from a local rancher. Artists, likely from Querétaro, north of Mexico City, worked with Indian laborers to sculpt and paint the extraordinary interior.

Two hundred years later the ornate altarpiece at its heart is undergoing restoration (facing

page). Conservators spend days on each figure.

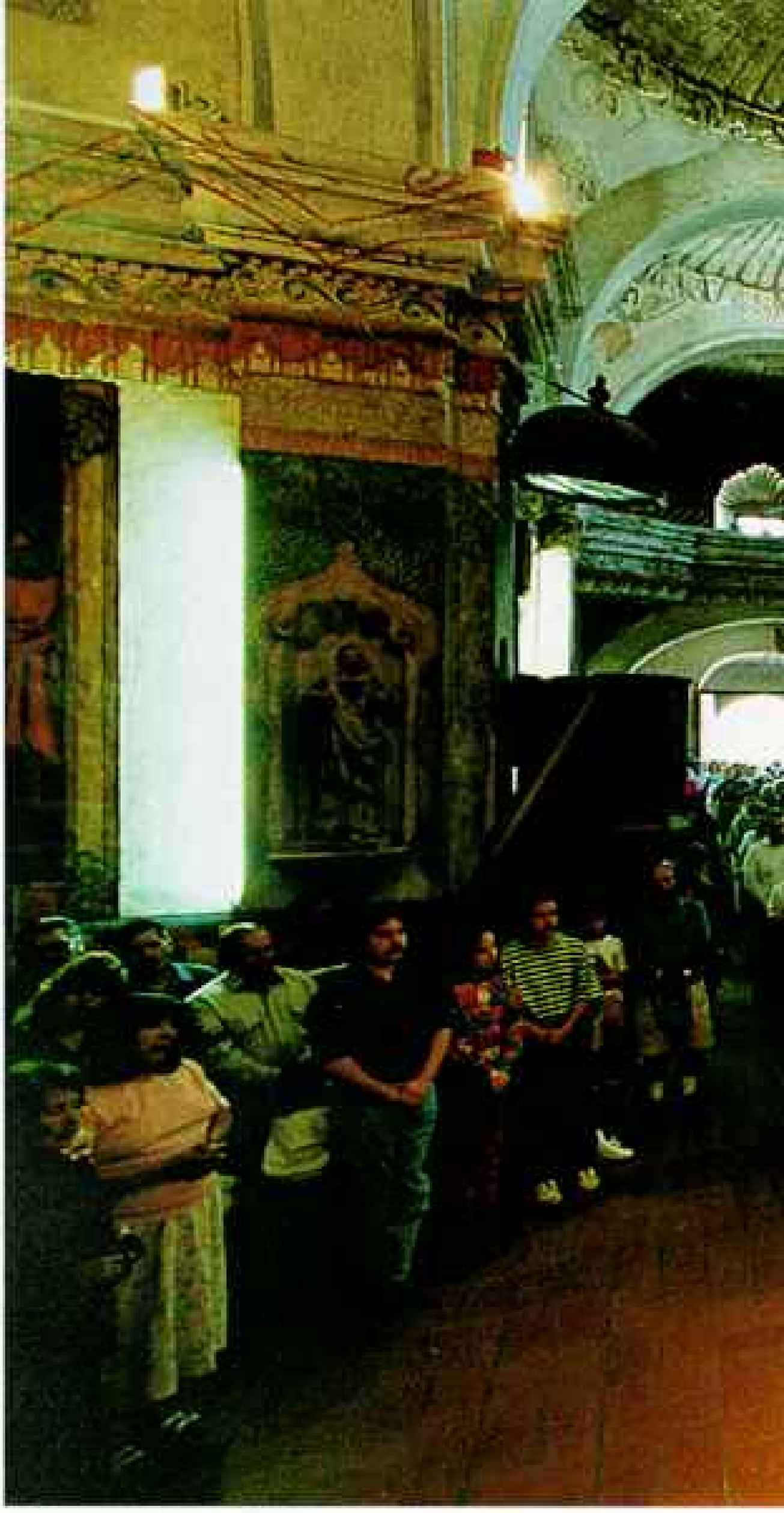
On the scaffold's top level, Paola Zari Pulieri (below) renders first aid to God, modeled in plaster over brick. She reattaches every loose flake of paint with a glue-filled syringe. Where no color survives, she tones down the underlying white plaster with a neutral watercolor wash.

Cleaning a seated figure with sheep on the arch over the altar—thought to be Christ, the Good Shepherd—led to a revelation: What had seemed to be a beard was in truth a woman's scarf; this was the Divine Shepherdess, the Virgin.

■ Baroque gone berserk is what resident priest Michael Dallmeier calls the altarpiece, its upper half now clean and glowing. With the scaffolding down, conservator T. Rıdvan İşler replaces a treasured 1759 statue of San Francisco Xavier within a section to be cleaned next year. İşler says of the flamboyant

style: "I think the Spanish wanted to show how big Christianity is, to impress the Indians." O'odham apprentice Tim Lewis believes future generations will be impressed by the work of Indian conservators: "I want to bring my grandkids here someday to show them what we did."

PAUL M. SCHWARTZBAUM



■ A magnet to believers, San Xavier draws Indian, Anglo, and Mexican-American worshipers to four Sunday Masses. Here Father Michael conducts Easter services. In the west chapel below the red-robed Christ, at far right, a bier holds a statue of San Francisco that has turned the mission into a place of pilgrimage.

Every day petitioners from throughout the U. S. Southwest and Mexico come to seek favors of the saint and leave tokens of their devotion. Some walk ten miles from Tucson.

In the east chapel (left) the faithful light candles to the Virgin, mingling with visitors awestruck by the art. Wall colors are the original pigments: costly imported vermilion and Prussian blue, as well as humble green earth and ochers, says conservation director Paul M. Schwartzbaum, chief conservator at the Guggenheim Museum in New York City.

High on the altarpiece a bust of the Roman martyr San Lorenzo (upper left, before and after cleaning) gazes from a cartouche covered with gold leaf, which along with silver leaf was discovered in abundance. Says O'odham trainee Gabriel Wilson, "I remember as a child looking up at the saints. They were so dark you could hardly see them."

After the restoration is completed, the O'odham hope to keep their baroque jewel shining for another 200 years. □

A Farming Revolution

SUSTAINABLE AGRICULTURE

A back-to-basics movement is shaking the very foundations of agribusiness by getting impressive yields with fewer chemicals. Sweet peas carried by Dru Rivers are among 60 crops grown on California's Full Belly Farm using crop rotation, natural fertilizers, and honest sweat.

BY VERLYN KLINKENBORG

PHOTOGRAPHS BY JIM RICHARDSON

Marching to battle: *Rod Repp and sons Kevin, 12, and Nathan, 10, track down weeds with hoes, not spray. In the richly soiled Palouse country of eastern Washington State, they raise peas, lentils, oats, and barley. "My granddad didn't use chemicals. He didn't have*

them," says Repp. "My father was the generation that lost the knowledge that my granddad had." For decades most farmers have relied on applications of commercial fertilizers, insecticides, and herbicides that can foul streams and pollute groundwater.

Artfully efficient contours *do triple duty on the adjoining Wisconsin farms of cousins Arlin and Myron Manske. Perpendicular to the incline, furrows catch rainwater, checking erosion, which had hit frightful levels in Vernon County. Alfalfa grown between corn*

rows further slows runoff and furnishes hay for milk cows, a departure from "monocropping." Many U. S. farms depend on a single cash crop, leaving fields vulnerable to a rogues' gallery of insects that over time can become immune to chemical bombardment.

LAST SUMMER my father told me a story about his father, who was a progressive farmer in northwest Iowa for most of the first half of this century. The story takes place in the early 1930s, when my father was still a boy.

In the fall the wagons came back full from the cornfields, and as the corn was being put into cribs, my grandfather watched for ears that looked especially full and large. These he tossed into bushel baskets, which were carried to the basement of the farmhouse. There, in the furnace room, it was my father's job to sort the corn onto wire grids 24 ears across.

From each ear of corn my grandfather took three or four kernels and placed them on an incubator tray—the position of the seeds on each tray matching the position on the wire grid of the ear from which they came. Then he dampened the kernels and waited. The ears whose kernels didn't sprout were fed to the hogs and chickens. The ears whose kernels showed good germination were set aside, shelled, and used as the next year's seed.

What interests me about this story isn't just the fact that my father tells it, or that it's a story about my grandfather, or that I see it as an instance of a golden age of American farming, because there are no golden ages in farming. The story is a reminder that the true agricultural technology is the knowledge of farmers, slowly accumulated and sometimes sorely tried.

By the 1950s and early 1960s, when I first began visiting that farm, the corn they were using had changed. The seeds no longer came from last year's crop; by then it was patented hybrid corn. It came in pallets full of 80,000-seed bags from national seed companies. It was purchased anew every year, because every year there was a new improvement and because hybrid corn will not develop properly from the planting of a previous year's kernels. Given enough chemical fertilizer, pesticides, and machine power, hybrid varieties of corn now result in yields my grandfather would have thought impossible in the 1930s—180, 200 bushels an acre, three and four times the yields he was getting in the good years. But to get these yields, farming had to change almost beyond recognition. It came to rely less on the skills of farmers and more on a chemical arsenal to suppress weeds and insects and to replace the diminishing fertility of the soil.

After World War II, production became the sole measure of a progressive farmer. It was all part of an order, a progress that seemed inevitable to someone growing up in Iowa, as I did, where people believed—and still do—that the duty of U. S. farmers is to feed the world. But alongside that new order, there were also farmers who worked their land according to a different belief, a different and in some ways more traditional conception of the earth and

Bug-eyed balloon is a low-cost scarecrow for Fred Kirschenmann, a North Dakota farmer renowned for lectures on sustainable agriculture. One aim: improving tilth—the soil's texture, nutrients, and ability to hold water. In Ames, Iowa, Keith Kohler of the National Soil Tilth Laboratory examines

corn roots, which can become stunted when farm machinery compacts soil, a condition reduced by using set tractor routes.

the farmer's responsibility to it. The practices of the few farmers who resisted the technological sea change of the past half century—the trend toward chemical, industrial agriculture—now look revolutionary in turn. Their principles, newly articulated, have inspired new research, new thinking. They have given rise to a movement called sustainable agriculture.

"Sustainable" is not yet a word with a clear-cut agricultural definition. It has been defined in many ways, but at its core lies a kind of farming that is, in a commonly used phrase, "economically viable, environmentally sound, and socially acceptable"—a kind of farming that encourages the farmer to earn a decent living growing good food on healthy land. Talking to researchers, policymakers, and farmers over the past year and a half, I've heard again and again the caution that there is no single approach to sustainability; there are many approaches. But what has changed in recent years is this: A broad effort has emerged on farms and at research institutions to discover which farming approaches are truly viable, sound, and acceptable and how they can be put to use out on the land. Behind this effort lies the awareness that the enormous yields of conventional farming have come at a high environmental and social cost, a cost we're only now learning to acknowledge.

There are as many visions of the farming future, of course, as there are definitions of sustainability. But they have in common greater cooperation with nature, greater economic independence from banks and government-subsidy programs, and diminished reliance on chemicals and petroleum.

I have found examples of sustainable farming on small urban farms in the East, plots just slightly too large to be called gardens, and I have found them on enormous tracts of land in the West, where growers like E & J Gallo, one of the world's largest commercial wineries, use sustainable growing practices to conserve soil, discourage insect pests, and improve their crops. But it scarcely mattered whether I was talking to a longhaired artichoke farmer on the California coast or a conservatively dressed member of the Nebraska Wheat Board. Wherever I went, I got the sense that a change of uncertain proportions had begun to come over agriculture. What I brought back from the road, from the farm, are some exemplary tales from a few places where sustainable agriculture has taken hold and is promising to spread throughout the United States.

Ways of the nomad work for Charlie Opitz, who constantly moves the livestock on his 3,000-acre Wisconsin farm. "They're healthier and happier," he says. His 1,200 dairy cows graze on grass and legumes such as red and white clover. After 12 to 72 hours, herds are moved to allow the grass to recover. Cows are also cultivators; to help keep sod from compacting, Opitz occasionally

"THIS IS WHAT gets us excited," says John Williams, the irrepressible owner of Frog's Leap Winery near St. Helena in California's Napa Valley. The list of things that get John Williams excited is a long one, but soil comes well toward the top. Williams is standing in the shade of a row of grapevines, and he is holding neither a cluster of grapes nor a bottle of wine. He has put shovel to earth between the

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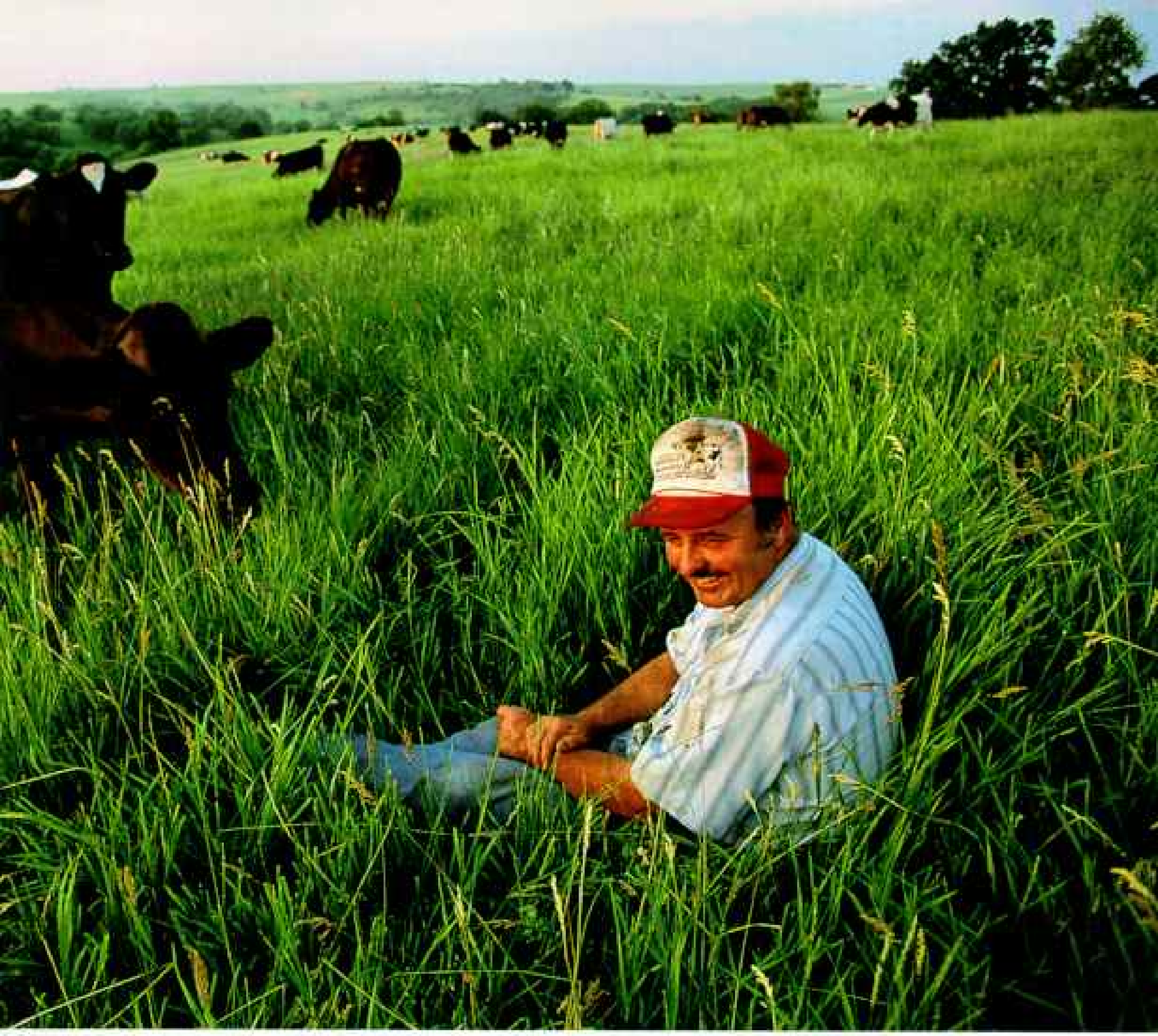
VERLYN KLINKENBORG's childhood summers on an Iowa farm sparked a lifelong interest that led to his first book, *Making Hay*, about agriculture in that region and in Montana. He currently resides in rural Massachusetts. Coloradan JIM RICHARDSON has photographed eight NATIONAL GEOGRAPHIC articles, including "Ogallala Aquifer: Wellspring of the High Plains" (March 1993).



crowds cattle in an area. Their hooves chew up the ground, allowing nitrogen-rich clovers to flourish. His approach is part of a movement away from fattening penned cattle with trucked-in hay or feed fortified with nutrients. "Grazing has been around a lot longer than confinement has," says Opitz, who asserts: "A civilization rises and falls on its agriculture. Grass is life."

trellises—earth blanketed with cover crops of peas, oats, and vetch—and he is raising what he has shoveled to my nose. "Smell how alive that soil is," he says. If the word "bouquet" means anything when applied to wine, it must mean something when applied to this soil. There are many undertones to the smell, but the overtone is that of a complex substance that is biologically alive.

Cover crops such as vetch, peas, and especially clover give farmers three good reasons to avoid many chemicals. First, these plants naturally supply an essential nutrient, nitrogen, to soil, largely eliminating the need to apply industrial fertilizers. Second, some cover crops provide habitat for beneficial insects that prey on destructive bugs; when that happens, the use of insecticides can be sharply reduced or eliminated. And finally, the very presence of a cover crop reduces erosion and hinders the emergence of competitive weeds; no weeds, no need to suppress them with a chemical herbicide.

We climb into the Frog's Leap pickup, and as we drive, Williams narrates a thumbnail history of Napa Valley farming. "In the old days almost none of these vineyards were planted on the

The natural approach *makes giant strides when huge concerns like California's Gallo-Sonoma Vineyards use sustainable tactics. Oats and vetch between rows of grapevines hold and enrich the soil, elbow out weeds, provide habitat for beneficial insects—and create*

healthier working conditions. Big agriculture has achieved stupendous production levels since World War II, feeding the nation and much of the world. But even its defenders worry about agrochemicals: Hundreds of millions of pounds are applied to U. S. croplands each year.

valley floor. This ground was too good. You could grow a real crop. The grapes were all up in the hills." Now the hills have been mostly relinquished to oaks and to California's soap-opera version of French provincial architecture. Three minutes up the road and we are trespassing in a very famous vineyard. The earth beneath the long rows of vines is absolutely bare. Applications of herbicides have suppressed the weeds. "This is what some growers really like," says Williams. "A little bit of green stuff growing in the middle but nothing under those vines. This is conventional farming at its best. Feel this soil." Williams chips at the soil and offers me a handful. It has the subtle undertones of an oily rag.

John Williams came to California from New York State in 1974 to study viticulture at the University of California at Davis. The first year Frog's Leap was in production, Williams sold 700 cases of wine. Last year he sold 45,000. The reason is quality. Nowhere on the Frog's Leap label do you see the word "organic," even though virtually all the grapes used in making it are grown organically. (Instead, below the warning statements on the back label, you see a small cautionary note: "Open Other End.") But over the years, with the help of an organic farmer and agricultural consultant named Amigo Bob Cantisano, Williams has one by one persuaded most of his growers to register with California Certified Organic Farmers, which requires them to use no chemical pesticides or fertilizers on their property.

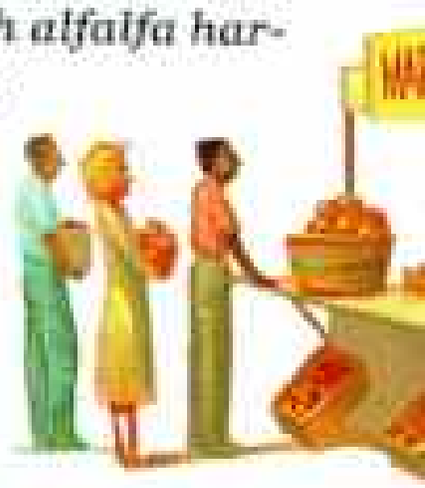
I talked one morning with Amigo Bob, as everyone calls him,

in a coffee shop in Colfax, a small town in the foothills of the Sierra Nevada range. In appearance Amigo Bob is an Illinois soybean farmer's nightmare, his long black hair pulled back in a ponytail.

If you travel the West Coast talking to farmers and researchers, you hear Amigo Bob's name again and again. He is a member of what I've come to think of as an alternative extension service, helping farmers make the transition from conventional

Cycles of a Sustainable Farm

Healthy soil is aerated by earthworms (1) and brims with fungi (2) and bacteria (3). Legume roots (4) fix nitrogen. Five-year crop rotation on this dairy farm (5) begins with alfalfa harvest; roots are left for soil enhancement. After corn is harvested, rye is planted for winter cover, a pattern repeated the second year. Oats and alfalfa replace corn and rye in the third year. In years four and five alfalfa is cut monthly late spring to fall.



Alfalfa and grasses provide feed for cattle (6), which produce fertilizer, as does plant residue (7). Public-spirited farmers welcome school tours (8). Ladybugs (9) and other introduced insects control pests; fewer insecticides enter the atmosphere to return to earth in rain (10), resulting in purer rivers (11) and drinking water (12). A cornucopia of organic produce (13) draws buyers to a local market (14), as a farmer hauls seed for next year's crop (15).

Proponents of sustainable agriculture laud its creation of new jobs. Willie Little of Macon, Mississippi (left, at right), prepares to plant peas for income and to provide work for his kin. Andrew Miller, at left, runs the Beat 4 Farm Cooperative, which helps farmers in Noxubee County hold on to their land.

