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THE REDWOODS are in danger again. The latest battle in this long war between beauty and utility, between cutting and conserving, centers on a bill now before Congress to enlarge the Redwood National Park before erosion caused by nearby clear-cutting destroys the grove containing the world's tallest tree.

National Geographic's continuing coverage of the magnificent redwoods of northern California is nearly as old as the Society itself. A 16-page article called attention to these natural wonders—and to the widespread cutting even then taking place—in May of 1899.

The Society came to the rescue of the trees in what is now Sequoia National Park by subscribing $20,000 in November 1916 to supplement a Congressional appropriation that had fallen short. The event was optimistically reported in the GEOGRAPHIC: "Our Big Trees Saved."

Another article, in June 1920, ended with an astounding bit of prophecy—that the tallest tree on earth would be found along Redwood Creek. Just so, for in 1963, the magazine's senior scientist, Paul A. Zahl, did discover the world's tallest tree at a bend in Redwood Creek. It was 367.8 feet high and stood in a grove that also contained the second, third, and sixth tallest trees.

In that year the Society supported a study undertaken by the National Park Service, which was concerned that the once mighty forest had been cut away to 13 percent of its former size, and at a rate that would remove all the remaining virgin timber by the end of the century.

A proposal, based on that study, called for the creation of a new national park to save the tallest trees. It won the approval of Congress, but only after compromises with the timber companies had produced a dangerously distorted park unit along Redwood Creek—a corridor called "the worm," eight miles long and only half a mile wide. It lies in the midst of a forest that is now being cut down (pages 360-61). The pending legislation would increase the park boundaries by 48,000 acres and provide retraining and replacement funds for hundreds of jobs—all at a cost of $411 million.

If we have learned anything since 1899, it is that problems can be solved only at a price. And this we also know: It took 600 years for those trees to grow—and would take another 600 to replace them.

Gilbert M. Grosvenor

NATIONAL GEOGRAPHIC

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COVER: *Wristwatch adds a modern touch to the traditional costume of a young Norwegian Lapp, at summer pasture with his family's reindeer. Photograph by Erik Borg.*