ILLUSTRATION BY SAM WARD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Weeds perish under the flame cultivator operated by Gary Zimmer outside Spring Green, Wisconsin. Though corn plants are scorched as well, they quickly rebound. A field can be treated with a few gallons of fuel instead of oceans of herbicides.

Everett Dietrick's weapon is the deceptively named lacewing, the pit bull of beneficial insects. His Ventura, California, company markets lacewing eggs, which hatch aphid-eating larvae. The larvae also feast on a host of caterpillar pests and other crop destroyers.

to sustainable agriculture. "I don't envision that everyone is going to be a certified organic farmer," Amigo Bob told me. "But the vast majority could cut their chemical use and save money and come out ahead. The irony is that they aren't doing that yet. Who shows up on the farm? A farm sales guy from the chem house. What does he talk about? Chemicals. Who else? A farm adviser. What's his experience based in? Chemicals. I think the transition to sustainable agriculture is 90 percent psychological and 10 percent technological."

It's one of the peculiarities of California agriculture that a vintner like John Williams can practice dryland grape farming in virtually the same climate as the one, 45 miles northeast, where Ed Sills grows organic rice in standing water at Pleasant Grove Farms. But as dissimilar as their crops may be, the two face many of the same problems and opportunities. Although California is one of the richest food-producing areas in the world, this state's farmland is being eaten up by real estate development. From Pleasant Grove Farms, a warren of barn-red buildings with a trailer office and a fenced yard, you can almost see the tract housing approaching, like smoke low on the horizon, across some of the most fertile soil in the state.

Ed Sills has a forestry degree from the University of California at Berkeley. His wife, Wynette, was a farm adviser when they met. Together they have taken an active stand to protect the farmland in their county, alerting neighbors to oppose a housing development that would destroy thousands of acres of agricultural land.

The Sillses grow organic rice, wheat, popcorn, beans, and almonds on 2,400 acres of flat alluvial land in the floodplain of the Feather River. Nearly all their rice is sold to Lundberg Family Farms, a major producer of organic rice in Richvale, 50 miles north of Pleasant Grove Farms. "The very top yield of rice grown conventionally around here," says Sills, "is about 100 hundred-pound sacks per acre. The top yield we get organically is about 85—which is fantastic, because for organic rice we're getting more than double the conventional price. Conventional rice farmers are putting on about 50 dollars' worth of nitrogen fertilizer an acre and about 50 or 60 dollars' worth of herbicides. A lot of times they're putting on one or two insecticides. We put on none of those things. I figure we spend at least a hundred dollars an acre less than they do."

CALIFORNIA IS BLESSED, from the farmer's perspective, with diverse local markets and a climate and soils that support an enormous variety of crops. But on the Great Plains everything is different—markets, crops, weather, soils—everything except the basic problems of farming.

In central North Dakota the history of agriculture seems somehow to lie closer to the surface than it does in the Napa Valley. At dusk in late July near Jamestown, the fields are edged with mosquitoes whirling upward in ghostly pillars. There is something about the country here, if only the wind-shorn crab apple hedges or the potholes where ducks are feeding, that reminds you how recently it was put to the plow. Even in summer, weather comes on suddenly, so when, at midday, I visit a

farmer named Fred Kirschenmann, who lives a few miles southwest of Jamestown, I'm almost blown onto the Kirschenmann place. The farmstead consists of an old clapboard house, a mobile home that serves as an office, and an array of farm implements, and all seem to have been deposited here during a drop in the wind.

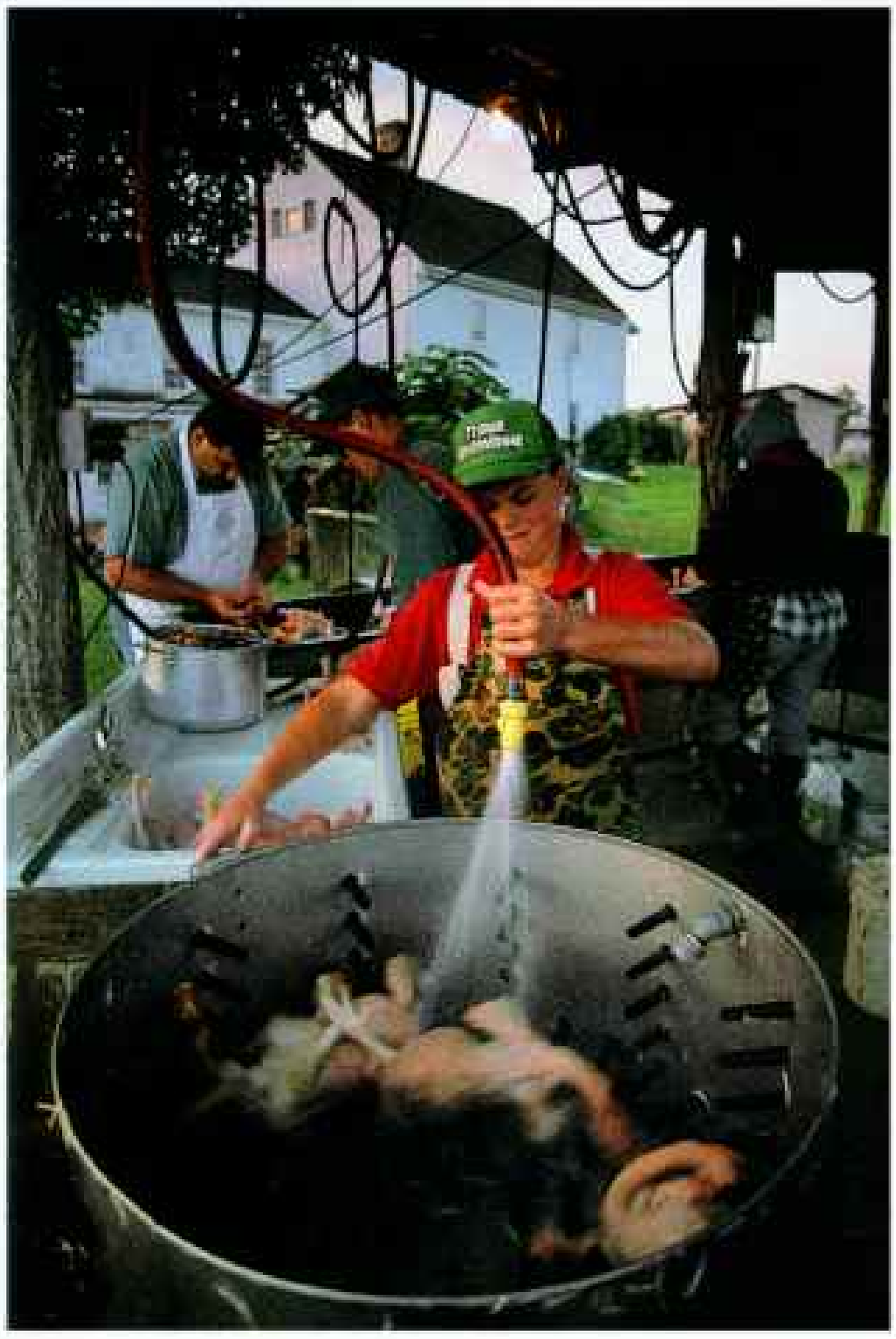
Today Fred Kirschenmann is wearing a T-shirt, work jeans, and boots. He carries a pair of pliers in a holster on his belt. A tall, well-muscled, well-spoken man of about 60, with thick glasses and ruddy hair, he is one of the founders and a past president of the Northern Plains Sustainable Agriculture Society, an organization that began at an organic fertilizer sales meeting in Bismarck in 1979.

We climb into Kirschenmann's old pickup and drive north past pastures, fields, and prairie potholes, toward a small town called Medina. I count the tractors in the fields as we drive, spot sheep in a distant pasture. We pull into the parking lot of a restaurant called the C & R Dairy Treat, where the walls are decorated with jigsaw puzzles. While we wait for our food, Kirschenmann tells me a story to which he knows the beginning but whose end he is still trying to imagine.

"My mother and dad started farming on their own in 1930,"

"A salad bar for chickens," quips Joel Salatin of his spread near Swoope, Virginia, which raises pastured broilers and eggs. By moving his cages each day, Salatin gives his chickens a fresh serving of grass, seeds, and insects, supplemented by his home-recipe feed.

Unlike the giant holding pens of some assembly-line producers, Salatin's method keeps hens from trampling



their own waste and breathing fecal particulates. Green grass supplies natural antibodies. Result: "I just don't get any disease problems."

On butchering day, son Daniel operates a feather picker. His mother, Teresa, checks for imperfections. As Joel eviscerates carcasses, he chats with farmer Steve Chaney of Brandon, Mississippi, one of the Salatins' many visitors.

he says. "Their first years of farming were during the heart of the Dust Bowl. That had an important impact on my father, because he experienced firsthand what could happen if you didn't take care of the soil. I remember, growing up, every time there was a little bit of wind erosion, he'd go crazy. So I grew up with this notion that you needed to watch what you did with the soil."

Kirschenmann places his heavy hands on the table and leans back in his chair. "When fertilizers came out in this part of the world in the late 1940s, early 1950s, my dad's first concern was, 'Is that going to be good for the land?' He talked to a couple of farmers whose opinions he respected, and he talked to the county agent, and they all assured him that it was. And so he bought the fertilizer attachments, and he bought the fertilizer. He saw his yields go up. And he became a convert like that. I remember him saying, 'I could never, ever farm again without fertilizer.' "

Fred Kirschenmann left the family farm and became a college teacher and administrator. One day in 1970, in a class he was teaching in Dayton, Ohio, he met a student named David Vetter, who had been studying what happens to soil under conventional farming practices, which rely heavily on nitrogen fertilizer, and what happens to it under organic farming practices, which recycle nonsynthetic nutrients like animal manure and plant residue. It was clear to Vetter that soil quality deteriorates steadily under the rigors of conventional farming. Chemical fertilizers, substituted for natural ones, deny soil the organic matter it needs to maintain its tilth—its texture, nutrients, and ability to hold moisture—and thus its fertility.

"I started talking to my father about some of these changes in soil structure," says Kirschenmann. "And he said, 'Yeah, I can see that on our farm. I know that's happening.' Of course it bothered him that there was a better way of taking care of the land, and it bothered me too. But he was 68 years old, and his response was, 'What you're talking about is a whole different way of farming. And that's not for me. It's too late for me.' "

In 1976 Kirschenmann's father had a mild heart attack, and Fred offered to take over the 2,600-acre farm if he could operate it organically. Having done that, he increased the average yield of spring wheat from 28 to 35 bushels an acre. And Kirschenmann no longer had to borrow money each spring—as his dad did—just to pay for tons of industrial fertilizer.

Kirschenmann has come to liken conventional farming to a

Close to mother earth, *baby Caleb rides with mom, Megan Gerritsen, digging Rose Gold potatoes on Wood Prairie Farm near Bridgewater, Maine. Leland Daugherty, an intern sponsored by an organic growers association, helps out. Megan and husband Jim*

sell 17 potato varieties, harvesting by hand to avoid bruising. Certified organic by two trade groups, the farm grows potatoes, grains, and clover in rotation. Soil fertility is sustained with barnyard manure, fish scales, sawdust, and plant residue, known as green manure.

treadmill, and organic farming to a dance. The dance lies in the rhythm of seasons and crops, in the way the same piece of farmland is made to alternate year to year between cool-season plants, like wheat, rye, flax, and oats, and warm-season plants, like buckwheat and millet, between broadleaf and grassy plants, between deep-rooted and shallow-rooted plants, between cash grain crops and soil-building legumes like yellow-blossom sweet clover. The dance helps break up disease and pest cycles and restores nutrients to the soil.

On a conventional farm, says Kirschenmann, you use a pesticide one year and then find the next year that it's not effective anymore because the surviving pests have built up resistance to it. "Each time you do that," he says, "it ratchets up your costs, squeezes the margins more. Seven hundred fifty million pounds of pesticides are now being used on farms every year in the United States, and we're losing more crops than were lost before pesticides came into use." (Crop loss due to all pests hovers around 37 percent, according to David Pimentel, professor of insect ecology at Cornell University.)

In agriculture as in almost everything else, it's easy to believe that if the present has gone astray, things must have been better somewhere in the past. Yet Kirschenmann takes exception when people say to him: "You're farming the way your grandfather used to." Not true, Kirschenmann is likely to reply. "The way my grandfather farmed, he'd break up a piece of prairie, plant wheat, maybe oats, maybe occasionally some corn, until the nutrients were mined out, and then he'd go break up a new piece of prairie. If you look at this thing historically, just about the time they ran out of new prairie—during the war effort in the 1940s—the commercial fertilizers became available, and that made it possible for him to stay in one place and go on farming the tired land year after year."

IN THE NOVEMBER WIND in Nebraska, 400 miles south of Fred Kirschenmann's farm, you can hear the rattle of dry cornstalks. On the horizon trains pass almost constantly along the tracks of the Union Pacific. This is corn country, a place where, as visibly as anywhere else in the U. S., the landscape has been shaped by the underlying economics of farming. "It's been all corn for, well, clear back into the fifties," says one farmer who is picking a field full of Pioneer 3417.

To sustain 45 years of growing corn—a heavy user of nitrogen—so much fertilizer was poured into the soil that the groundwater became contaminated with nitrates, and many towns and farms in this region have had to dig deeper wells to find safe water. Excessive nitrates in drinking water are believed to be responsible for reducing bloodstream oxygen to dangerous levels in infants.

I have just visited David Vetter's farm near Marquette, in east-central Nebraska. In a region where single-family farms of more than 2,000 acres are common, Vetter farms on 280 acres. That land helps support his own family, his parents, and his sister's family. He employs 13 neighbors in his grain-processing operation. By rotating crops, Vetter, like his former teacher Fred Kirschenmann, is actually improving his soil, year by year,

Agricultural oasis in suburban Santa Barbara, California (below), is no eden for some neighbors, who complain of crowing roosters and dust in swimming pools. But Fairview Gardens Farm wins praise for educating city children in the ways of the country. Like Fairview, the Community Supported Agriculture Program in Kimberton, Pennsylvania (right), sells shares. As manager Kerry Sullivan bags carrots, a blackboard shows the current allotment, available once a week at $550 a year or twice a week at $880.


PARSLEY - 4
TOMATOES - 6
PEPPERS - 6
EGGPLANT - 2
ONIONS - 3
POTATO - 2
SPINACH - 2
SUNFLOWER HEADS - 1


BEARITOS
LITE BUTTERY
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while the soil on neighboring farms is deteriorating. Vetter told me: "My number one management decision is what's best for the soil." And his father, Don Vetter, said: "Farming you learn every year. You don't get it all at once. One of the hardest things for farmers, and I include the researchers in this, is that to change, they've got to admit they've been wrong in the past, and it's awful hard for us human beings to admit that we've been wrong about something."

Near the Missouri River, the state of Nebraska begins to crumple and tilt. The highway east toward Walthill drops from a crest that shows you the whole town at once, laid out between railroad tracks and the hillbound horizon. Like many small farm towns, including the one I grew up in, Walthill in some weathers looks like emptiness.

There has been a string of bad years in farm towns across the Midwest. The number of farm families has diminished. Those that remain are not numerous enough to support the business life of a small town. The schools are gone. So are the car and farm-implement dealerships, the clothing and furniture stores. This is often explained as an economic fact of life, a natural consequence of industrial agriculture, in which farmers either seek to increase the amount of land they cultivate or stop farming, sell out, and move away.

But anyone who grew up in a farm town during its heyday remembers a time when the link between a populous countryside and the busy streets of town was a vital one. It's not just nostalgia to believe that something important has been lost. Small farm towns are now little more than depots for the bushels of grain that pile up in their elevators and spill onto their streets in bumper years. Eventually the grain is carried away and turned into profits somewhere else.

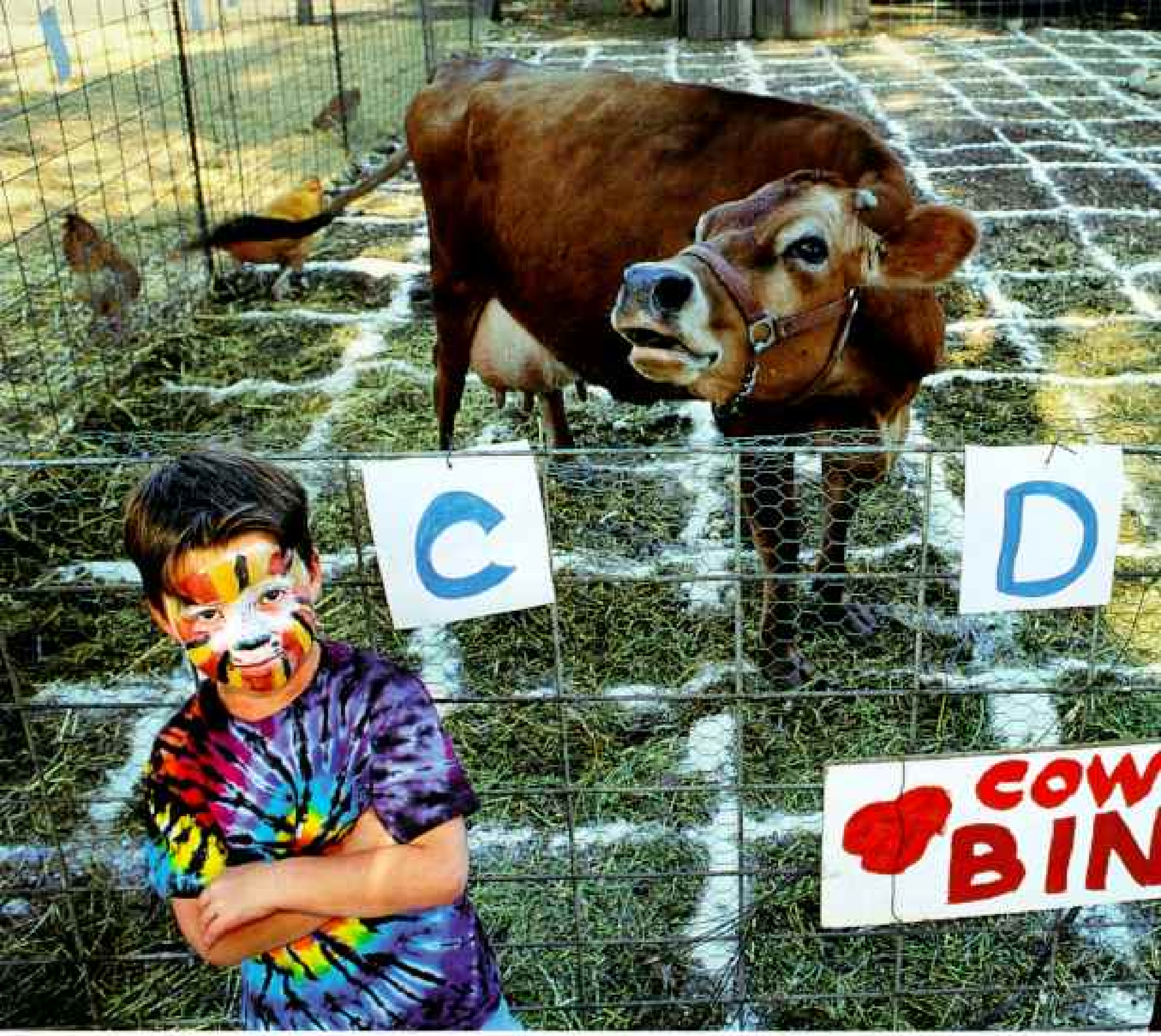
I STOP AT AN OLD BRICK BUILDING on the edge of uptown Walthill, the home of a nationally known agricultural institute called the Center for Rural Affairs. I have come to visit staff member Chuck Hassebrook, one of the most cogent voices in a nationwide organization called the Campaign for Sustainable Agriculture. The campaign aims to build provisions for sustainable agriculture into the farm bill Congress is debating this year. Among those provisions are plans to reform the USDA commodity programs, so that farmers who rotate their crops don't risk losing their eligibility for price supports and other benefits. There are also plans to enhance soil- and wildlife-conservation programs, to promote marketing alternatives for farmers, and to redirect scientific research toward sustainability.

Hassebrook and I sit at a large table in a second-story room that looks like the office of a derelict law practice or a one-horse

Popcorn pinup? Nebraska farmer Dale Bye's celebrity shows on shipping-case labels. His distributor builds customer loyalty by picturing farmers who grow crops organically. At a farmers' market in Takoma Park, Maryland, Cass Peterson stands behind her work. She left a Washington Post reporting job for a Pennsylvania farm. "I don't want to get bigger," she says of the 12 acres she plants. "If we do, we stop being farmers and become managers." The French Embassy favors her baby lettuce and black currants, helping her gross $10,000 an acre—far above the average for conventional crops.

Plain design *of a 19th-century German bank barn allowed farmers to unload hay from wagons directly onto the second level. Today it's part of the Rodale Institute near Kutztown, Pennsylvania, founded in the 1940s by J. I. Rodale, who became a champion of organic*

farming through research and publishing. Now agriculture professors accept ideas once scoffed at. "We are moving piecemeal toward sustainable," says the University of Missouri's Harold Breimyer. "Fossil fuels to make fertilizer will eventually run out."



newspaper. Hassebrook has the big-boned frame of a young man who has tossed his share of hay bales. He has spent the past 18 years analyzing the problems of farmers across the Midwest. He grew up on a small Nebraska farm and came to Walthill in the mid-seventies as a VISTA volunteer. That was a prosperous time for U. S. agriculture, an era when farming looked like a high-profit venture with little risk.

It's a ripe autumn day in Nebraska, and farm trucks are barreling down the gravel roads outside Walthill, their boxes full of corn. But in town, below the windows of the room where we are sitting, the streets are still, the shops empty—a reminder, in this busiest of farm seasons, of how depopulated the countryside has become. "If there's one thing that's clear," Hassebrook says, "it's that the process of big agriculture continues, and it's killing these towns. But the farming approaches that can be beneficial environmentally are the same ones that can be beneficial socially. If we can learn to farm in concert with nature by using a farmer's knowledge and skills instead of purchasing fertilizers and pesticides, we can help the environment, but we can also carve out a bigger share of the food dollar for the

Not exactly the state lottery, but you can win garden tools, organic foods, and even cash if Blossom the Jersey milk cow favors your square at the Hoes Down Harvest Festival. Held on Full Belly Farm near Guinda, California, northwest of Sacramento, the fall event features face painting, jugglers, and watermelon seed spitting. Draft-horse-plowing and

cow-milking demonstrations advance a more sober cause: building awareness of how a farm works.

Proceeds benefit the Committee for Sustainable Agriculture, which strives to persuade farmers to hop on the small but growing sustainable-farming bandwagon and to urge city dwellers to support them by buying organic products.

farmer, and we can create a role for more people in agriculture."

From time to time it has become clear to me how sweeping the ambitions of the sustainable agriculture movement really are. This is one of those times, sitting in a dimly lit room in a tiny farm town, drinking stale coffee, listening to a man with his feet up on the table while dusk settles in outside.

After more than a century of migration from the country to the city, the number of U. S. farmers has reached a new low. In 1910, farming families represented nearly 35 percent of the population. Today fewer than 2 percent of American families farm, yet the acreage in agricultural production has increased. What Hassebrook and his colleagues envision is not more acreage but more farms, *smaller* farms, more carefully managed farms, intensive only in their use of a farmer's knowledge, not in terms of the chemical consumption. And with the coming of new farmers to the land, they also envision the renewal of rural towns.

"We take a pretty broad view of what constitutes sustainable agriculture," Hassebrook says quietly. "We say that if agriculture is worthy of being called that, it needs to sustain community and provide decent economic opportunities for people."

ONE LAST STOP, on the eastern edge of the Palouse, one of this country's most fertile agricultural regions, a rolling sweep of pea and wheat fields. This is a place where agriculture is still young, yet the crowns of many of its hills are nearly bare, the topsoil washed downhill. Just east of Moscow, Idaho, I visited Paradise Farm, run by Mary Jane Butters and her husband, Nick Ogle. He is a lifelong farmer in his mid-40s who grew up on the land he farms. She was raised in Utah and worked for many years as a wilderness ranger and fire tower lookout for the U. S. Forest Service before buying five acres at the base of Paradise Ridge. In 1986 Mary Jane Butters founded the Palouse Clearwater Environmental Institute, an organization committed to sustainable agriculture, environmental preservation, and consumer education. Mary Jane and Nick have been married for two years. He lives at his house, just a mile and a half down the road, with his children, and she lives at her house with her children. There is a family reunion almost every day.

I came to visit in June. The roadsides were full of cow parsnips, or "floating doilies," as they're called on this farm. Mary Jane's farmhouse is perched on a knoll, surrounded by perennials set in straw mulch, and it looks out over mature conifers onto the fields of the Palouse, which roll off to the horizon like heavy seas. Her mail-order company is called Paradise Farm Organics, Inc.—instant falafel, hummus, tabbouleh, and dried turtle beans, lentils, and split peas. She has recently introduced a line of organic backpacking foods called Backcountry Eco-cuisine. The raw ingredients are grown by local farmers, and the foods are packaged by Moscow residents, some of whom make two and three times the local average hourly wage working for Paradise Farm Organics.

"We had as many sales the first week of June as we had the whole month of May," Mary Jane says. We are standing in what would be the living room of an ordinary house. But shelving

runs around the walls of this room, and on a clean, wooden bench there is a food scale and a heat-sealer and a rack to hold open unfilled food packages. Barrels of bulk grain and spices line the floor. The scent of cumin hangs in the air. "Because we created a market," says Mary Jane, "we made it possible for farmers to convert to organic production. It's not like you're dealing with politicians or beating your head against the wall. You just do it. I like the idea of creating social change through the business community."

Later that morning Nick and I drove down the road to get the mail and to look at two pea fields planted side by side, one grown conventionally, the other organically. I found it hard to tell them apart, if only because in the Palouse it is hard to keep your eyes from following the hills as they porpoise off into the distance. "What we're trying to do here at Paradise Farms," Nick said, "is to make it profitable to go out and try new things. The conventional farmer gets his price-support check, but I don't view that as being a price support for the farmer. It's for the consumer, keeping the price of food down so the consumer can have cheap food and more disposable income. That'll catch up with us. The fact is we're going to run out of oil. I don't care if it's 50, 100, 200 years, we will run out of oil. We will run out of coal, all the things that agriculture feeds on. We're using resources at an alarming rate, and people don't realize that there's going to be an end to all this."

A marriage of lands followed the wedding of Nick Ogle and Mary Jane Butters of Moscow, Idaho. His 640 acres of wheat borders her 5-acre plot, where she raises organic herbs and garden vegetables for a mail-order, instant-meal business. Ogle has now begun to try sustainable methods, motivated not only by his wife but also by soaring chemical costs and declining income.

"Chemicals have become a substitute for knowledge," says Butters, who is suspicious of what she sees as a too cozy relationship among farm officials, chemical manufacturers, and federal regulators. As an old farmer told her: "It took us 40 years to get into this mess. It'll take us 40 to get back out."

IT'S TEMPTING TO BELIEVE that sustainability is an issue that begins and ends on the farm. But that is neither where it begins nor where it ends. Standing beside a pea field, listening to Nick, I was reminded that it is the consumer who should—but often does not—have the final voice in how farmers farm. In hundreds of locations a growing number of consumers are having their say: In downtown farmers' markets from Manhattan to Hollywood, at roadside stands on rural routes in the Berkshires and the Great Smoky Mountains, through co-ops and consumer-owned farms scattered across the country, through mail-order outlets such as Paradise Farm. To be sure, the marketplace still lags behind the demand. The challenge of reestablishing a distribution system that once connected the consumer with small farmers remains a formidable one throughout much of the nation.

Still, in the tone of Nick's voice out by that pea field, I was reminded of something Fred Kirschenmann had said to me at the C & R Dairy Treat in Medina, North Dakota. He was telling me about an evening when he and a television interviewer visited a friend of his, a successful conventional farmer. "She asked him a whole bunch of questions about how he was running his farm," Kirschenmann said. "And then as she was about ready to go, she said, 'Tell me how you feel about the future.'

"It got real quiet, and he said, 'Well, I'll tell you. I'm just glad I'm as old as I am. There's so many problems, I'm glad I won't be around much longer.' "

Fred pushed back his chair and laughed. "My feeling was, hell, I wish I was at least 40 years younger. There's so many things I want to do." □

BY JAMES RESTON, JR.

ORION

Where Stars Are Born

A scattering of stars in the heart of the Orion nebula illuminates an unfolding cloud of gas and dust reaching across six light-years of space (35 trillion miles). Unprecedented views of the nebula's center reveal the birth pangs of stars, and perhaps the creation of planetary systems like our own.

DAVID MALIN, ANGLO-AUSTRALIAN OBSERVATORY

IN A SPECTACULAR space shuttle mission two years ago, astronauts repaired the blurred vision of the Hubble Space Telescope, and at last a new epoch of astronomy began. The Hubble telescope is the modern equivalent of the one Galileo used to prove that the earth revolves around the sun—a brilliant new device that allows us to peer far more deeply into the heavens.

On December 29, 1993, the instrument was turned on the great Orion nebula. As the brightest, the youngest, the closest, and perhaps the most romantic nebula in the northern winter sky, Orion made an appealing target. The nebula (the word means "mist" or "cloud" in Latin) spreads its gas and dust across an unimaginable 35 trillion miles of sky and is bursting with young stars.

For C. Robert O'Dell, an astronomer at Rice University in Houston, Texas, and the lead scientist for these Hubble observations, the fresh look at the Orion nebula promised to solve a tantalizing riddle. With Hubble's previously suspect vision, he had found an unexpected set of splotches he couldn't identify. The dots, irregular in shape and random in placement, might be "artifacts" introduced into the picture by the imperfect optics of the telescope, just as surely as air bubbles in the lens of Galileo's telescope could have appeared to be moons around Jupiter. If the dots were real, why were they so luminous? What could they be?

He suspected that they might be planetary systems coalescing out of the gas and dust around young stars. If so, their discovery would increase the probability of detecting life elsewhere in the universe. Only planets have the right density of material for DNA to grow and multiply, and only planets are likely to have a suitable temperature range to sustain life as we know it.

While Robert O'Dell was working with data from the Space Telescope Science Institute in Baltimore, Maryland, I was repairing

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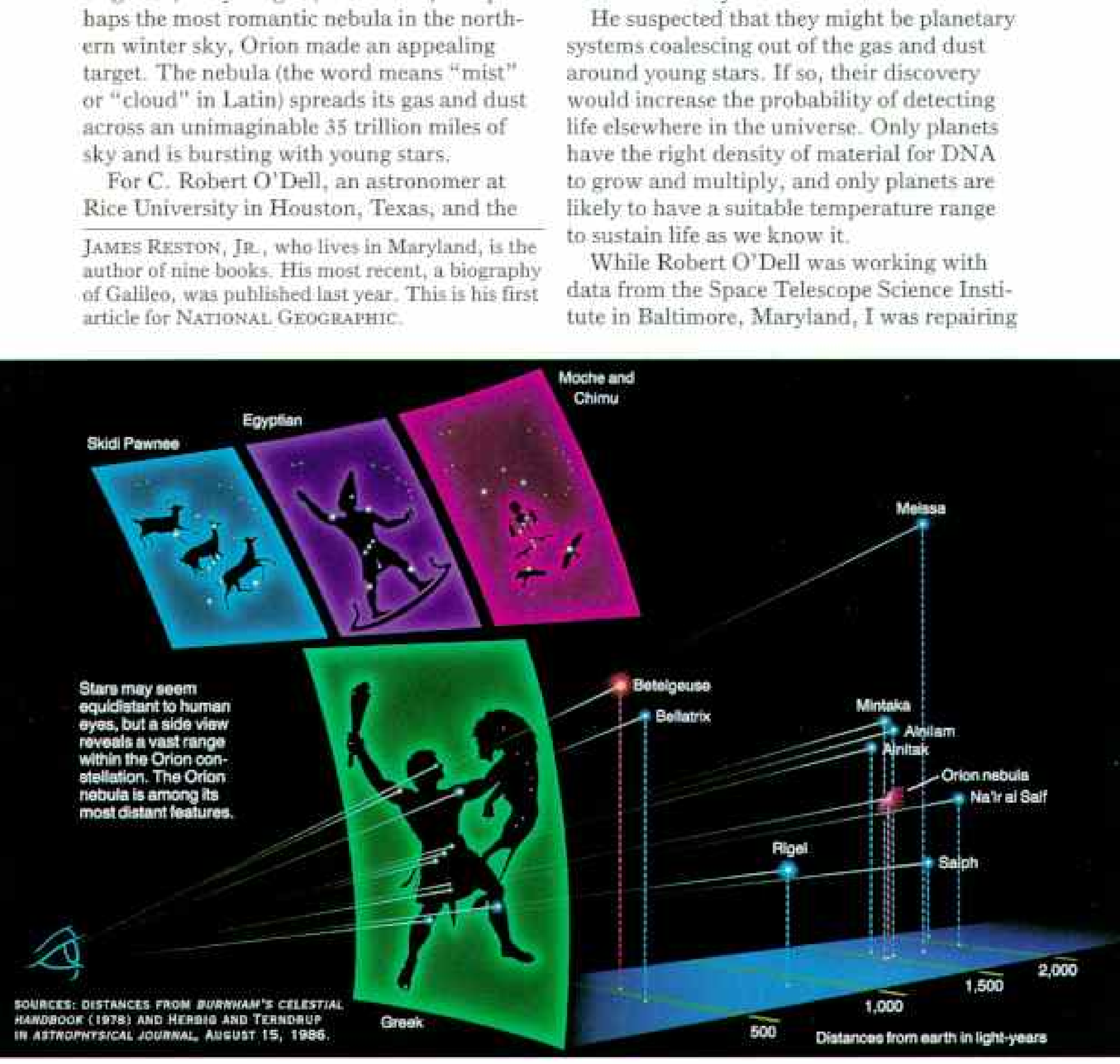
JAMES RESTON, JR., who lives in Maryland, is the author of nine books. His most recent, a biography of Galileo, was published last year. This is his first article for NATIONAL GEOGRAPHIC.



Its namesake nebula glowing red in this time exposure, the giant constellation Orion commands the winter sky (left). The Greeks saw a hunter (above), Pawnee imagined deer, Egyptians the god Osiris, and South America's Moche and Chimu a thief thrown to buzzards.

ROGER RESSMEYER (LEFT); PAINTING BY JOE TUCCIARONE

HARVARD COLLEGE OBSERVATORY (TOP); NEW YORK ACADEMY OF SCIENCES

First photograph of the Orion nebula was taken in 1880 by American astronomer Henry Draper. He mounted a bulky glass-plate camera on a telescope and followed Orion with a tracking mechanism for 51 minutes to produce this inverted view.

to Pigeon's Perch, a hill near our family farm in Virginia, to look at the Orion constellation with Devin, my 15-year-old son. Combining science with folklore, Orion's blazing stars and sheets of gas and dust would allow me to tell Devin about the entire night sky.

WE PAD THE WAGON of the lawn tractor with pillows, carefully place the eight-inch reflecting telescope I have borrowed from a Johns Hopkins astronomer on its bed, and putter off. By the time we set up at 9 p.m., Orion is already low in the sky. It is spring, and the constellation is about to go into hiding behind the sun for a few months. When it reemerges in July, it will deliver a message written by the Greek poet Hesiod and heeded by farmers for almost three millennia: "Forget not, when Orion first appears, / To make your servants thresh the sacred ears."

"Tell me the story of Orion," Devin asks. I explain that Orion and the other constellations, so romantic in their conception and yet so useful, are simply an invention of the human mind, a way of ordering chaos. They place us in the heavens.

Around 2000 B.C., stargazers joined dots in the sky and conjured up a figure that the Greeks came to know as Orion the Hunter. Artemis, the goddess of the hunt, fell in love with Orion, but her twin brother, Apollo, was jealous and sent a scorpion to kill him.

"I like that," Devin says, thinking of his older sister and her annoying boyfriends.

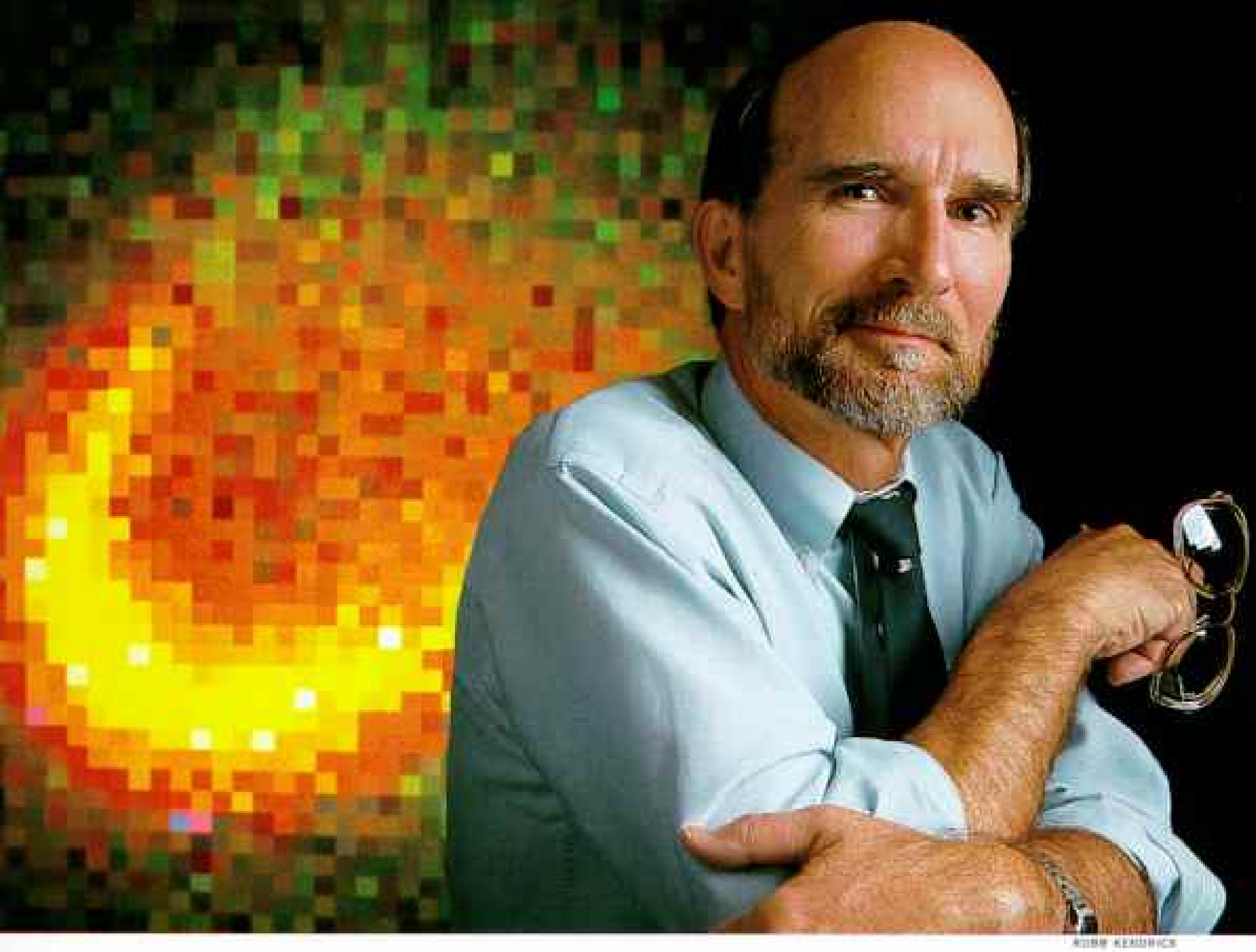
The hunter faces us. His belt is formed by three almost perfectly aligned, perfectly spaced stars that are among the most luminous anywhere in the Milky Way galaxy. The Orion nebula can be seen below the belt as the second of the three points of light that form the hunter's scabbard. His right armpit looms as Betelgeuse, an enormous pulsating red star 20 times as massive as our sun. North of Betelgeuse six smaller stars outline the giant's club. Rigel, a brighter, more distant star, is his left knee. Saiph marks his right knee; and Bellatrix, the Amazon star, his left shoulder. A semicircle of stars extends out from his left arm.

By the end of our celestial tour it is nearly midnight. Orion has ducked behind the hulk of Mount Marshall, and Scorpius, the scorpion constellation, is emerging from the glow of metropolitan Washington. For father and son, with the passage of the hunter, the sky has become a collection of interwoven bedtime stories.

Meanwhile Robert O'Dell had confirmed that the Hubble's latest look at the Orion nebula was free of artifacts and any confusing clutter. "We're seeing Orion as it really is," he said, "and we're seeing the unexpected."

The first clear-sighted observation, a portion of the nebula's center, revealed 110 stars—and a surprise. Fifty-six stars were surrounded by pancake-shaped clouds, the puzzling splotches O'Dell had noticed in the earlier, flawed images. He surmised that there were more: Some, less brightly lit by nearby stars, would have escaped even the telescope's keen eye.

Whatever explains the clouds, the stars inside them—and all other stars—are the



ROBB KENDRICK

source of all matter, from the gas molecules in the Orion nebula to the planets in our solar system and the trees in your backyard.

Like us, stars are born, mature, reach old age, and die. Exactly what triggers a new star is still a mystery, but gravity must play an important part. If, for some reason, a knot of gas in a nebula becomes more dense than the material around it, the knot will start to collapse because its own gravitational force is greater than that of the surrounding material. As the clump continues to contract through self-gravitation, it becomes even more dense and its core heats up.

When the center reaches a certain density and temperature, nuclear fusion begins. A star is born—a nuclear furnace of hydrogen and helium enveloped in a spinning cloud of gas and dust. O'Dell and other astronomers have long believed that this rotating cocoon is the raw material of planets. Eventually the cloud is blasted away to reveal the luminous mass within.

A star's color depends on its temperature. Betelgeuse, a reddish star, is cool—only 3000°C at the surface. Our sun is an average yellowish star with a temperature of 5500°C.