LEONARDO DA VINCI

A MAN FOR ALL AGES

By KENNETH MACLEISH
SENIOR ASSISTANT EDITOR

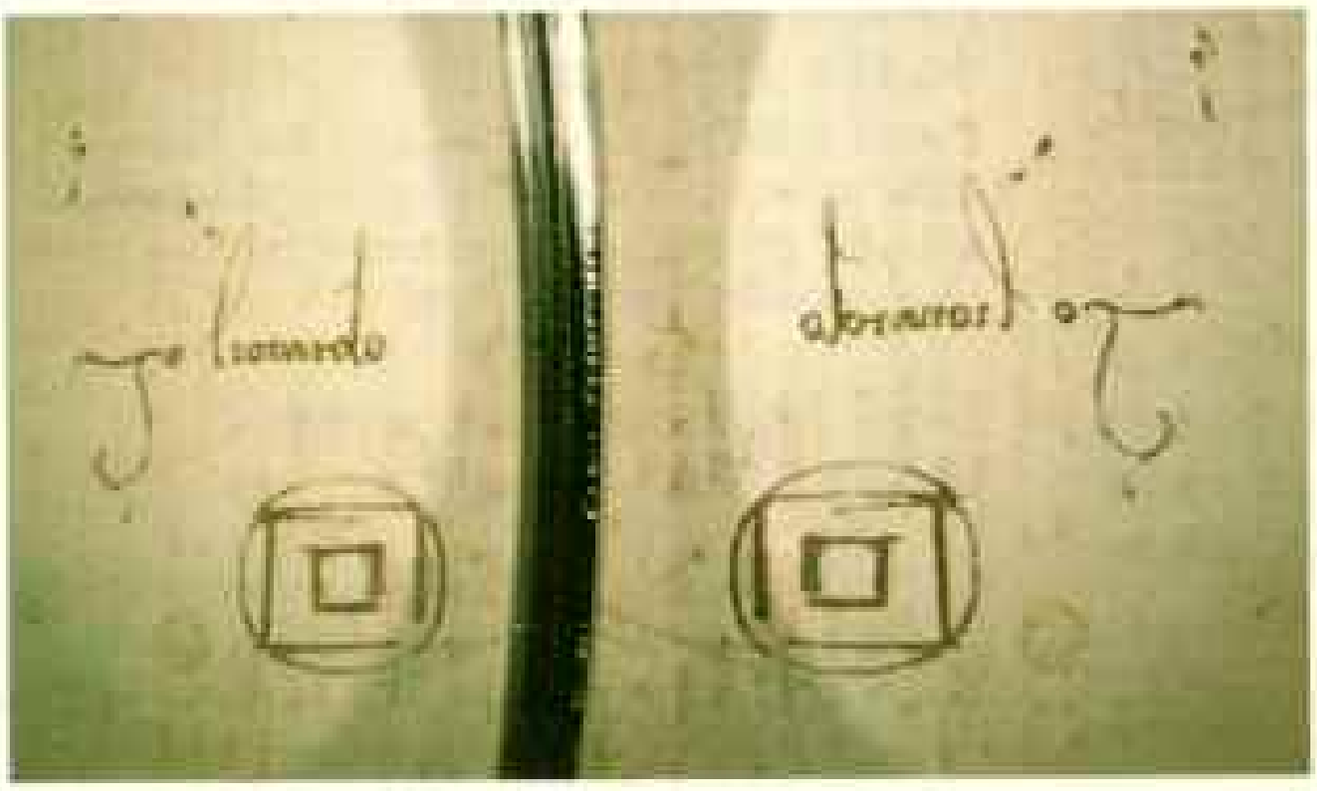
Photographs by JAMES L. AMOS
NATIONAL GEOGRAPHIC PHOTOGRAPHER

"Peruse me, O Reader, if you find delight in my work, since . . . the perseverance to pursue it and to invent such things . . . is found in few people. And come, men, to see the wonders which may be discovered in nature by such studies." —LEONARDO DA VINCI, MADRID CODEX I

BRAVE WORDS. Arrogant, if you like. But if any man in 15th-century Florence, or Europe for that matter, has earned the right to pen them, it is the elegant gentleman cantering up the mountain road. He rides like a nobleman; his short cloak swirls, his big beard blows in the breeze of his passing. Maestro Leonardo cuts a fine figure.