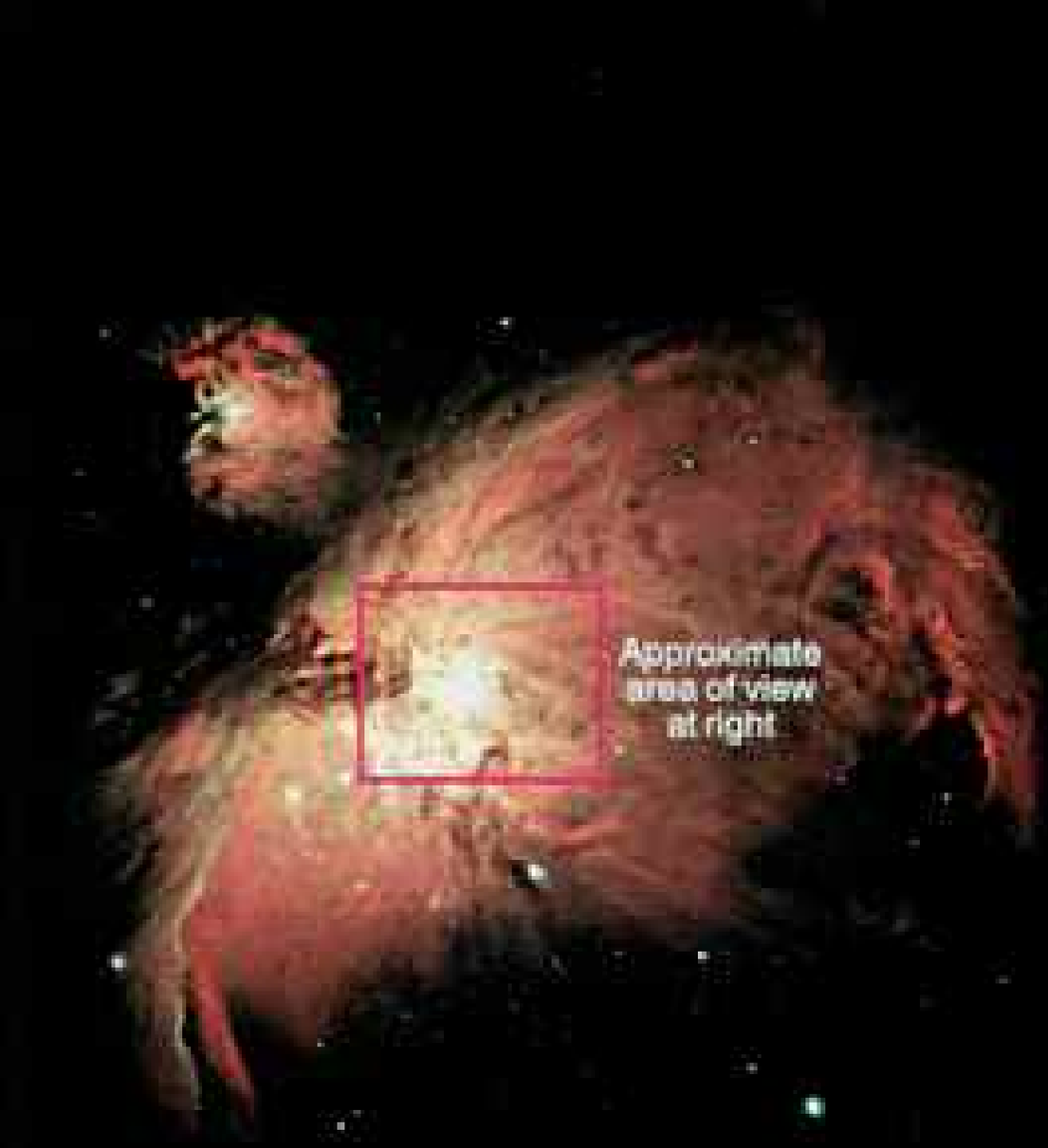
"It has it all," says C. Robert O'Dell, who has studied the Orion nebula for 30 years. "It's the brightest nebula, the closest, the youngest." His Hubble Space Telescope mosaic of Orion (following pages and supplement) used millions of optical pixels.

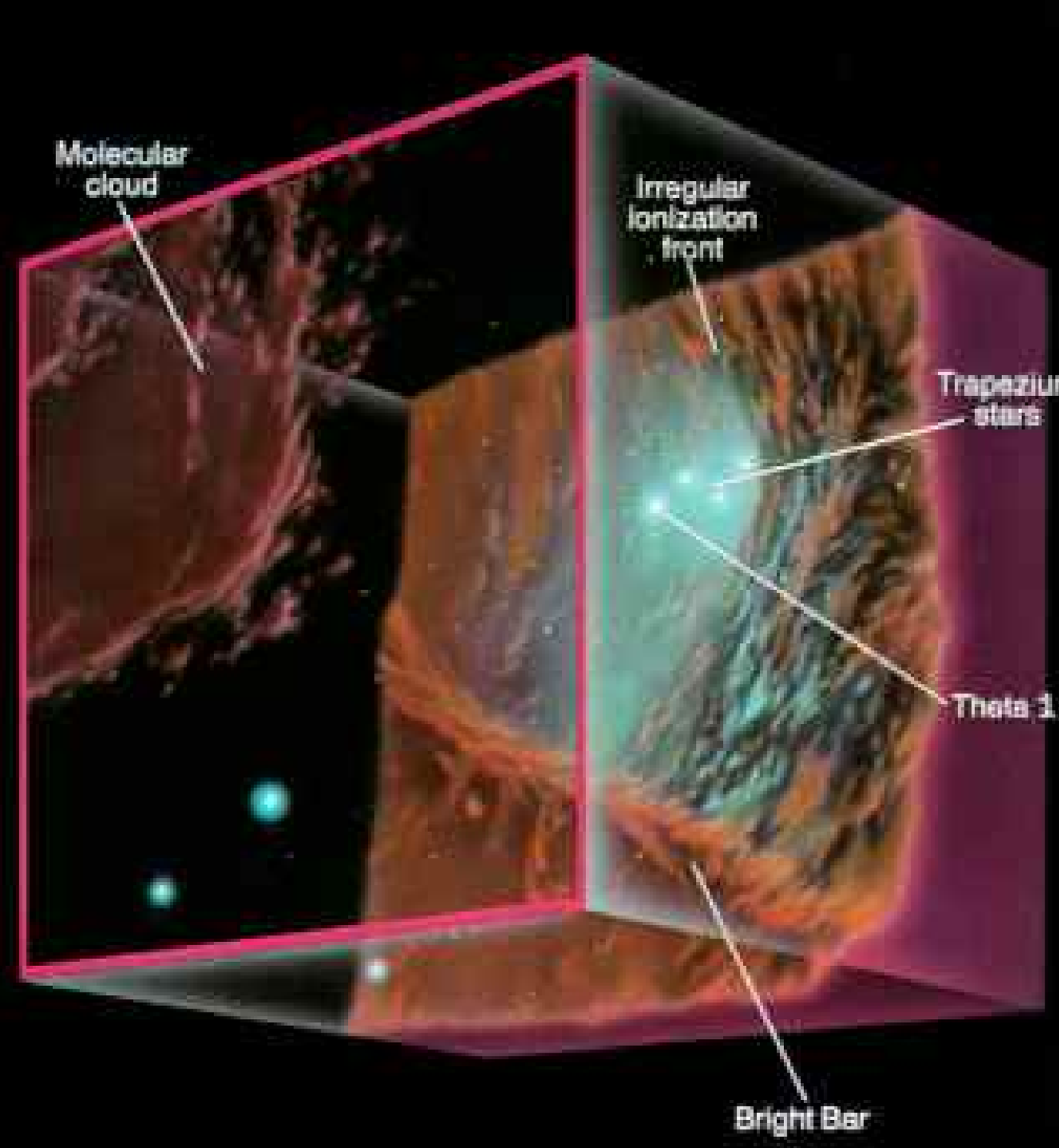
Massive, hot stars like Rigel are blue-white and glow at 10,000°C. Such stars rapidly consume themselves as their hydrogen converts to helium.

In its old age a massive star converts helium to carbon and carbon to iron. It becomes a red supergiant, like old, bloated Betelgeuse, and when the nuclear furnace shuts off, gravity causes the star to collapse. The energy from this sudden contraction is released in a huge explosion, or supernova—a fate that no doubt will befall Betelgeuse.

If the explosion occurs near a cloud of gas and dust, the shock waves may compress part of it. The gas becomes more dense, and the star cycle begins anew.

Of all the stellar nurseries scattered throughout the spiral arms of our galaxy, none is more *(Continued on page 100)*





Anatomy of a Nebula

The Orion nebula (above), lit by the Trapezium stars, is a bright spot on a vastly larger dark cloud of molecular gas and dust a hundred light-years across.

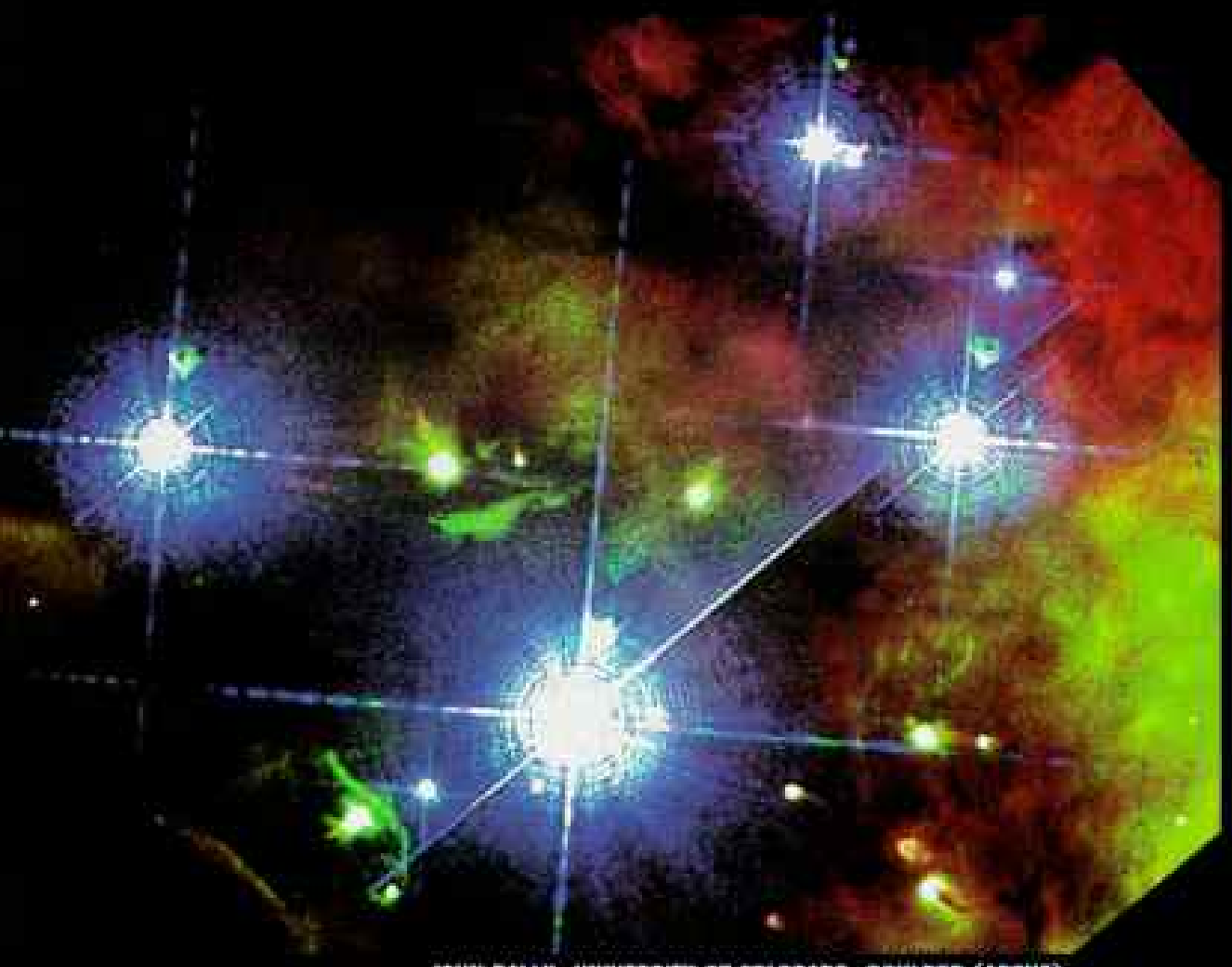
The stars (below and at center in the Hubble Space Telescope mosaic at right) were born somewhere inside the molecular cloud. They drifted out of it just yesterday by star standards—no more than a million years ago.

The brightest of the four Trapezium stars, Theta 1 C, provides 99 percent of the light energy in the nebula, illuminating both its brilliant star-forming center and the nebula's wispy extremes. Orion is one of the few nebulae that shine so brightly they can be detected with the naked eye.

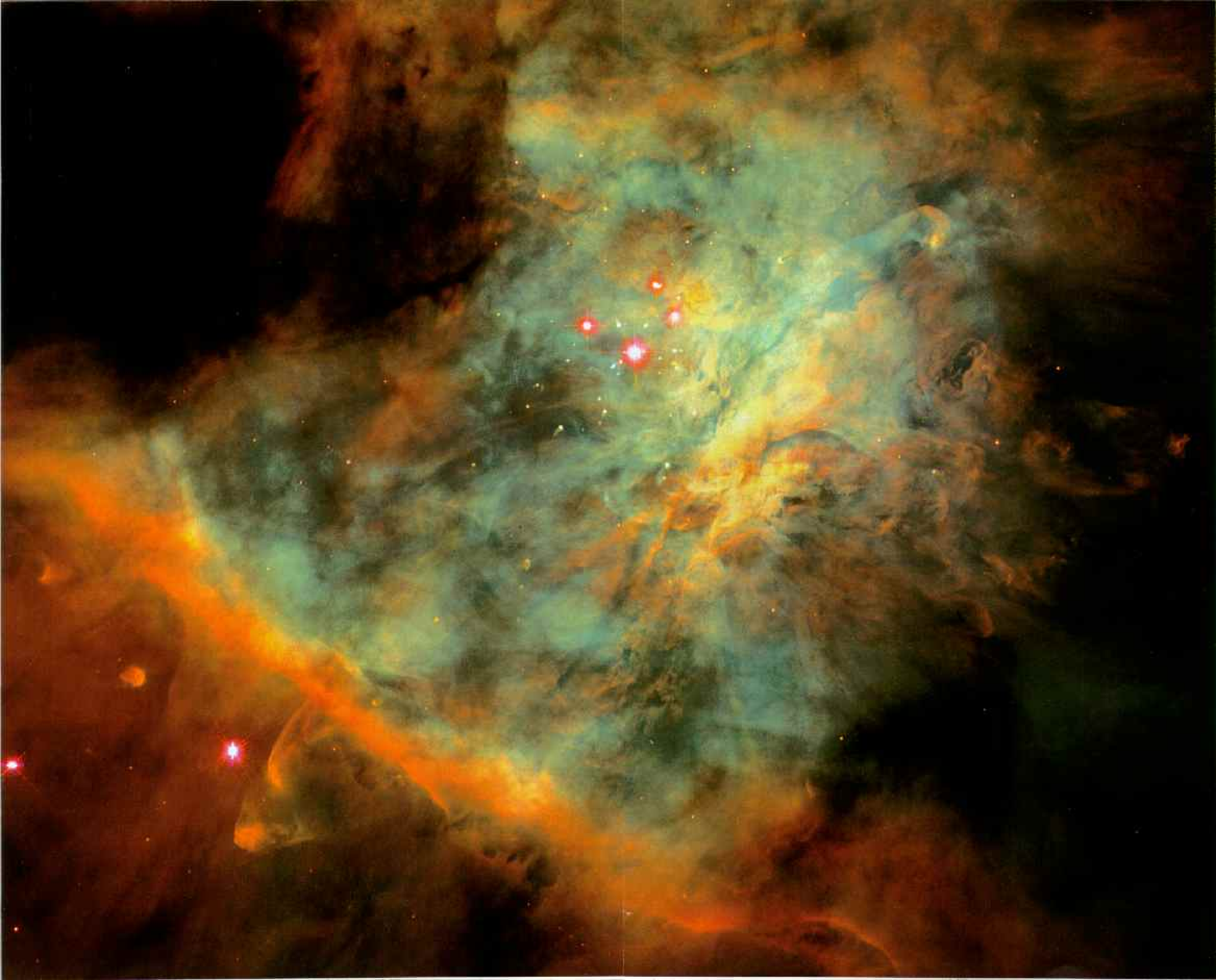
The stars of the Trapezium share the interior of the bowl-shaped nebula (3-D painting above), which they enlarge through sheer light power. As ultraviolet light, primarily from Theta 1 C, excites hydrogen molecules in the dark molecular cloud, they emit the light we see from earth and release hydrogen atoms, which quickly escape.

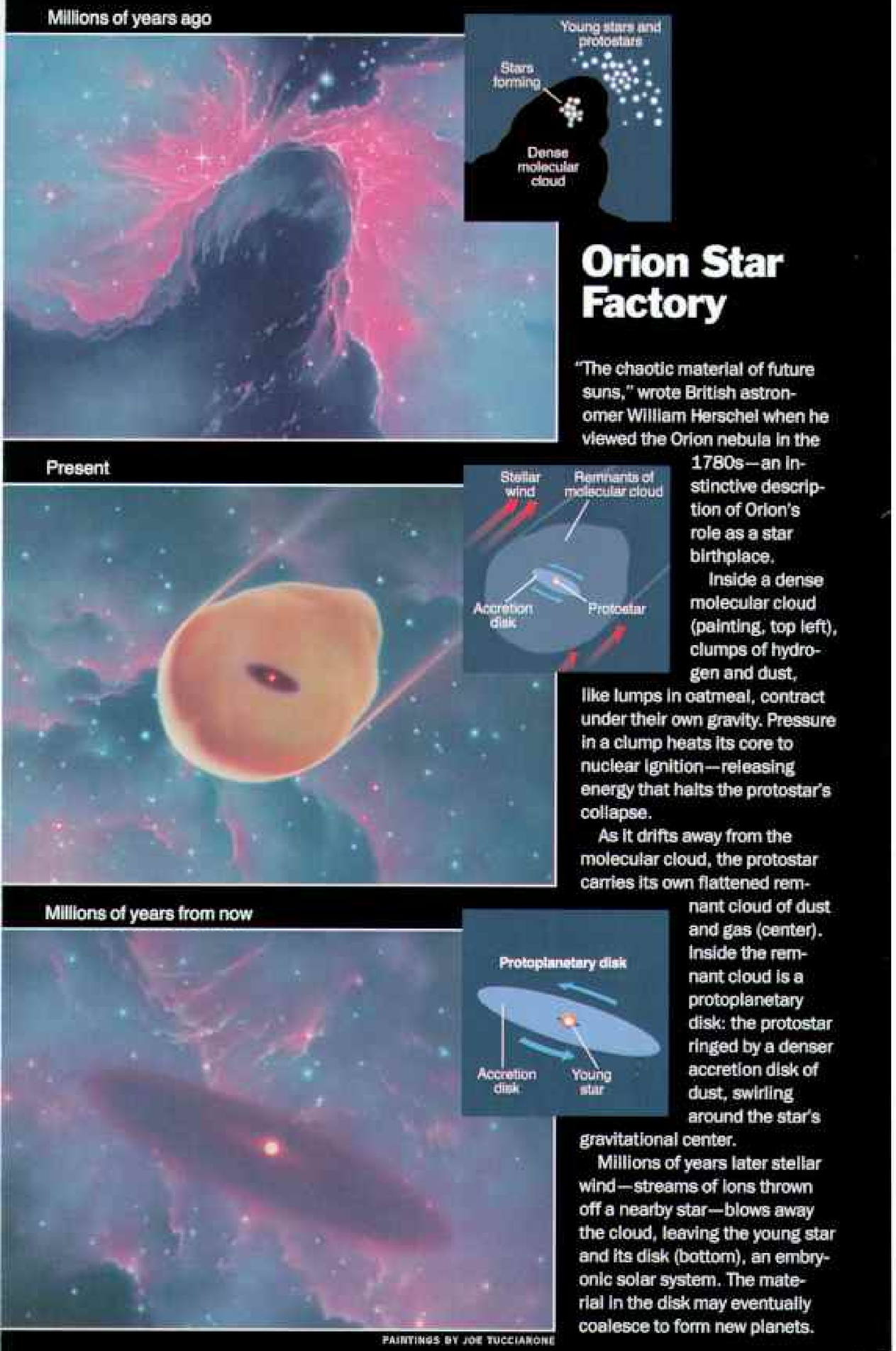
So intensely is Theta 1 C burning, and so fast are hydrogen atoms flying off, that a hole is being bored right into the molecular cloud along a visible area astronomers call the ionization front. The front is irregular, as denser areas of the cloud erode at a slower rate.

A ridge in the bowl, called the Bright Bar, is seen as a luminous orange streak at the lower left of the Hubble mosaic.



JOHN BALLY, UNIVERSITY OF COLORADO, BOULDER (ABOVE); DAVID MALIN (TOP); PAINTING BY JOE TUCCIARONE; C. ROBERT O'DELL AND SHUI-KWAN WONG, RICE UNIVERSITY (FOLDOUT)





PAINTINGS BY JOE TUCCIARONE

Orion Star Factory

"The chaotic material of future suns," wrote British astronomer William Herschel when he viewed the Orion nebula in the 1780s—an instinctive description of Orion's role as a star birthplace.

Inside a dense molecular cloud (painting, top left), clumps of hydrogen and dust, like lumps in oatmeal, contract under their own gravity. Pressure in a clump heats its core to nuclear ignition—releasing energy that halts the protostar's collapse.

As it drifts away from the molecular cloud, the protostar carries its own flattened remnant cloud of dust and gas (center). Inside the remnant cloud is a protoplanetary disk: the protostar ringed by a denser accretion disk of dust, swirling around the star's gravitational center.

Millions of years later stellar wind—streams of ions thrown off a nearby star—blows away the cloud, leaving the young star and its disk (bottom), an embryonic solar system. The material in the disk may eventually coalesce to form new planets.

vibrantly dynamic than the Orion nebula. Although it is 1,500 light-years away (one light-year equals about six trillion miles), you can see it clearly in the winter sky.

When Galileo pointed his telescope at the Orion constellation from his window in Padua in 1610, he somehow missed the nebula. It was first observed, in the same year, by Nicolas-Claude Fabri de Peiresc, a French lawyer and amateur astronomer, using a telescope given to him by Galileo. Through a telescope, the nebula looks pearly gray. Our eyes isolate only its brightest parts, which appear essentially colorless. We cannot see the red outer edges, painted by nitrogen and hydrogen emissions.

The nebula is actually a hot spot of glowing gases—mainly hydrogen but also helium, carbon, nitrogen, and oxygen—on a much larger dark cloud of gas and dust called the Orion molecular cloud. The presence of dozens of different kinds of molecules, including water and carbon monoxide, suggests the cloud is laden with the material from which stars are made.

The topography of the illuminated nebula is highly irregular. Ultraviolet radiation from its hottest stars enlarges the nebula, expanding it most in places where the molecular cloud is thinnest, much as a brush fire on a prairie rushes through the thin grass and slows down where the brush and trees are thicker. The most striking feature is its brow, a long, visible streak known as the Bright Bar, which is actually an upturned edge of the nebula's concave form.

"When we look at Orion," says O'Dell, "we're seeing a star factory and what our solar system looked like in its infancy." Most of the stars in the nebula are between 300,000 and one million years old—mere toddlers, given that our sun is 4.5 billion years old. The smallest ones are usually reddish and low in mass.

Four massive hot stars, visible as a kite-like box, form the Trapezium, the throbbing heart of the star factory. Theta 1 C, the largest, is 20 times as massive as the sun and 100,000 times as luminous. It alone can light up the entire nebula. Ultraviolet radiation from the stars of the Trapezium, which are probably no more than a million years old, causes the nebulous material near them to glow brightly in all the hues of the rainbow.

The area around the Trapezium is packed

JOHN BALLY

A teardrop 40 billion miles across, a cloud elongated by stellar wind envelops a young star in Orion's Trapezium cluster. Silhouetted at upper right is a star surrounded by a disk of dust—possibly the beginnings of planet development. Such protoplanetary systems have been seen around most of the nebula's dust-clad stars.

with a thousand lesser stars. Indeed, because of the abundance of soupy material in the nebula, this is one of the most densely congested star clusters of any known region in our galaxy.

By the spring of 1995 the space telescope had revisited the Orion nebula four more times, capturing 15 different areas of its varied topography. It took O'Dell several laborious weeks at his computer to align the stars in the overlapping edges of each Hubble image, but in the end he had a single, coherent picture of the heart of Orion's stellar nursery.

"It's a violent, stirred-up place, where material is moving at supersonic velocities," he explains, taking me on a guided tour of the richly textured image, with its knots of starlit gas and arcing shock fronts.

Shock fronts remain one of the Orion nebula's last mysteries. Whatever their cause, they are worthy of Jackson Pollock: inspired bravura strokes across the background of swirling gas. The most dramatic shock front spouts off the Bright Bar, and O'Dell affectionately refers to it as his diplodocus, the

MARK MCCAUGHREAN, MAX PLANCK INSTITUTE FOR ASTRONOMY, GERMANY

Pearls in the mist, a cluster of stars emerges when the Orion nebula is viewed in infrared wavelength. Cool stars, like most of those in the nebula, glow primarily in the infrared range. Some 700 stars are visible, about 63.5 stars per cubic light-year—a density 20,000 times as great as our stellar neighborhood.

head and neck of the great Jurassic dinosaur.

Astronomers believe shock fronts define the forward edges of gas jets streaming from an infant star. They are thought to be formed by the magnetic field present in the star's original gas cloud. As gravity shrinks the cloud, the magnetic field is compressed with it—but only to a certain limit. "A magnetic field cannot be squeezed too tightly," O'Dell says. When it reaches that limit, magnetic energy escapes from the spinning mass, accelerating the particles of gas along its path to very high speeds. "The easiest place for the magnetic energy to spew out is at the poles. So the jets probably mark the magnetic poles of nascent stars."

If shock fronts suggest the forces at work in newborn stars, the saucers of gas and dust around young stars—protoplanetary disks—provide the strongest evidence yet for the birth of planets.

"We use the word 'protoplanetary,' " says O'Dell, "because we are seeing the necessary ingredients for the formation of planets. The disks are the missing link in our understanding of how planets like those in our solar system form."

Protoplanetary disks seem to substantiate Immanuel Kant's 1755 hypothesis that planets form out of spinning clouds of gas, where material collapses into a dense center, spawning a star. The leftovers spin off as planets.

Most of the protoplanetary disks O'Dell has identified are flat rather than spherical—evidence, he says, that an active, evolutionary process is at work. (If a cloud is to spawn planets, it must be rotating, and as it rotates, the spinning motion flattens it into a disk.) Some appear circular, in part because an object's shape varies with its angle of view. Others are tear shaped. This is apparently because their material is being blown out by the powerful stellar winds of the Trapezium stars.

When O'Dell measured the disks, he found that some are much larger than our solar system. The blackness of one disk made it easy to measure precisely: seven and a half times the diameter of the solar system. At its center glows a faint red star with a mass one-third that of our sun.

IT IS LIKELY that many of the stars in the disks will form their own planets, and it is possible that some of those planets will support life. "The universe is a very big place," says O'Dell. "I have always believed there is life out there somewhere. I believe it more strongly now."

Parallel studies strengthen the case for planets elsewhere in our galaxy. It had been thought that stars formed by the thousands in huge clusters, but astronomers at the Kitt Peak National Observatory in Arizona who turned new infrared equipment on a cloud south of the Orion nebula saw stars forming in clusters of only 10 to 50. This could be the way most stars in the Milky Way are born. Nearly all the stars observed were encased in disks of gas and dust. As these stars drift away from their birthplace, they may come to resemble our sun.

Speculation aside, Robert O'Dell is excited enough by the hard science of his discoveries. Gazing with a hint of pride at the Hubble image of the Orion nebula, he says, "In the future there will be bigger and better space telescopes, and there will be another giant step forward like this one. But it will take a long time. I feel fortunate to have been around at this moment." □

By PETER MILLER
SENIOR ASSISTANT EDITOR

Photographs by
MICHAEL NICHOLS

Face-to-face with humanity's closest relative, Jane Goodall has spent 35 years studying the ways of chimpanzees in the wild. Here she draws from that intimate understanding to comfort a chimp in captivity—La Vieille, an aged female half crazed from spending years alone in a Congolese zoo. In 1994 the Jane Goodall Institute moved La Vieille to a happier home—a sanctuary nearby.

Crusading for Chimps and Humans . . .

JANE

GOODALL

GRABBING ROOTS AND VINES to keep from sliding, Jane Goodall eases down the steep slope on all fours. It is just before dawn in Tanzania's Gombe National Park, and the 61-year-old primatologist is in a hurry. She wants to find the wild chimpanzees before they waken and climb down from their nests. Stopping beside a sprawling fig tree, whose branches are black fingers against the plum-colored sky, she points to a nest where dark shapes are stirring.

A small face pops up—two bright eyes surrounded by oversize milk-chocolate ears. It's Ferdinand, the three-year-old son of Fifi, the last survivor of the chimpanzees Jane first studied at Gombe 35 years ago. The daughter of ragged-eared, bulbous-nosed Flo, who died in 1972, Fifi has six offspring of her own, including 24-year-old Freud, the dominant, or alpha, male, and Frodo, a 19-year-old bully.

Fifi sits up and stares at Jane, who is wearing her graying hair in her familiar, youthful ponytail. It has been more than six months since Jane's last visit to Gombe. Her days as a field researcher ended a decade ago. She still longs for time with the chimps, but her globe-spanning crusade to promote conservation, create sanctuaries for chimp orphans, and improve conditions for captive chimps keeps her away.

A streak of muscle named Maxillo patrols the fence at the Jane Goodall Institute's Tchimpounga Sanctuary in Congo—leaving no doubt who is the refuge's alpha, or dominant, male.

Above us on the ridge, Freud climbs down from his nest. He has decided to wake everybody up. Hooting and screaming at the top of his lungs, he charges down the hillside, tossing up leaves and pounding on the ground in a display of authority. Startled chimps peer down from every tree. Most leave their nests and wander off into the forest.

Most, but not all. Frodo steps out of the shadows. A hundred twenty pounds of bulging shoulders and arms, Frodo stares at Jane belligerently. Chewing on his upper lip as he does before misbehaving, he advances ominously toward us.

"Here he comes," Jane warns, as Frodo rushes ahead. *Slap!* He hits Michael Neugebauer, an Austrian publisher, on the head. *Bang!* He pushes Michio Hoshino, a Japanese photographer, over onto Jane. Leaping over Bill Wallauer, the Gombe videographer, Frodo grabs a small tree with both hands, plants his feet on my back, and kicks me down the hill. Then he circles around for Jane. Seizing her ankle in a vise-like grip, he pulls her down the slope for ten feet, then releases her to grab Katrina Fox, another researcher, to drag her against a tree.

And then he is gone.

We are shaken but uninjured. Frodo didn't mean to hurt us. He was only showing off.

"He makes me so angry," Jane says. "I almost wish I knew a lot of swear words."

A spoiled brat at heart, the muscular teenager has jumped Jane before, stamping on her head so hard he nearly broke her neck. Unlike most Gombe chimps, who accept her presence peacefully, he seems to want to dominate Jane, showing that chimps, like people, may be kind or cruel, caring or cold, thoughtful or stupid.

"When I first started at Gombe, I thought the chimps were nicer than we are," Jane recalls wistfully. "But time has revealed that they are not. They can be just as awful."

Frequently tender and compassionate, humanity's closest living relatives are also capable of scheming, deceiving, and waging war. It came as a shock to Jane in 1974 when patrols of chimpanzees from the Kasakela community—one of four groups in the 20-square-mile park—began attacking chimps from the Kahama community to the south. She was stunned by reports of stealthy warriors moving through the forest in single file, hair bristling from fear and excitement, stepping from stone to stone to avoid making noise in what came to be known as the Four Year War.

By the end of the conflict, the Kahama community—seven males and three adult females and their young—had been annihilated. Researchers witnessed five of the attacks, in which Kasakela chimps tore at their victims' flesh with their teeth as if they were common prey.

Fortunately, nothing so horrible has darkened the forest recently. To catch up on the latest news, what has been called the "continuing soap opera" at Gombe, Jane climbs the trail to the feeding station with Bill Wallauer and me. We sit outside the small metal building, bathed in the fragrance of the ripe

Jane's first encounter with chimpanzees came at age two, when she was given Jubilee (above), a stuffed toy. Fascinated by animals, Jane later read* Dr. Dolittle *and dreamed of living in Africa. In 1957, at the age of 23, she traveled to Kenya and met paleontologist Louis S. B. Leakey, who stunned everyone by assigning her to study chimpanzees in what is now Tanzania's Gombe National Park. Her patient, unobtrusive approach brought her close to the chimps, including tiny Flint (opposite).

MICHAEL NICHOLS has collaborated with Jane Goodall on several Society projects, including the 1993 book *The Great Apes: Between Two Worlds.* For more information on Dr. Goodall's work, write to the Jane Goodall Institute, P.O. Box 599, Ridgefield, CT 06877.

bananas inside, to gossip about the chimps whose life stories represent the world's longest continuous study of animals in the wild.

"It's so sad looking down this list," Jane says, scanning the names of chimps who have come and gone at Gombe: David Greybeard, the confident male who first accepted her presence; Mike, the diminutive fighter who bluffed his way to the top position by banging empty kerosene cans; the aging Goliath, who was murdered by

NANCY KILLSTONE (OPPOSITE); HUGO VAN LAWICK

former chimpanzee friends; "Auntie" Gigi, the mannish old maid who surprised everyone by adopting three orphans; and Flint, the eight-year-old mama's boy who died of grief when old Flo passed away. Each gave Jane a glimpse into the chimpanzee mind.

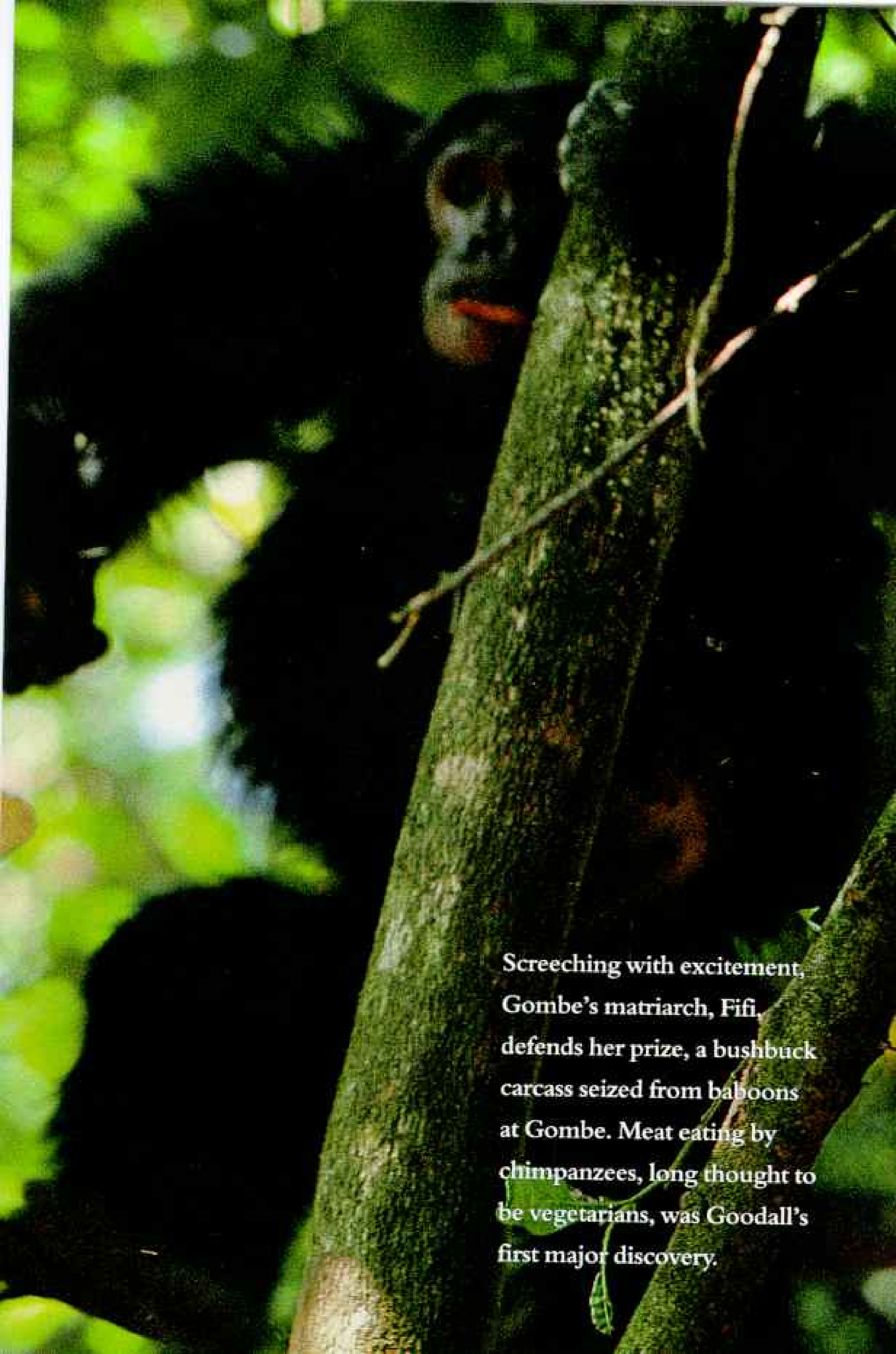
I ask about Passion and her daughter, Pom, who were seen to kill and eat three Kasakela infants and almost certainly killed seven newborns over a period of four years—a horrible time when Jane agonized over ways to stop them. She considered moving the pair to another valley, she says, or even temporarily crippling them. But the killings came to an end when Passion herself gave birth again in 1977. Four years later she was dead, victim of a painful, unidentified disease. And Pom, facing the hostility—and long memories—of Kasakela females, was forced to migrate to the Mitumba community to the north.

As we sit in the sunshine, a pair of olive baboons chase each other across the thatched roof of the feeding station. The forest all around buzzes with the music of cicadas.

"Chimpanzees are so inventive," Jane says. "They do lots of things they don't need to for survival." In different parts of Africa, chimps have been observed cracking open nuts with rocks, using twigs for "sandals" to protect their feet from thorns, consuming bitter plants apparently as medicine for stomachaches, and hunting in organized groups.*

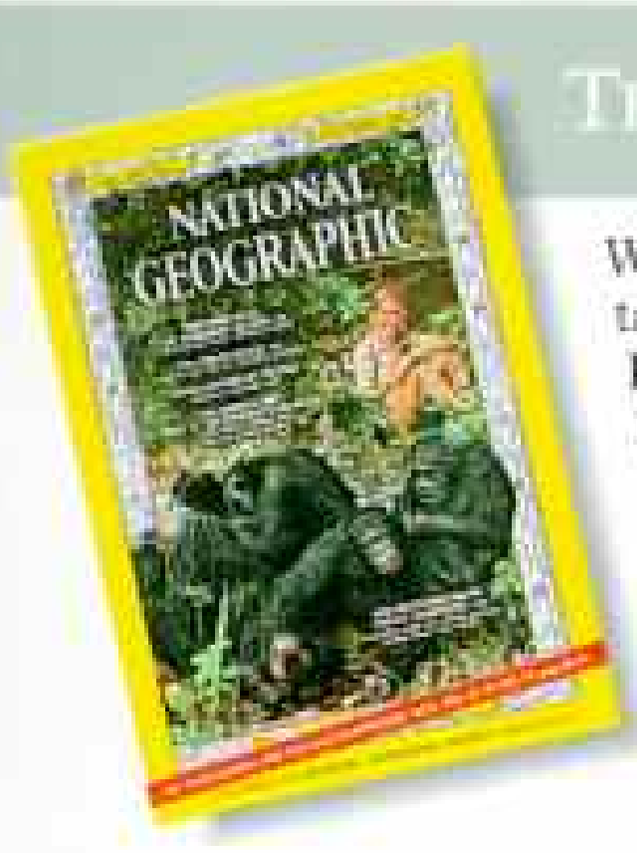
They are also very *(Continued on page 114)*

*Eugene Linden reported on chimp research in "A Curious Kinship: Apes and Humans," in the March 1992 GEOGRAPHIC.



Screeching with excitement, Gombe's matriarch, Fifi, defends her prize, a bushbuck carcass seized from baboons at Gombe. Meat eating by chimpanzees, long thought to be vegetarians, was Goodall's first major discovery.

THIRTY-FIVE YEARS OF INSIGHT INTO OUR CLOSEST KIN



When Jane Goodall began her study in 1960, Louis Leakey warned it might take ten years. She laughed and thought "maybe three." Both were wrong. By 1965, when her research was the subject of a GEOGRAPHIC cover story (left) and a TV Special, Goodall was revolutionizing our view of chimps. Today, three chimp generations later, her work with Gombe's Kasakela and Mitumba communities ranks as the longest field study of animals in the world. Time—and patience—was the key. "Had my colleagues and I stopped after ten years, we would have been left with the impression that chimpanzees are far more peaceable than humans," she says.

1960

Meat eating

In Jane's first year, she observed David Greybeard eating a baby bushpig—proving that chimps are carnivorous.

1960

Toolmaking

A second breakthrough came when David Greybeard trimmed a wide grass blade to probe a termite nest—the first recorded instance of tool manufacture among nonhumans in the wild.

1964

Planning

Figan demonstrated deliberate planning and intelligence when he "kidnapped" Flint to get Flo and the rest of the group to follow him to another location.

1964

Using man-made objects

Turning a chance discovery to his advantage, Mike showed superior intelligence by using empty kerosene cans to create a noisy charging display. Banging the cans to intimidate larger males, he bluffed his way to the top.

1966

Polio

Polio—a disease that afflicts both humans and chimpanzees—struck hard at Gombe. Genetically, chimpanzees are closer to humans than any other animal: More than 98 percent of their genetic material is identical to ours.

1970

Awe

The sight of a waterfall inspired the chimps to perform a spontaneous dance-like display. Goodall believes that such expressions of awe may resemble the emotions that led early humans to religion.

1974

Warfare

In a shocking development, war broke out between the Kasakela males and the seven males of a splinter group, lasting four years and apparently claiming all the émigrés. Intercommunity violence had not previously been observed.

1975

Cannibalism

Passion killed and ate Gilka's infant, Otta, sharing the flesh with her daughter, Pom. Mother and daughter then continued the killing spree for two more years, snatching and eating a suspected toll of ten Kasakela infants.

1975

Transfer of females

Little Bee, a female whose migration may have fueled the war, moved from Kahama to Kasakela in 1975. The transfer of adolescent females from one community to another is relatively common.

1987

Adoption

After three-year-old Mel's mother died of pneumonia, he was "adopted" by an adolescent male, Spindle —the first time that a nonrelated chimp was observed to adopt an orphaned youngster.

1975

Coalitions

Figan's status as the alpha male had been bolstered by his close relationship with his brother Faben. When Faben disappeared, Figan had a hard time fending off challengers by himself—although he managed to reign for ten years.

1994

Consortship

Researchers have observed that male chimps sometimes lead females away from the community and establish brief monogamous relationships, increasing the likelihood that offspring are their own. Recent genetic fingerprinting confirmed that Winkle, who was Evered's consort, gave birth to his son, Wilkie.

1994

Technology transfer

The use of twigs to catch carpenter ants had been seen at Gombe only in the Mitumba community. Yet after a Mitumba chimp joined the Kasakela group, Flossi, daughter of Fifi, suddenly began using the Mitumba technique. This transfer of technology from one community to another had not previously been observed.

1995

Twins

Rafiki gave birth to twins named Roots and Shoots. Only once before had twins been observed among the Gombe chimpanzees.

1995

Medicinal plants

Ongoing research indicates that some chimpanzees swallow the leaves of *Aspilia*, a medicinal plant —perhaps to relieve stomach pains or reduce internal parasites.

PAINTINGS BY ALAN HARRIS

Ever the observer, Goodall joins a group of playful chimps including longtime favorite Gremlin (reclining at center). Jane's emphasis on individual animals, whom she named instead of numbered, revolutionized primatology.