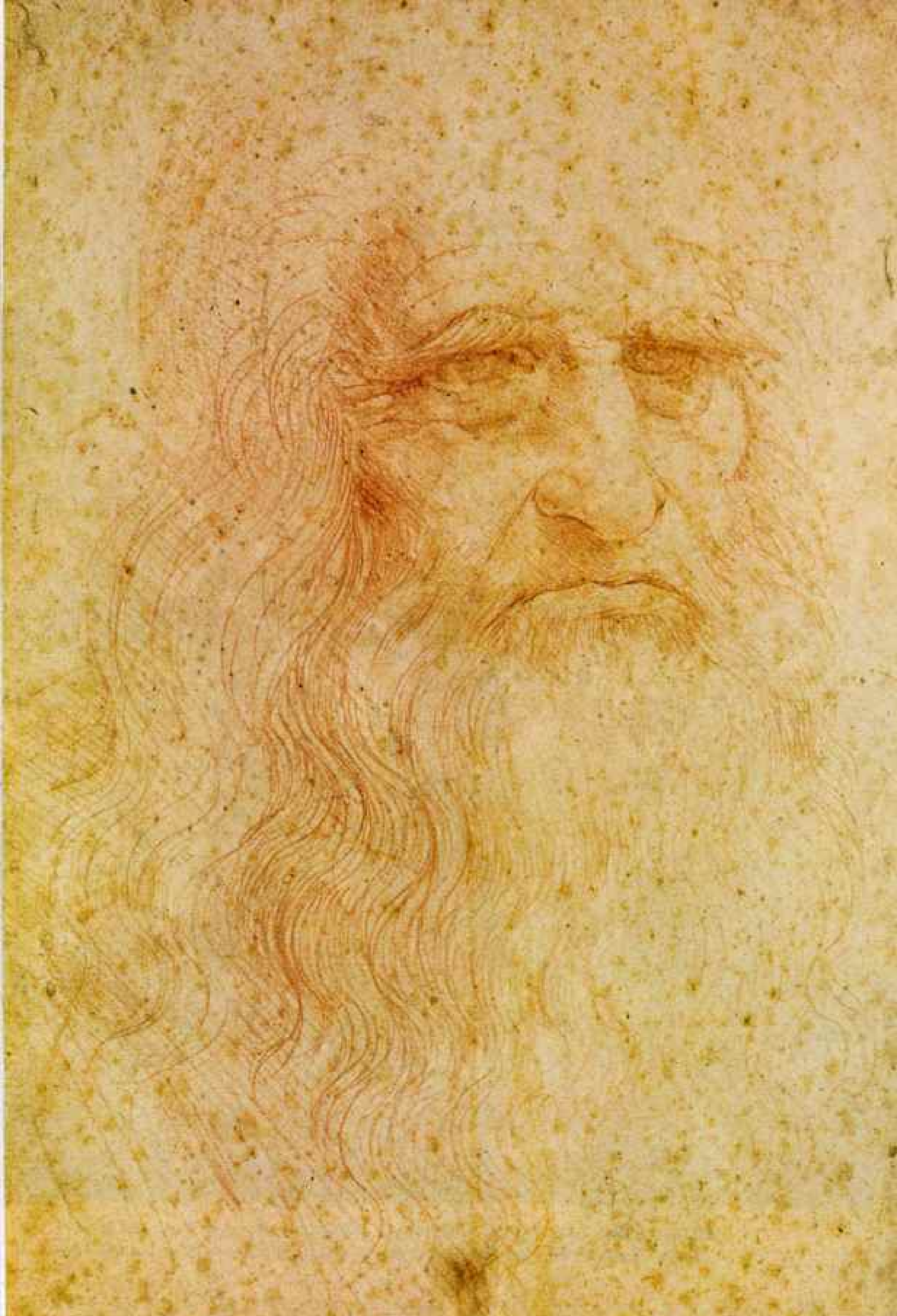
Still, if anyone who knew him well should pass him on the trail today, he would see despair in those enigmatic eyes—the most perceptive eyes in an age of perception. Capable of picturing the planet's past or future, they can stop and study the motion of a bird's wing in flight, or of water raging against rocks. It is well that they see what ordinary eyes do not. They serve the most compulsive curiosity ever recorded. But today they are empty with remembering.

Knowledge is Leonardo's great love. Knowledge, and the experience from which it may be drawn. To acquire it, he has turned to mathematics, *(Continued on page 302)*