(Continued from page 107) political, she says. Male chimps at Gombe, like neighborhood bosses, engage in much handshaking, back-slapping, and hugging as they form shifting alliances.

"Has Frodo challenged Freud lately?" she asks Wallauer.

"No, but he's becoming more confident," he replies. "Frodo never pant-grunts submissively to Freud anymore. The most he will do is climb out of his way."

Wallauer, dressed in camouflage pants, soccer shoes, and a sleeveless black T-shirt, is one of the team continuing the work Jane began here. Following the chimps up and down Gombe's steep trails to videotape their behavior, the 30-year-old Oregonian melts into the underbrush as effortlessly as his subjects. He identifies with them so closely he sometimes refers to the Kasakela chimps as "we."

"The key to the political situation now is Goblin," Wallauer says, referring to a shrewd former alpha. "If Goblin sides with Frodo, Frodo will easily defeat Freud to become the new alpha. But Goblin keeps going back and forth between them."

"So they both need him," Jane says.

"Exactly. Goblin sides with whoever looks most powerful. So no matter who wins, he can't lose. Meanwhile he has access to any female he wants, right in front of everyone. Neither Freud nor Frodo will stop him, or they might lose his support. So smart."

"Testosterone does such magic for men," Jane says, a twinkle in her eye.

NO ONE KNOWS her as Jane Goodall at her home in Dar es Salaam, 675 miles east of Gombe. Here they call her Mama Bryceson, remembering her second husband, Derek Bryceson, who was a member of Tanzania's parliament and director of national parks.

"It was a real love match," says Mary Smith, a longtime friend and former editor at NATIONAL GEOGRAPHIC. "She was absolutely nuts about him."

When Derek died of cancer in 1980, after only five years of marriage, Jane was devastated by the loss. Some of her heartache lingers in the house they shared in Dar, where we sit on the patio, looking out on the Zanzibar Channel. Men with their pants legs rolled up are clamming in the low tide, shadowed

Marathon woman, Goodall makes dozens of public appearances around the world each year, exhausting everyone who tries to keep up. "Jane doesn't eat, and she doesn't have much patience with those who do," says photographer "Nick" Nichols, who carries pocketfuls of snacks when he's covering Goodall. Her goal: to build environmental awareness, to raise funds for the nonprofit Jane Goodall Institute, to improve conditions for chimps in captivity, and to slow human encroachment on their homeland (right). "In 1960 chimpanzee habitat stretched as far as I could see at Gombe," Jane recalls. "Today the chimpanzees are imprisoned as if they were on an island."


AFRICA
SENEGAL
MALI
GUINEA
GUINEA-BISSAU
SIERRA LEONE
CÔTE D'IVOIRE
GHANA
LIBERIA
NIGERIA
CENTRAL AFRICAN REPUBLIC
CAMEROON
EQUATORIAL GUINEA
GABON
CONGO
ZAIRE
SUDAN
UGANDA
RWANDA
BURUNDI
KENYA
TANZANIA
ANGOLA
CABINDA (Angola)
Atlantic Ocean
EQUATOR
Nile River
Lake Edward
Lake Tanganyika
Tchimpounga
Pointe-Noire
Kinshasa
Bujumbura
Halfway House
Kigoma
GOMBE NAT. PARK
Kitwe Point
Uganda Wildlife Education Centre
Sweetwaters
Zanzibar
Dar es Salaam
Chimpanzee sanctuary
Chimpanzee range
0
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MILES
NGS CARTOGRAPHIC DIVISION

Fighting last-minute snags as she checks her slides, Goodall is invariably buoyed by standing ovations at venues like Cornell University (right). Says Harvard professor Richard Wrangham, a Goodall protégé: "It's amazing how many people entering the field of primatology say they were inspired by Jane."

by herons doing the same. A boy swatting at cattle with a switch is trying to move them along the beach.

If a person's home reflects her life, you might fairly conclude that Jane is a solitary individual. Aside from her residence in Dar, she has a concrete-block house at Gombe and shares her mother's seaside Victorian home in Bournemouth, England. But Jane lives on the move.

"During the past nine years, the longest I've spent in any one place has been three weeks," she says.

Although her breezy house in Dar is full of visitors, it feels empty, just as Jane herself can appear lonely when surrounded by friends and admirers. The small bedroom she keeps for herself lacks personal touches, except for a plastic photo cube on her nightstand. Besides a favorite snapshot of Derek, it holds pictures of Jane's mother, Vanne, in her late 80s, who lives with Vanne's older sister, Olly; of Jane's 28-year-old son, Grub (his real name is Hugo, after his father, Hugo van Lawick), who runs a sportfishing business from the cottage next door; and of her old friend Fifi cradling an infant—little Frodo.

"Jane hates it when I compare her to Mother Teresa, but she has certain similar qualities," says Mary Smith. "She's the most selfless person I know, has no interest whatever in material possessions, and lets nothing stand in her way."

Soon after her marriage to Derek, Jane faced one of the most difficult episodes in her life, a kidnapping of students at Gombe. The terror began during the night of May 19, 1975, when a boatful of rebel soldiers from Zaire landed on the beach near the camp, looking for white foreigners to hold for ransom. They beat Rashidi Kikwale, a longtime Gombe worker, then seized four researchers and took them back to Zaire.

"We thought we'd never see them again," says Tony Collins, a researcher then at Gombe. "We thought they were dead." The hostages were eventually freed, but only after two agonizing months and payment of a ransom. For months after, Jane was forbidden by the Tanzanian government to live at Gombe because of the threat of kidnapping. In Dar she turned her attention to analyzing

data from her first 15 years with the chimps.

"Gombe was still the best place in the world for me," she says. "But I came to realize the chimps needed me elsewhere. That phase of my life. . . ." She lets the sentence go. "I knew I had to use the knowledge the chimps gave me in the fight to save them."

Out of that period came *The Chimpanzees of Gombe*, a book published in 1986 that prompted Stephen Jay Gould of Harvard University to describe her work as "one of the Western world's great scientific achievements." And Jane was gaining the confidence she needed to speak out on issues she had previously avoided—the loss of habitat across Africa, the illegal trade in chimp babies, and the abuse of chimps in medical research.

"Before, when someone said, 'Jane, you could go meet President Mobutu in Kinshasa and try to save the orphan chimps in the market,' I just laughed. Why would Mobutu want to see me?" she says. "It took a while for me to realize that people would listen."

In the years since, she won financing from Conoco Inc., the oil company, to build a 65-acre fenced sanctuary near Pointe-Noire in Congo, where Graziella Cotman now looks after 50 orphan chimps confiscated by the government from traders. In Bujumbura, Burundi, she set up a "halfway house" for ten orphans in a private backyard. At the Uganda Wildlife Education Centre in Entebbe she helped support 26 more orphans. With her advice the Lonrho corporation built a 200-acre sanctuary at the Sweetwaters Game Reserve in Kenya, where Jane stops by to see ten chimps who have been moved here from the Bujumbura Halfway House.

"Hello there," she says to Poco, kneeling to offer him her hand. Until his owner surrendered him to authorities, Poco had been kept in a cage behind a gas station—one so small he was forced to stand most of the time. Now he looks cocky. Doing his best to impress Jane, he swaggers by on two feet, throws his shoulder against the cage, and sprints through a raceway between two cages.

Surprisingly, not everyone who cares about chimps applauds Jane's efforts to save orphans. To some conservationists, money spent on sanctuaries would be better used to preserve forests where chimps are still free. "There are thousands of orphan chimps in Africa. How are you going to save them?" asks Geza Teleki, who once headed Jane's programs in Africa. "We should worry about habitat, not orphans."

That isn't Jane's way. Her heart belongs to the individual. She believes in the need to protect habitat and has even helped start a reforestation program in Tanzania. "But there are not many people," she writes, "who,

Twins—extremely rare in chimpanzees—were born last February to Rafiki, a high-ranking female who is also a skilled and attentive mother. As Goodall's research shows, not all infants are so lucky.

Roots & Shoots, Goodall's program for children, reaches everyone from street kids in Tanzania (right) to schoolkids in Connecticut. "Teaching them to care for the earth, and each other, is our hope for the future," she says. "And if we can't give our children hope, we really might as well pack it in."

after meeting an orphaned infant and looking into those desperate eyes, can turn away."

"I THINK my institute is trying to kill me off," Jane says, looking waiflike in a rumpled raincoat at the municipal airport in Ithaca, New York. It is day 22 of her annual North American lecture tour, a 15-city marathon to raise funds for the Jane Goodall Institute (JGI), the nonprofit organization that supports her projects around the world. She has just arrived on a commuter flight from Durham, New Hampshire. Tomorrow she flies to White Plains, New York.

"They've got me doing four or five talks and meetings a day," she says. Her voice is croaky. Though she often travels with someone on her staff, today Jane is alone, carrying little more than a toothbrush, a change of clothes, and a pile of paperwork.

"Jane likes to travel, to do what she wants. She doesn't like to be managed," says Dilys Vass, director of the JGI chapter in England. "She feels at home wherever she is and never complains when planes get canceled or people don't show up. Africa training, perhaps."

Until recently another problem had added a nerve-racking urgency to her campaign: Her institute was going broke.

"Everybody would say, 'But Jane, you must have all the money you need,' " she recalls. "But by mid-1993 we were only four months from everything coming to a stop."

With revenues shrinking and project costs swelling—it takes $500,000 a year to run the sanctuaries alone—Jane hired a new director, Don Buford, a former political consultant from Texas with a knack for fund-raising. Since then contributions have doubled and membership increased sevenfold. Buford gives the credit to Jane.

"She has this boundless, optimistic enthusiasm that inspires people," he says. "She's not just a motivational speaker like some guy selling videotapes. She holds a lofty mirror up to what is best in us all."

"She's my hero," says Biruté Galdikas, whose studies of orangutans in Borneo, along with the late Dian Fossey's work with mountain gorillas in Rwanda, are frequently likened to Jane's. "She has this amazing effect on people, especially young women. I've seen

it many times when I've been on lecture tours with her."

At a reception for students at Cornell University, a ring of young women closes around Jane, who is describing how adolescent chimp females often leave their community to join another. Kimberly Phillips, a graduate student in genetics, asks what kind of welcome a female can expect from the new community.

"Well, the males are delighted," Jane says. "But the females beat her up. They don't want the competition. One strategy the newcomer can use, however, is to attach herself to a high-ranking female, even if she is treated badly by that female. The others will eventually accept her."

"God, it sounds just like high school," Kimberly says.

That evening at Bailey Hall, where Jane is to give a lecture, she sinks into an armchair backstage and closes her eyes. She is wearing black slacks and a black sweatshirt decorated with the names of Gombe chimps—her elementary school outfit. "Didn't have time to iron a dress," she says, a crooked smile on her lips, as if sharing a secret. I recall what her mother told me about Jane hating to bother with clothes as a child.

"She couldn't bear it," Vanne said. "One day I said, 'Look Jane, you have to have a new tunic.'

" 'Why?'

" 'Because the back of your tunic is going through. It's getting threadbare.'

" 'I'm not having a new tunic. It's a waste of money,' she said. 'Nobody looks at my back view. They look at my front.' "

The lecture at Cornell has been sold out for weeks. The hubbub of a thousand voices drifts behind the curtain to where Jane sits.

"I feel totally incapable of giving a lecture," Jane says. "I always do—until the moment I go out. Then I get something from all the people."

Tonight is no different. As soon as she hears the audience laugh at her first story, Jane's voice rises and she is off. She tells how, at the age of five, when she and her mother were visiting relatives in the English countryside, she followed a hen into a chicken coop to find out where eggs came from. As she squeezed inside, the terrified hen came flying out, squawking.

"That was when I learned my first lesson in what is essential for anybody who wants to study animals—patience," she says. "I hid in the straw at the back of the stuffy little hen house. And I waited and waited."

It was late afternoon, getting dark. She'd been missing for more than four hours. Her

Drinks are on the house at the Tchimpounga Sanctuary for orphan chimps. Older animals wait their turn as a keeper tends the youngest, still recovering from such nightmares as cramped cages, starvation, and the shock of seeing mothers shot by poachers. Built by Conoco Inc. after a Congo visit by executive Max Pitcher (bottom), now retired, Tchimpounga remains a company special project.

distraught family summoned the police.

"Then finally my mother, calling in the gloaming, saw this excited little girl come running across a field with shining eyes and straw all over her. And instead of scolding me, which would have taken away all the joy, she sat down to hear my story."

After the lecture a crowd jams the lobby of Bailey Hall, where Jane sits at a table signing books. Among those waiting is Patty Erickson, a 37-year-old mother of two, who swept cages at the Metro Washington Park Zoo in Portland, Oregon, when Jane visited in 1984.

"I wanted to meet her in the worst way back then," she says. "But I stayed in the back. Who was I, an unimportant zookeeper. But Jane noticed me somehow and went out of her way to say hello. When someone asked for a group photo, Jane called me over. I couldn't believe it."

Inspired by Jane's example, Erickson resolved to go back to school. She is now enrolled in Cornell's program in veterinary medicine.

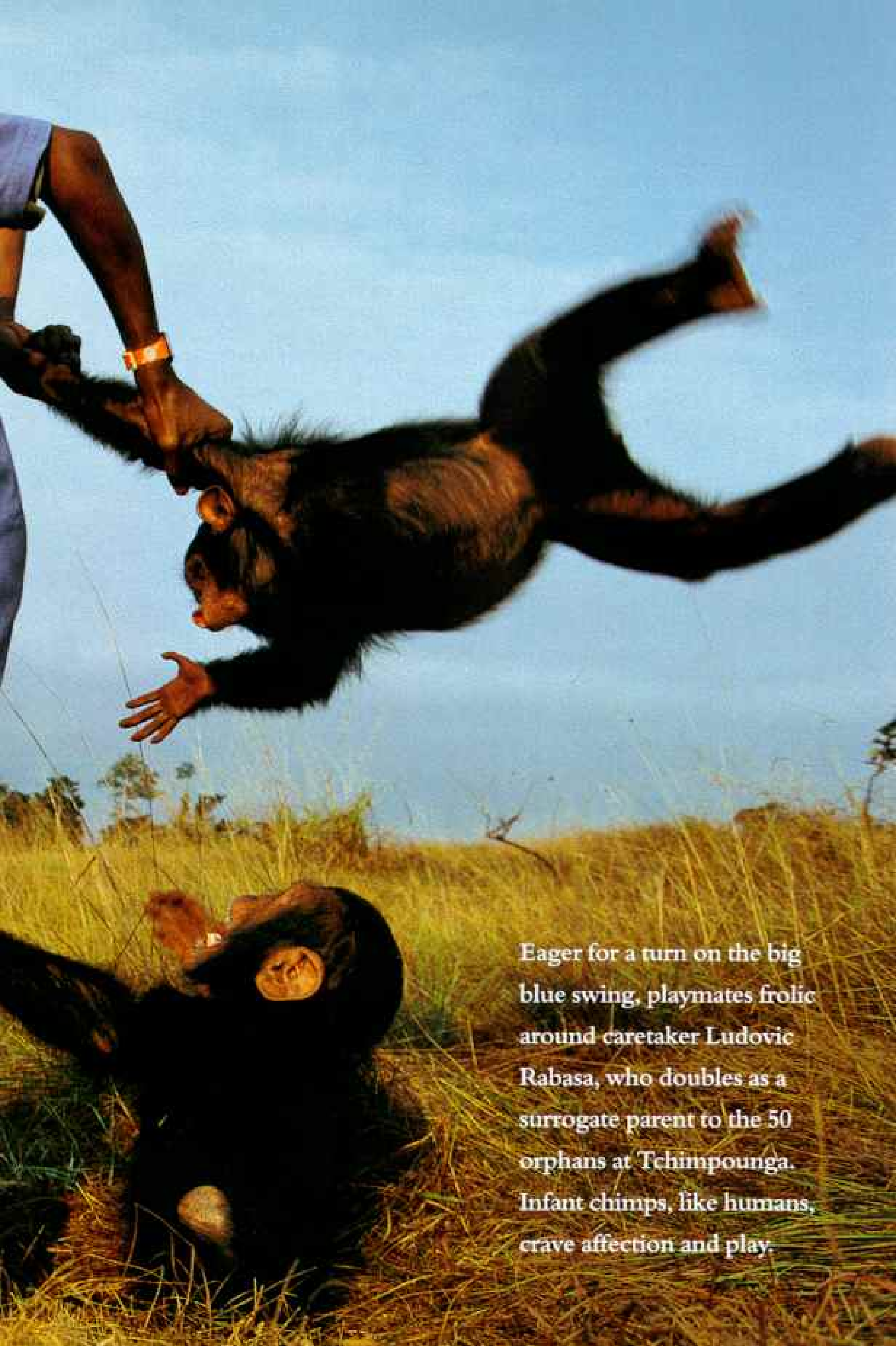
It is after 11 o'clock by the time Jane signs the last book at Bailey Hall. Yet her evening is not over. Another group is waiting at still another reception that will not end until after midnight. Ted Lazcano, a patrolman with the Cornell University Police, has been standing beside Jane for the past hour and a half. It's his job to be here, but he's also been listening to what people have been saying to Jane. And he's seen what she has written in their books: "Follow your dreams." As Jane puts on her raincoat and heads out the door, Lazcano reaches into his wallet and drops two dollars into the donation box.

THERE IS ANOTHER Jane Goodall aside from the one you want to hug. This one is relentlessly focused, impatient with excuses, and tough as nails. Just ask John Landon.

"Jane Goodall brutalized me for four years," says Landon, a genial, silver-haired executive whose company, Bioqual Inc., of Rockville, Maryland, uses chimpanzees to test vaccines for the National Institutes of Health. "She condemned me as one of the cruelest people in the world."

Landon's troubles began on a Sunday morning in December 1986, when a lab worker phoned him at home to say that four chimps were missing. They had been taken by a group of animal activists called True Friends, who had broken into the lab, copied records, and made a videotape of the cages.

A second group, People for the Ethical Treatment of Animals (PETA), edited the tape and mailed a copy to Jane in



Eager for a turn on the big blue swing, playmates frolic around caretaker Ludovic Rabasa, who doubles as a surrogate parent to the 50 orphans at Tchimpounga. Infant chimps, like humans, crave affection and play.

Bournemouth, where she was spending Christmas with Vanne and Olly. The tape showed a roomful of tiny cages resembling microwave ovens stacked on top of one another. Inside were young chimps rocking from side to side, apparently driven mad by their sterile, cramped confinement.

"We all sat watching the tape, and we were all shattered," Jane recalls in the 1993 book *Visions of Caliban*. "I had, of course, known about the chimpanzees who were locked away in medical-research laboratories. But I had deliberately kept away, knowing that to see them would be utterly depressing, thinking that there would be nothing I could do to help them. After seeing the tape, I knew I had to try."

Three months later, at the invitation of NIH, Jane visited the lab, which was then called SEMA, Inc. It was her first venture into what she calls the "nightmare world" of medical research. She was shocked by the listless chimps, whose eyes, she wrote, were "dull and blank, like the eyes of people who have lost all hope, like the eyes of children you see in Africa, refugees, who have lost their parents and their homes." When Jane left, she was crying.

Within days she denounced the lab in a lecture at the University of Maine, where

Landon's daughter happened to be a student. "If we shouldn't do something to humans," she asked, "should we do it to chimps?" She kept up the pressure during the following months, visiting other labs in the United States, where about 1,700 chimpanzees are kept mostly for research on hepatitis, AIDS, and respiratory viruses. She met with lawmakers and helped draft proposed changes to USDA regulations on cages. She held press conferences and gave interviews, accusing labs of subjecting chimps to conditions "not unlike concentration camps."

When Jane met Landon again at a scientific conference in 1991, she was surprised by his cheerfulness. "For years you were my worst enemy. I could have strangled you," he said. "But now I want to thank you and show you what we have done."

Landon had built 24 spacious new cubicles for his chimps, complete with glass walls, sleeping platforms, climbing equipment, and toys. The chimps, now kept in pairs, could see one another through the walls and play with lab workers, sometimes pressing their backs against the glass for a pretend scratch.

"When they moved into the new enclosures, their personalities changed. I could see it," Landon said.

Today he and Jane are friends. Instead of ripping into him in her speeches, Jane praises what Landon has done as a model for the future. "Of course I should like to see all lab cages standing empty," she says. "But as long as it is thought necessary for animals to be used in labs, they should be given the most humane treatment possible, and the best living conditions."

Still, there is much more to do, Jane says. The chimps at labs such as Landon's normally spend only two or three years in testing programs. Then they are shipped off to holding facilities, where they can live to be as old as 50. "Why should they be locked up like criminals?" she asks. "Having done their duty for science, don't they deserve better?"

Jane Goodall

"MIND THE DUCK," Jane tells me as I climb into an open boat filled with heaps of green bananas. The bird is trying to settle in beside a village woman nursing an infant. The woman has taken shelter from the rain beneath a plastic tarp. I find a place with the other passengers on the boat's slippery gunwales.

We are in Africa again, on our way from Gombe to Kigoma, 12 miles to the south along the shore of Lake Tanganyika. As the boat bangs up and down on the waves, the

Fast friends, a pair of orphans face the future together at Tchimpounga, whose very existence is a source of controversy. "Many conservationists feel it's a waste of money to build sanctuaries for orphaned chimpanzees," says Goodall, agreeing that saving habitat is important too. "But there are not many people who, after meeting an orphaned infant and looking into those desperate eyes, can turn away."

stern rises out of the water and the outboard motor races wildly. After 40 minutes of pounding, the battered bow springs a leak, and we are forced to pull into a fishing settlement for cotton to stuff in the seam.

Once we arrive in Kigoma, Jane and I are driven by minibus to the village of Mgaraganza, where Balagaye G. Balagaye, headmaster of the Mlati School, greets us beneath the shade of *msonobari* trees with canary yellow blossoms. There are 650 children at his school, seven to sixteen years old, with no paper or pencils and only a few books.