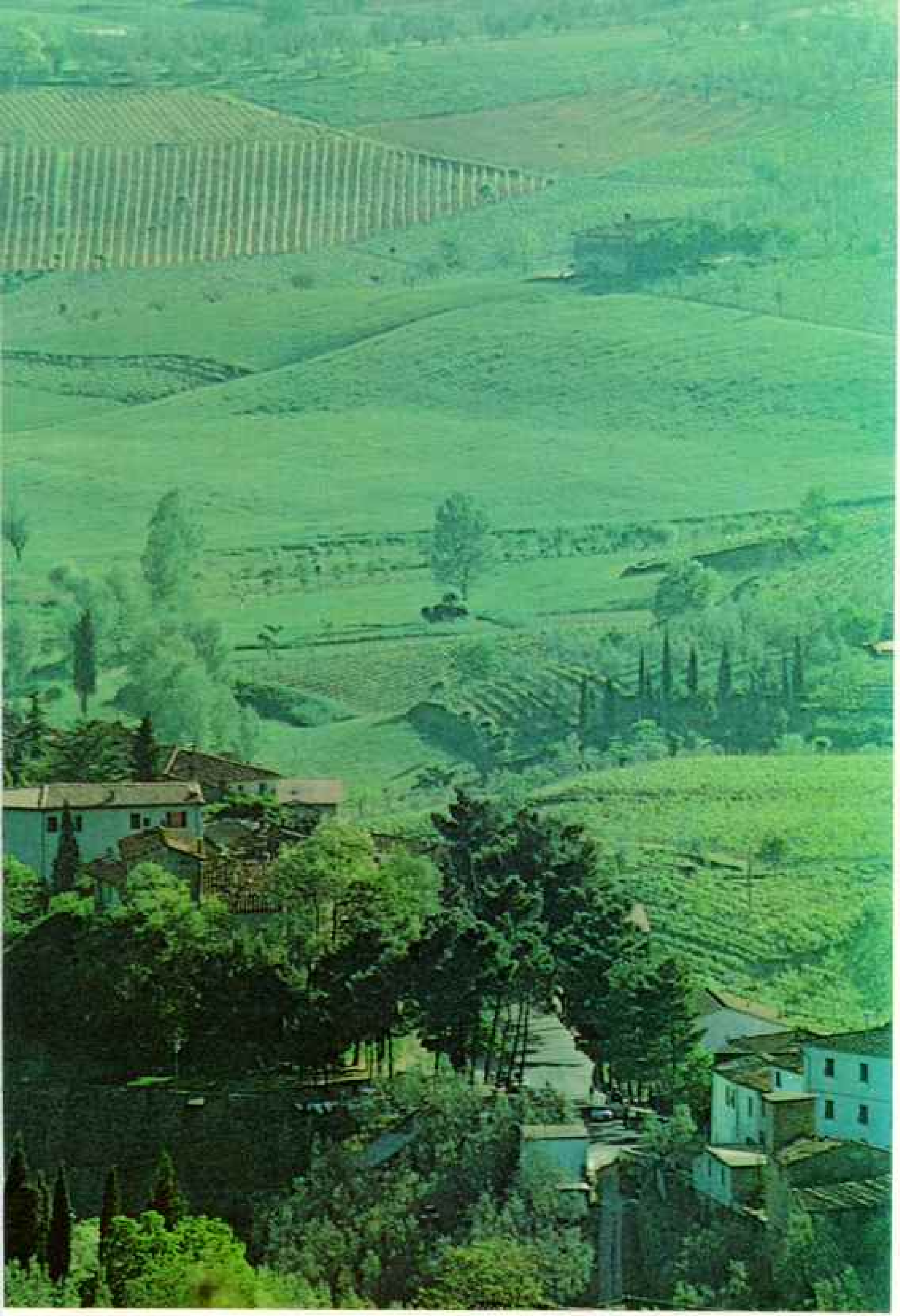


Giant among giants, Leonardo da Vinci towered over the Renaissance, an age when all things seemed possible. Blending artistic brilliance with scientific curiosity, he relentlessly pursued knowledge—from anatomy to aeronautics, from music to mechanics. A left-handed penman, Leonardo wrote his notebooks in reverse (**left,** at right); a mirror turns his self-confident signature around—"I Leonardo."