"Welcome, Dr. Janie, welcome, Dr. Janie, *karibu*, Dr. Janie, *karibu*, Dr. Janie," sings a class of teenagers who have waited years for this day. They are celebrating Roots & Shoots Week, part of the environmental education program Jane started in Dar es Salaam in 1991. Following Jane out into the sunbaked schoolyard, hundreds of youngsters gather around her as she plants a small shade tree. After patting the soil, she kneels to kiss the tree, and the children cheer. Many are holding seedlings to plant around the village.

Later, as we say our good-byes to the headmaster, he takes Jane aside to give her a letter of thanks. At the bottom he has written a list of items he urgently needs for his students: a radio, a camera, a globe, a new secondary school building—not necessarily in that order. Jane shakes her head and sighs.

"He doesn't realize that I don't have any money," she says.

As we climb back into the minibus, the students perform one last song. "Don't forget us, Mama Janie," they sing. "Don't forget us, don't forget us, until we meet again."

When Jane started Roots & Shoots, her aim was to raise the awareness of African children about animals and thus plant the seeds for future conservation. But the idea of a program for young naturalists caught on in the U. S., Canada, Germany, Japan, and more than 20 other countries as well, and now there are over 250 Roots & Shoots groups.

"Jane is the spark," says Martin Smith, the program director. "She infuses hope."

ON HER LAST MORNING at Gombe, as she is sipping a cup of coffee from her thermos, Jane hears a group of chimps hooting in the forest above her house. She slips on her sandals and sets out for the feeding station.

The first chimp to stroll out of the forest is Gremlin. Intelligent and affectionate, Gremlin inherited a natural dignity from her high-ranking mother, Melissa, who died in 1986. With Gremlin this morning is Galahad, her seven-year-old son, and Gaia, her two-year-old daughter.

Fifi and her family make their entrance next. Carrying little Ferdinand on her back, Fifi gives Gremlin a kiss on the lips, then sits down at Jane's feet beneath a palm tree, swinging Ferdinand around into her lap.

"Here you are, my sweetheart," Jane says. I am reminded of the wide-eyed girl who first came to Gombe years ago, with her long blond hair and high-top basketball sneakers, knapsack slung across her back. At moments like this, that young girl, as Jane once recalled, "is still there, still part of the more mature me, whispering excitedly in my ear."

Fifi's son Faustino, feeling his oats, chases his buddy Galahad around the trunk of the palm. Five, six, seven times. Then Goblin wanders out of the forest, and Gremlin, his sister, gets up to greet him. She sits down next to him and grooms his back. The sky rumbles with distant thunder, and a wave of mist cascades over the deep green forest up on Sleeping Buffalo Ridge.

"I can't imagine a better morning," Jane says.

Suddenly the clouds open and it pours. We all rush inside the feeding station. To everyone's surprise, Fifi troops right in behind us, sitting in the doorway with Ferdinand in her lap, her long black hair glistening with rain. Jane is mesmerized by this gesture of trust.

"Just think of all the knowledge packed into that head," she marvels, her eyes fixed on Fifi. Another crack of thunder, and Fifi turns to leave. She ambles off down the path to rejoin her species, lugging her baby along.

The chimps have worked their magic on Jane once more. For a moment she has forgotten her crusade to promote chimpanzee research, save orphan chimps, improve the lives of lab animals, and inspire human children. Filled with new energy, she is suddenly up and running, chasing Michael Neugebauer around the inside of the building. Around and around they go, like Faustino and Galahad. Jane is crafty, faking one way, then going another. She catches him and laughs. And the cares of the world, for a while, are lifted from her heart. ***

A Message from Jane Goodall

A FEW YEARS AGO a chimpanzee named Joe-Joe was fighting with another chimp at the Detroit Zoo and fell into a water-filled moat. Chimpanzees don't swim. Three times he came to the surface, gasping for breath, and then he was gone. Fortunately, a visitor to the zoo, Rick Swope, quickly jumped in after him. Grasping the 135-pound dead weight around the middle, Rick heaved Joe-Joe onto the steep bank.

With security guards yelling warnings of danger, Rick turned to rejoin his wife and three frantic children. But suddenly Joe-Joe, still unconscious, began to slide back into the water. Rick rescued him again, holding him on the bank until he came around. Rick then looked up, just in time to see the other male chimp rushing toward them, hair bristling, canine teeth bared in a scream. Vaulting the enclosure fence, the rescuer narrowly escaped what could have been a savage attack.

The scene was captured by a woman with a video camera, and that night the story was flashed across America's TV screens. One of my colleagues saw it and called Rick. "What you did was very brave. You must have known it was dangerous. What made you do it?"

"Well," said Rick, "I looked into his eyes. It was like looking into the eyes of a man. The message was, Won't anybody help me?"

I know that look well. I have seen it in the eyes of chimps tied up in African markets, locked behind the steel bars of laboratory prisons, or chained beneath the frills of the circus. I have also seen it in abandoned, abused human children, in youngsters desperate to rise above the inner city or the poverty-stricken village. So many problems, so much suffering, for humans and nonhumans alike. Poverty, malnutrition, disease, pollution. And violence—in war-torn Africa and across the developed world, with gangs, drug abuse, homicides.

As I write these lines at my home in Dar es Salaam, I feel overwhelmed. We love to point fingers when we try to deal with difficult problems such as the environment, to lay the blame on industry or science or politicians. And there is no question that industrialization has polluted our surroundings. But who buys the products? We do, you and I, the vast, amorphous general public. Each of our actions has a global impact.

That is why each of us must do our part, no matter where we live, in city or countryside, in Africa, America, or elsewhere. In Tanzania we spread this message through song. When our conservation team, led by project manager George Strunden, visits a village, our women's choir entertains. Then the team shows residents how to set up nurseries for fruit trees. With every seedling the villagers plant, they join the global struggle.

Children are quick to see the value of individual action. All around the world, when I talk to them, I find them aware that they are part of the problem, convinced they can make a difference, and eager to help, just as Rick Swope did for Joe-Joe. Therein lies our hope—more and more people are opening their hearts to the desperation they see around them and springing to action. For this is how we can attain our human potential for compassion. And for love. □

FLASHBACK

■ FROM THE GEOGRAPHIC ARCHIVES

A 32-mule-team harvest

Muscling a combine over undulating fields, mules generated the horsepower to reap a Washington State wheat crop in the early 1900s. "Two mules led the team," says 88-year-old Edna Slusser George, who as a young girl helped on her family's nearby farm. "You were at its mercy if a mule decided not to pull its share. We kept a bucket of pebbles by the seat up top to toss down on the backs of the laggers. We didn't hurt them—just reminded them that they were working along with us."

Driving the mule team shown here, farmer Robert Mires spent a month harvesting 1,200 acres. His grandson Darrel—who grows wheat on the same land today—can do the job in one-third the time with his gas-powered combine. "I don't own even one mule," he says.

This photograph ran in an April 1922 GEOGRAPHIC article titled "The Scenery of North America."

ASAHEL CURTIS

Steller's Sea Eagle *(Haliaeetus pelagicus)* **Size:** Length, 1 m; wingspan, 2.5 m **Weight:** 5.5 – 9 kg **Habitat:** Coastal regions of eastern Russia and Hokkaido, Japan **Surviving number:** Estimated at 6,000 – 7,000 Photographed by Eiji Ishii

WILDLIFE AS CANON SEES IT

In the frigid, subarctic climate of Hokkaido, over 2,000 Steller's sea eagles gather every winter to feast on an abundance of fish. Called *o-washi* in Japan, these imposing eagles leave their roosts before dawn and spread out across the Nemuro Channel to fish, resting sometimes on platforms of sea ice. The Steller's sea eagle is especially vulnerable to coastal disturbance due to its restricted breeding and wintering ranges. To save endangered species, it is vital to protect their habitats and understand the role of each species within the earth's ecosystems. As a global corporation committed to social and environmental concerns, we hope to foster a greater awareness of our common obligation to ensure that the earth's life-sustaining ecology survives intact for future generations.

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NATIONAL GEOGRAPHIC

DECEMBER 1995

The Cover

Jane Goodall is groomed by Grégoire, a chimp at the Brazzaville Zoo in the Congo. Photograph by Michael Nichols

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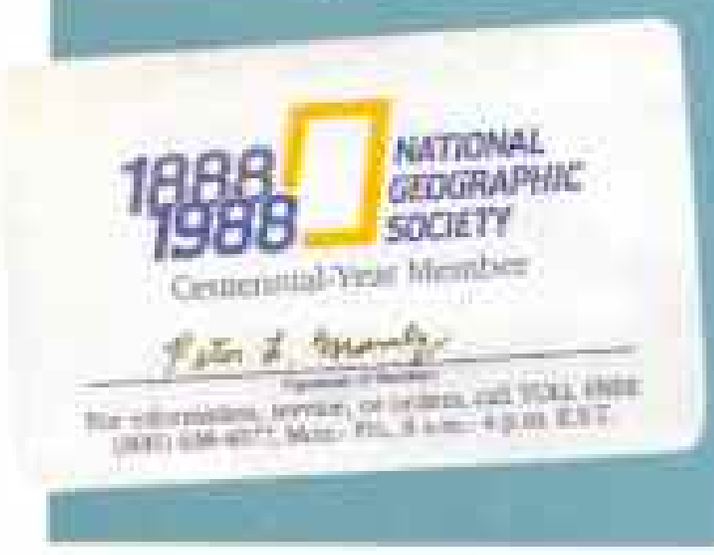
NATIONAL GEOGRAPHIC

Behind the Scenes

Don't Leave Home Without It

WHEN SOCIETY MEMBER Peter Manly arrived in South America as a volunteer on an astronomical expedition, carrying thousands of dollars' worth of equipment, he was detained at customs for importing "luxuries." Officials demanded a hefty cash duty. "They kept asking for more identification, so I searched my wallet. Then that little card with the golden rectangle appeared. '¿*La Nacional Geografic?*' one man asked. Suddenly the mood changed. I wasn't a smuggler but a welcome scientist. A guard even carried my luggage."



Like Father, Like Son

SOME KIDS have all the luck. Throughout his childhood Bryan Harvey traveled the world with his father, photographer David Alan Harvey, as here in Malaysia in 1976. So when National Geographic EXPLORER wanted to profile a photographer in the field, it chose independent filmmaker Bryan Harvey, now 28, to produce the show. The subject? His dad.

The pair spent several weeks in Puerto Rico last spring; David shot the land and its people, and Bryan shot David. "I don't like to separate my life from my work," says David. "Bryan is a big part of my life."

Says Bryan, "It's my father's fault that I'll never work a desk job."

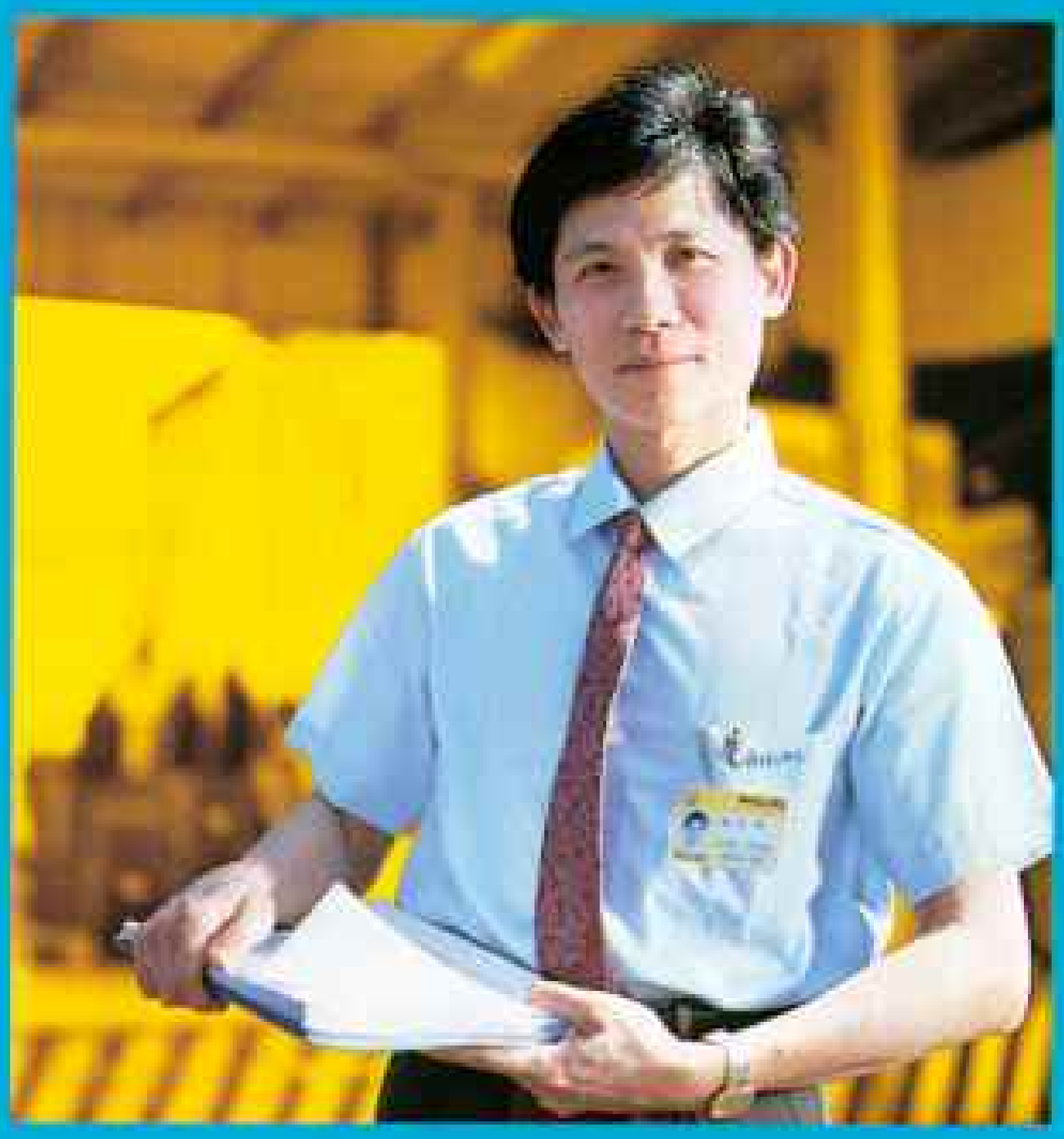
■ FAVORITE PLACES

Queen Charlotte Islands

OUR GLOBE-TROTTING STAFF is often asked about memorable travels. Expeditions Editor Peter Miller recalls the Queen Charlotte Islands' rain forests, where velvet mosses upholster the ground so thickly they even muffle the sound of your voice. "There is something about the quiet there. Stepping through the trees, you get the feeling of being somewhere sacred. And you are." The islands off British Columbia have been the homeland of the Haida people for some 10,000 years.

SAM ABELL

First we aim for perfection, then we redefine it.



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Mike Chang, Engineering Manager, Monitor Factory,
Tanyuan, Taiwan.

Perfection is obvious once it's achieved; but like climbing a mountain, there are many false peaks on the way. Nowhere is this more true than in computer hardware.

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PHILIPS

ROBERT CAPUTO

Words To Live By

"DON'T WALK where the cows haven't" is the minefield motto followed by staff writer Charlie Cobb in war-torn nations. In Zimbabwe Charlie faced a field studded with explosives; a path trampled by livestock showed him the way out.

For a 1996 article Charlie reports on now peaceful Eritrea (above), also the subject of an Africa News Service documentary aired on National Public Radio that won him a 1995 National Association of Black Journalists Award and a Harry Chapin Media Award from World Hunger Year.

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Ducking the Question

IN VIETNAM photographer Mike Yamashita saw ducks everywhere—in fields, in yards, crated in trucks. But every time he tried to order roast duck, his local translator told him, "Not on the menu." Then at one meal Mike asked a U. S.-educated Vietnamese agronomist, who pointed to an entry. Queried further, Mike's translator said, "Oh, I thought you said 'dog.'"

■ RECENT SIGHTING

The Movie *Waterworld*

THE GEOGRAPHIC makes a surprise splash in the costliest film ever made when Kevin Costner's character (right) uses mocked-up magazines to confirm existence of dry land. Says producer Dave Fulton, "In *Waterworld*, finding the GEOGRAPHIC is like finding buried treasure."

BEN GLASS, UNIVERSAL STUDIOS

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Forum

Sicily

I found Jane Vessels' article on Sicily (August 1995) beautifully written, incisive, and precise. It conveyed accurate information about and empathy for a people and a current and historical situation. I have lived my life among Italian immigrants, many of them Sicilian, in east Utica in upstate New York. The article ran like an electric current among Sicilian Americans here. Everyone was reading it and touting it to their compatriots. It is what I feel a model GEOGRAPHIC article should be.

EUGENE PAUL NASSAR
Director, Ethnic Heritage Studies Center
Utica College of Syracuse University
Utica, New York

We take offense to the reference to Palermo as being an ugly and barely functioning city. We have walked all of Palermo; it is picturesque and historic, and while not without problems, in no way is it ugly.

D. A. AND J. A. DeLISE
Troy, Montana

The article focused too much on the Mafia's role in Sicily, a topic that sadly has become too commonplace in the American media.

MICHAEL GIAMMARELLA
New York, New York

Saving North America's Bats

As an electrical engineering graduate student, I find bats' navigation and detection capabilities nothing short of exceptional and certainly unmatched by man's most advanced technology. However, I couldn't help but think of an alternate title for the article: "Bats Experience a Real Estate Boom."

A. FARRAS ABDELNOUR
New York, New York

A native Texan, I was reminded of a bat-watching technique we used to thrill guests on the Burnett Ranch near Wimberley. A portable spotlight laid on the roof of a car, pointing up, attracted lots of night-flying insects. The bugs found the light and the bats found the bugs, sometimes swooping right over our heads.

ALLEN D. McASHAN III
Aurora, Colorado

Silver-haired bat rabies is identified every year or two in New England and New York State. This virus caused a death two years ago. I would caution anyone exhibiting a live bat to hold the animal in quarantine for at least two months. Second, everyone—especially children—should be warned about the need to report any contact to a physician, so that, if necessary, a vaccination program can be initiated.

LAMSON BLANEY, M.D.
Mansfield Center, Connecticut

National Geographic Photographers

I had considered your staff work as "a good way to make a living." It is much more. It is a passion and a dedication that eludes most of us everyday people. Now I will go back to my collection of GEOGRAPHICS and look at it with different eyes.

DANTE F. ROCHETTI
West Hills, California

This otherwise great issue was tarnished by 20 pages of pure schlock. "Reel to Real" is perhaps the worst example of media self-glorification I've ever encountered.

MICHAEL DOWNEY
Helena, Montana

For 25 years I have taught art education and shared the magazine with students, even though the younger children can't read the material. Cathy Newman's article is wonderful for our discussion time; we have talked about the dedication of photographers and the importance of good writing skills. Students need models to understand that hard work, perseverance, and attention to detail are important in all jobs.

CARLETTA WALLENFANG
Green Lake, Wisconsin

I'm a professional photographer and have always admired the quality of your photographs. But I have to chuckle over how much film and equipment your photographers pack. I sometimes think it is overkill.

CHARLES McENIRY
Stoughton, Wisconsin

Ever since I was little (I am 13), I have wanted to be a photojournalist for NGS. Everyone told me I was strange. Most girls have role models like movie stars or models, but mine was Jodi Cobb. I have studied a lot about photography and NGS, but now I've learned that it's more than just writing stories and taking pictures; it's really seeing and understanding.

CASSANDRA HARTLEY
Sandy, Utah

Hiroshima

The day your August issue arrived, my father recounted returning from a three-day combat patrol against the Japanese on Luzon. When he learned that the atomic bomb had effectively ended World War II and there would be no invasion of Japan, his single thought was, Now I'll live. On Okinawa my mother, a combat nurse, realized that the flood of casualties anticipated would not appear.

As horrifying and costly as Hiroshima and Nagasaki were, without the introduction of the atomic bomb, the price would ultimately have been many times higher.

DAVID PETERSON
Berkeley, California

I remember the afternoon of August 5, 1945, when I stood beside the *Enola Gay* and watched as they winched the bomb from the pit into its silver belly. I remember when we flew over the flattened, devastated, brown city of Nagasaki surrounded by its lush green mountains. I think of the *hibakusha*, and I sorrow. Then I remember how happy I was when our B-29 flew over the battleship *Missouri* in Tokyo Bay, and the war was all over.

GEORGE E. GLAWE
Las Vegas, Nevada

The Chinese sage Mencius asked the rhetorical question, "Is there any difference in killing a person with a club or a knife?" Of course there isn't. The victims of Hiroshima deserve the same sympathy, but not an iota more, as the tens of millions of Chinese civilians who died from Japanese atrocities during World War II.

MARSHALL CHAO
Midland, Michigan

Servicemen were not the only ones saved by the A-bomb. Do not forget all the prison camps with Europeans and Eurasians. I am a former "guest" of a women and children's camp in Bangkinang on Sumatra. Our nanny was lamed; my younger brother and I, almost 6, barely made it. I am sorry to say I do not feel any compassion for the A-bomb victims, but I do for the orphans, even though their parents murdered my parents. None of the Japanese speaking in this article acknowledged the "why" of the A-bomb. Don't they know of the cruelties their people performed for years? I want to stop hating; I don't know how.

ELSKE BOSWIJK
Zandvoort, The Netherlands

I am a 14-year-old, and the article opened my eyes about nuclear bombs. I knew they could inflict terrible wounds, but I didn't understand or believe that they could be so cruel. I had no idea what impact the A-bomb had on the city and the people.

ANGHARAD THOMAS
Bridgnorth, Shropshire, England

African Voodoo

When I was a Peace Corps volunteer in the Ewe region of Ghana, I enjoyed daily contact with the adherents of voodoo, so wonderfully evoked in your article. Often as I lay awake in the hot evenings, breezes would bring the sound of Ewe drums, layered upon the rich voices of a people in contact with a world strange and distant, yet right outside my window. The Ewe I knew were hard-working teachers, doctors, farmers, and mechanics no different from ourselves, yet infused with the faith of a religion brimming with love and power.

SCOTT R. SLUSHER
Fort Collins, Colorado

While I cannot claim to explain everything the authors describe, some of the "mysteries" are explainable by well-known physical principles. I do demonstrations of inertia for physics classes that are as spectacular as the mortar-on-the-chest episode. Other instructors accomplish feats such as fire walking or dipping hands in molten lead to show that vaporizing moisture can provide a protective barrier against intense heat for a short time—an explanation that I suspect applies to the hot knife on the tongue.

DAVE TOOT
Associate Professor of Physics
Alfred University
Alfred, New York

I was disturbed by the article on what we Haitians respectfully label *vodou*, *vodun*, or *vaudou*. The spelling "voodoo" itself is a misrepresentation. Vodou's African roots and values are not discussed, leaving only a graphic depiction of exterior manifestations and peak experiences that outsiders are clearly not able to penetrate. Vodou is a philosophy of life, a world view, an all-encompassing, spiritual mode of living.

CLAUDINE MICHEL
Department of Black Studies
University of California, Santa Barbara

Bowhead Whales

I have had the privilege to see the beautiful bowhead whale myself but in a different and more remote part of the Arctic. On a ski expedition in April 1993, a friend and I crossed from Franz Josef Land to Spitsbergen and saw three or four bowheads in a lead just north of Alexandra Island. When I showed photographs of the whales to the Norwegian Polar Institute, they told me that bowheads were believed to be extinct in that area of the Arctic. Now they estimate that 50 to 100 bowheads are breeding there.

BØRGE OUSLAND
Oslo, Norway

Your article on bowhead whales has failed to note that the Alaska Eskimo hunting technique—the use of traditional harpoons—possibly prolongs the animal's suffering. Modern harpoons usually kill the animal within minutes. On the other hand, traditional harpoons do not kill upon impact. The whale bleeds and struggles until it finally loses its strength and is taken.

ANNY H. WONG
Honolulu, Hawaii

Behind the Scenes

I'm so gullible! I too spent time in the library in search of the real Robert Kincaid. Thank you for your explanation in the July issue. It has prompted me to renew for two years instead of one. By the way, how about a story on the bridges now? You've already got a great cover.

BARB MICEK
Chicago, Illinois

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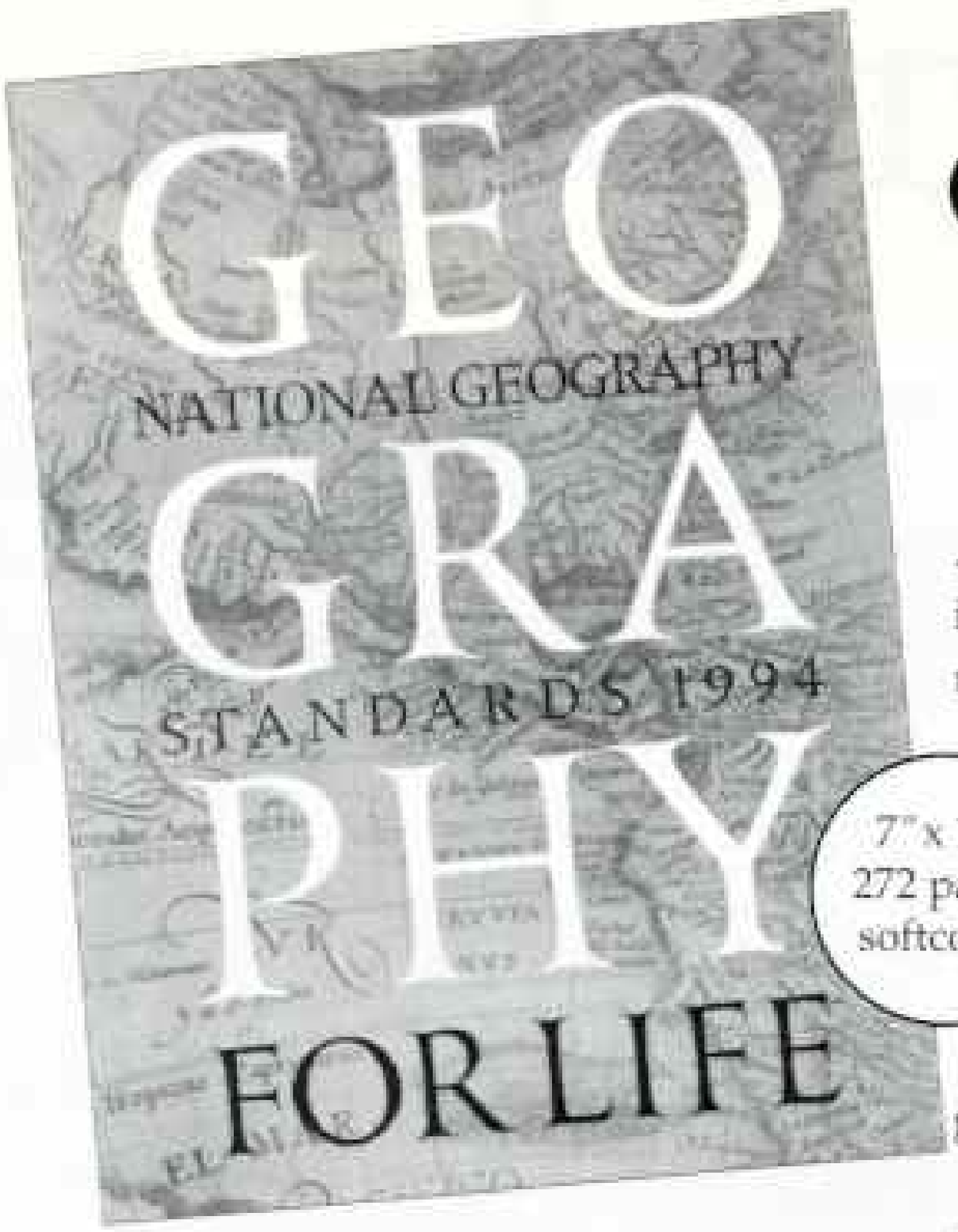

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The Short, Dangerous Life of a Waterspout

SCOTT NORQUAY was painting his house on Lake Winnipeg when he spotted "wispy spouts reaching from the water to the clouds" across the lake. For 25 minutes the Manitoba dentist photographed this pair as "they came closer and closer, until I got scared and ran for cover."

Good idea. A spout is potentially lethal, literally "a tornado on water," says NOAA's Joseph Golden, the world's leading expert on the phenomenon. One killed a Chicagoan windsurfing on Lake Michigan in 1993. A waterspout is a column of rotating wind that develops downward from a line of cumulus clouds to the ocean or a lake. Spouts can pack winds up to 200 miles an hour and move 10 to 15 miles an hour. The funnels Norquay spotted were notable because waterspouts rarely appear so far north.

The Florida Keys are the world's waterspout capital, according to Golden. While filming a waterspout in the keys for a National Geographic Television Special airing November 29, he watched from a helicopter "in horrified amazement" as a large boat sailed into the spout. Luckily the waterspout was breaking up, and no one was hurt.

SCOTT NORQUAY, TOM STACK & ASSOCIATES

Fighting to Save Pearl Harbor's Last "Veteran"

BETTMANN ARCHIVE (TOP); JAMES A. SUGAR

DECEMBER 7, 1941: Struck by a hail of Japanese bombs, the sinking battleship *Nevada* struggles to avoid blocking Pearl Harbor's major channel to the open sea. A small tugboat, *Hoga* (top, at right), races in, shoves *Nevada* out of the channel, and beaches the helpless giant. *Hoga*'s 11-man crew battles blazes on the *Nevada* for hours, then spends two days fighting fires on the disabled battleship *Arizona*.

Today the 100-foot-long *Hoga* is the sole surviving Pearl Harbor vessel still afloat in the United States. She is docked at Treasure Island Naval Station in San Francisco Bay.

Built in 1940, *Hoga* —the Sioux word for "fish"—won praise from Adm. Chester W. Nimitz, commander of the Pacific Fleet. Of skipper Joseph McManus and his men, he wrote that each worked "in a most efficient manner and exhibited commendable disregard of personal danger" throughout the ordeal. *Hoga* served at Pearl Harbor for the duration of World War II, then was shipped to San Francisco Bay, where, as *City of Oakland*, she was a fireboat for 45 years, retiring in 1993.

"*Hoga* has been obscured in history by bigger ships, but she was the little boat that could, and did," says Daniel A. Martinez, National Park Service historian at the U.S.S. *Arizona* Memorial. Martinez is an adviser to a group called Friends of *Hoga*, which is raising money in hopes of repairing her, returning her to Pearl Harbor, and restoring the Navy gray she wore in 1941.

KENNETH JAMES/S. CONTACT

Blackfeet Hail Spanish Mustangs

TO THE BLACKFEET, the pony formed the heart of their culture. Brought to the New World in the 16th century by Spanish colonists, the tough, maneuverable mustangs were adopted by the Plains Indians, who used them to extend their nomadic, buffalo-hunting ways. But after the Blackfeet were settled on a Montana reservation in the 1880s, farm horses replaced the mustangs, which by 1910 had almost vanished.

Bob Brislawn of Oshoto, Wyoming, kept the breed going. Recently his son Emmett sold the Blackfeet two yearling stallions and six mares, which roam the Browning, Montana, ranch of Darrell Norman. Says Norman, "This is a part of our culture coming back to our people." Tony and Sheldon Ground (left) helped break the steeds that, the Blackfeet hope, will launch a tribal herd.

—BORIS WEINTRAUB

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DAVID DARBER, SPL/PHOTO RESEARCHERS

■ EXPLORER, DECEMBER 10

The Sun and the Moon: Orchestrators of Nature

CELESTIAL CONDUCTOR, the sun is captured in time-lapse photography (above) as it sets on September 23, 1986—the autumnal equinox, when day and night are of equal length around the world. Thus does night follow day, and day follow night, in nature's most powerful cadence.

EXPLORER's "Rhythms of Life" investigates how this cosmic music organizes the daily and seasonal lives of animals and plants.

Each morning jellyfish swarm to daylight to nourish the food producers—brown algae—that grow in their translucent bodies. Every evening sea urchins come out to graze. In between, bathed in the pale light of afternoon, a riflebird spreads his plumage, inviting his mate to dally.

Of all earth's creatures, only humans seek to defy the celestial pulse of the planet. Yet we stream into cities at daybreak like schools of fish on a reef. And like birds to roost, we hurry home to our nests before dark.

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Why the Birds Really Went Berserk

TERROR WIDENS THE EYES of actress Tippi Hedren, slashed by gulls in Alfred Hitchcock's movie *The Birds*. Hitchcock was intrigued by a 1961 incident in Santa Cruz County, California. Seabirds, inexplicably unable to fly, staggered around coastal towns and bit several people.

Biologist David Garrison and his colleagues at the University of California at Santa Cruz may have solved the mystery — they think the birds were poisoned. Ocean waters sometimes bloom with plankton that produces domoic acid, often toxic. If anchovies eat the plankton, and if seabirds eat the anchovies, the birds may suffer widespread neurological damage, Garrison says. In 1987 four people died after eating mussels containing domoic acid.

New Life for Old Disks

MILLIONS of computer disks bite the dust around the world every day and wind up in incinerators, where several kinds of plastic release toxic gases, or in landfills. Such numbers mean business to David Beschen, president of GreenDisk, an environmentally friendly company that recycles computer disks.

Each month his employees in California and Washington process about two million disks, most from obsolete software that was never sold. The manufacturer's information is erased; the disks are reformatted and repackaged for sale. Most disks are sold to corporations and government agencies. The company also recycles consumers' used disks, which must be broken down, mixed with new materials, and remade.

RICHARD DIWINS

Eagle Eyes Watch Desert Eagles

NOT FAR FROM Phoenix, Arizona, dwell some very special birds—30 pairs of bald eagles that nest in the Sonoran Desert. Last spring's record 25 chicks included the one shown below. Scant prey and scarce nesting sites on trees and ledges limit the population, increasingly vulnerable to disturbance by recreationists from mushrooming Phoenix.

Every year since 1978 human mother hens have fussed over the eagles in a nest-watching program sponsored by the Arizona Game and Fish Department. Screened and trained, some 20 volunteer biologists set up camp near eagle nests and scrutinize them from February through May.

"They warn away visitors who come too close. We also have buoys on some lakes to keep boaters away from nests on shore," says Game and Fish spokesperson Susan Sferra.

GREG BEATTY, ARIZONA GAME AND FISH DEPARTMENT

Another concern is biological. Most bald eagles don't breed until they are at least five years old. But many of the desert eagles are breeding before that age, and older eagles are disappearing.

Is Newfound Frog Already Croaking?

DISCOVERED ONLY seven years ago, a new species of frog hopped out of an Arizona pond. It delighted Creighton University biologist James Platz, who dubbed it *Rana subaquavocalis*—underwater talker—because of the mating calls males emit while submerged, rare behavior in frogs.

Of the Ramsey Canyon leopard frog, as it is better known, 60 adults were counted in a pond on the Nature Conservancy's Ramsey Canyon Preserve and two others nearby. But last spring only 25 turned up. A clue: Algae that the tadpoles eat had vanished.

Now biologists are raising tadpoles in tanks supplied with the algae, and a new breeding population is being established at another preserve pond.

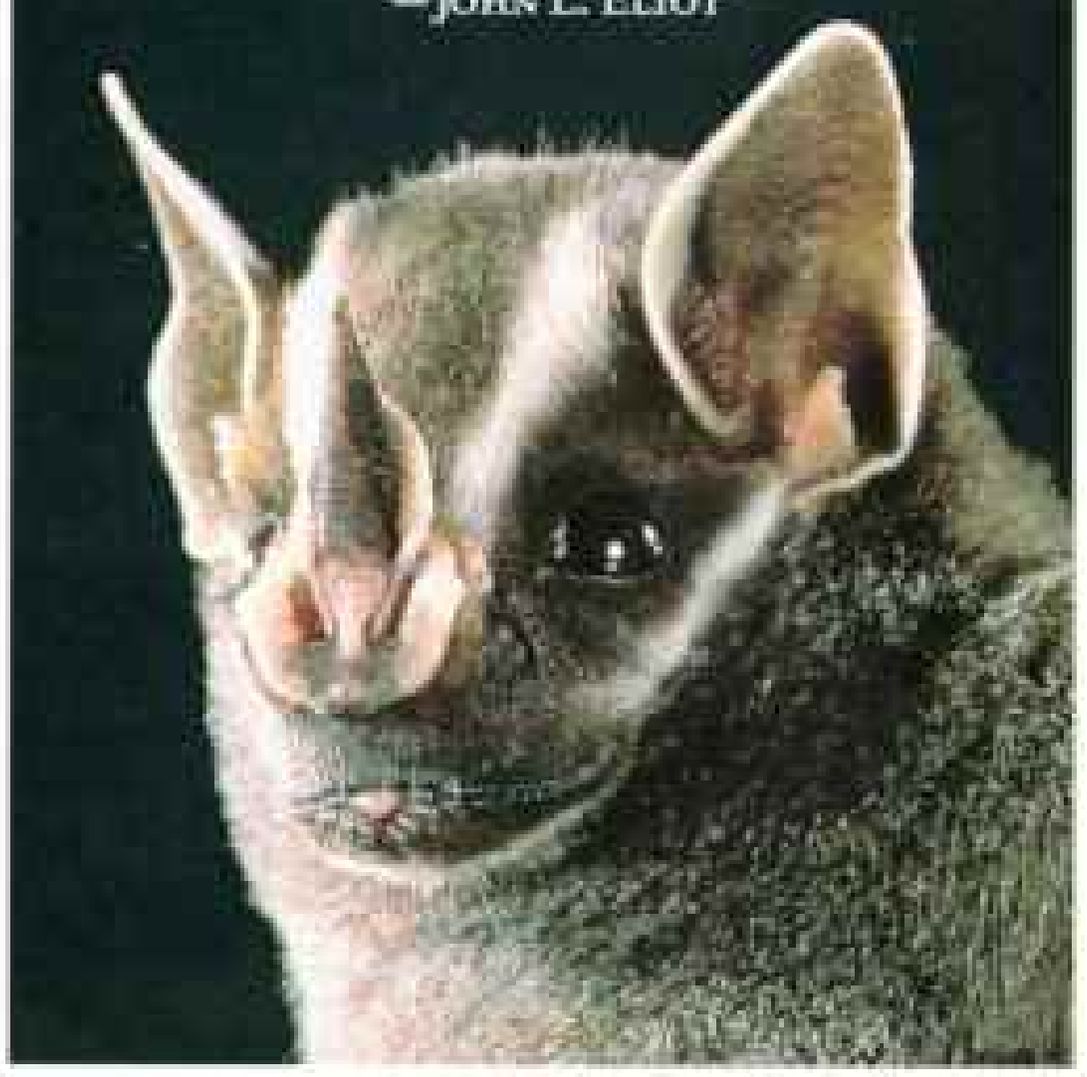
CECIL SCHWALBE

JAE C. CHOE

Bat Umbrellas Foil the Rain

DESPITE DELUGES, a clever little veteran of Central and South America's rain forest stays dry by building elaborate tents of leaves. Eighteen bat species are known to chew a single leaf's rib until it droops to make a shelter. But Peters' tent-making bat (below) boasts expedition-strength tents; it gnaws as many as 14 leaf ribs in a spiral until the leaves overlap like an umbrella. The ingenuity of this bat was discovered by Harvard University biologist Jae Choe. On a Panamanian island, he found 25 shelters, most made from *Coccoloba manzanillensis* leaves; a tent of genipap leaves (above) appears to be the same species' handiwork.

—JOHN L. ELIOT



(VAMPYRODES BILIDIATUM) MERLIN D. TUTTLE, BAT CONSERVATION INTERNATIONAL

NATIONAL GEOGRAPHIC

On Assignment

■ A FARMING REVOLUTION

How to Handle a Camera Hog

"I GREW UP on a farm," says photographer JIM RICHARDSON, "so I speak fluent pig." The skill didn't help much while he was documenting an Iowa hog pasture for the article on sustainable agriculture. This curious piglet petitioned for a close-up, "then tried to eat my lens shade, then my shoes."

Jim learned photography on that boyhood farm in Belleville, Kansas. As a 12-year-old armed with an old folding camera, he specialized in "bugs, sunsets, and lightning strikes" in the woods behind his house. After attending Kansas State University in Manhattan, he shot for newspapers in Topeka, Omaha, and Denver, then turned freelance.

"In a way, it was like going home again," Jim says of photographing farms. "I know from experience what farmers worry about: weather, water, making ends meet. But this story dealt with a whole new spectrum of things I'd never even heard of. The challenge was showing the diversity. You can take only so many pictures of people riding tractors."

Jim and his wife, Kathy, live in Denver with their son, Tyler. They own no pigs.

MICHAEL NICHOLS (ABOVE); JIM RICHARDSON

■ JANE GOODALL

The Millers' Tale: Passing the Phone

IN GOOD HANDS, an orphaned chimpanzee cuddles with author PETER MILLER at Kenya's Sweetwaters Game Reserve. "Don't tell my kids," jokes Peter, whose two sons are grown, "but baby chimps are twice the fun of human babies."

Peter earned his doctorate from the University of California at Irvine, then wrote for newspapers before joining the GEOGRAPHIC staff in 1979. He first met Jane Goodall by long-distance telephone in 1987. "She called my house from England," says Peter. "My son Matthew answered. 'It's Jane Goodall!' he whispered, passing the phone to my son Charley. He told Jane I'd be right with her, then handed it to my wife, P. J.—who told her the same. We all wanted to say we had talked to Jane Goodall!"

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NATIONAL GEOGRAPHIC

Geoguide

Farming the Natural Way

Keeping an eye on her cat, Hallie Muller (above) helps her parents milk on their organic farm in California. In Wisconsin, Ross Smith uses his cultivator and plastic, rather than herbicides, to keep strawberries weed free.

■ As you read the article about sustainable agriculture, can you list at least six techniques farmers use to enrich soil and protect crops without using chemical fertilizers and pesticides? What are the advantages of these techniques? Which ones could you use in your garden?

■ A weed is not a special kind of plant; it's simply a plant growing where you don't want it. The same plant we value in a wild meadow might be called a weed among farm crops—or in your garden. Why are weeds undesirable among crops? Why are cover plants such as clover grown between rows of corn or grape vines better for the crops than weeds growing there?

■ To see the effect of weeds, you can try an experiment at home. In each of two small pots of fresh soil, plant a few flower or vegetable seeds. In one of the pots also plant a generous amount of grass seed to produce "weeds." Water the soil as needed. As the plants grow, compare those growing in "weeds" with those growing in plain soil.

■ One farmer said that he had to take care of the soil—otherwise it would blow away. What else can happen to soil if a farmer doesn't take care of it?

■ As farms have grown larger, farming towns have shrunk. Why? How might sustainable agriculture affect the population of farming towns? Why?

BOTH BY JIM RICHARDSON

USE GEOGUIDE ALONG WITH THE ARTICLE "A FARMING REVOLUTION" IN THIS ISSUE TO HELP CAPTURE THE INTEREST OF YOUNG READERS AND STIMULATE DISCUSSION WITH THEM. GEOGUIDE IS FEATURED FOUR TIMES A YEAR.