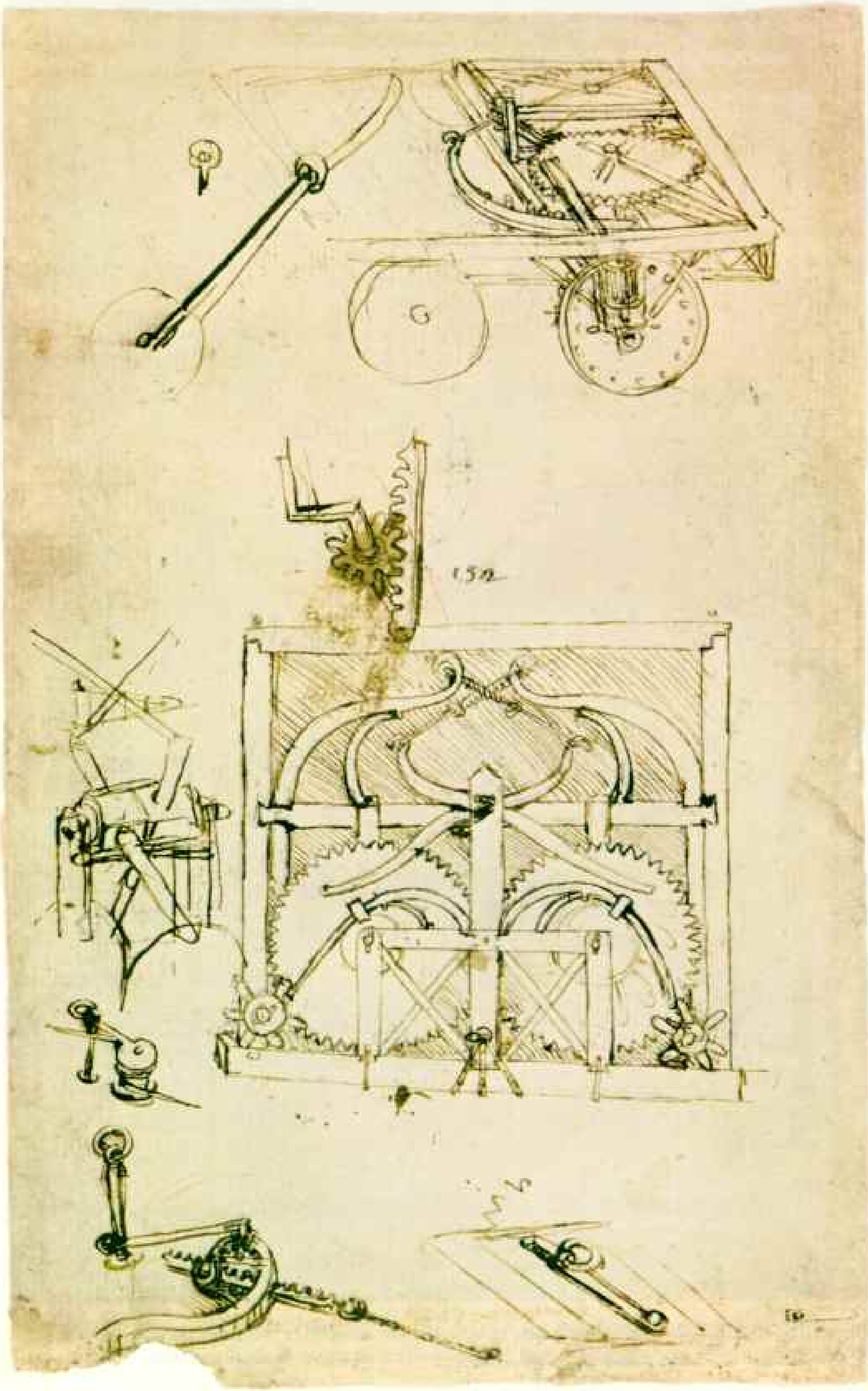
SELF-PORTRAIT, 1512, BIBLIOTECA REALE, TURIN (RIGHT); COURTESY GIUNTI PUBLISHERS, FLORENCE (LEFT)



Nature's notebooks opened in marvelous profusion to the child Leonardo in the Italian village of Vinci, amid the Tuscan countryside. Tradition says he was baptized in



the steepled church, following his birth here in 1452. He saw miracles in blossoming wild flowers, darting birds, and brightly garbed insects—and set off to find the how and why.



IMAGES OF GENIUS FOUND IN FRAGMENTS

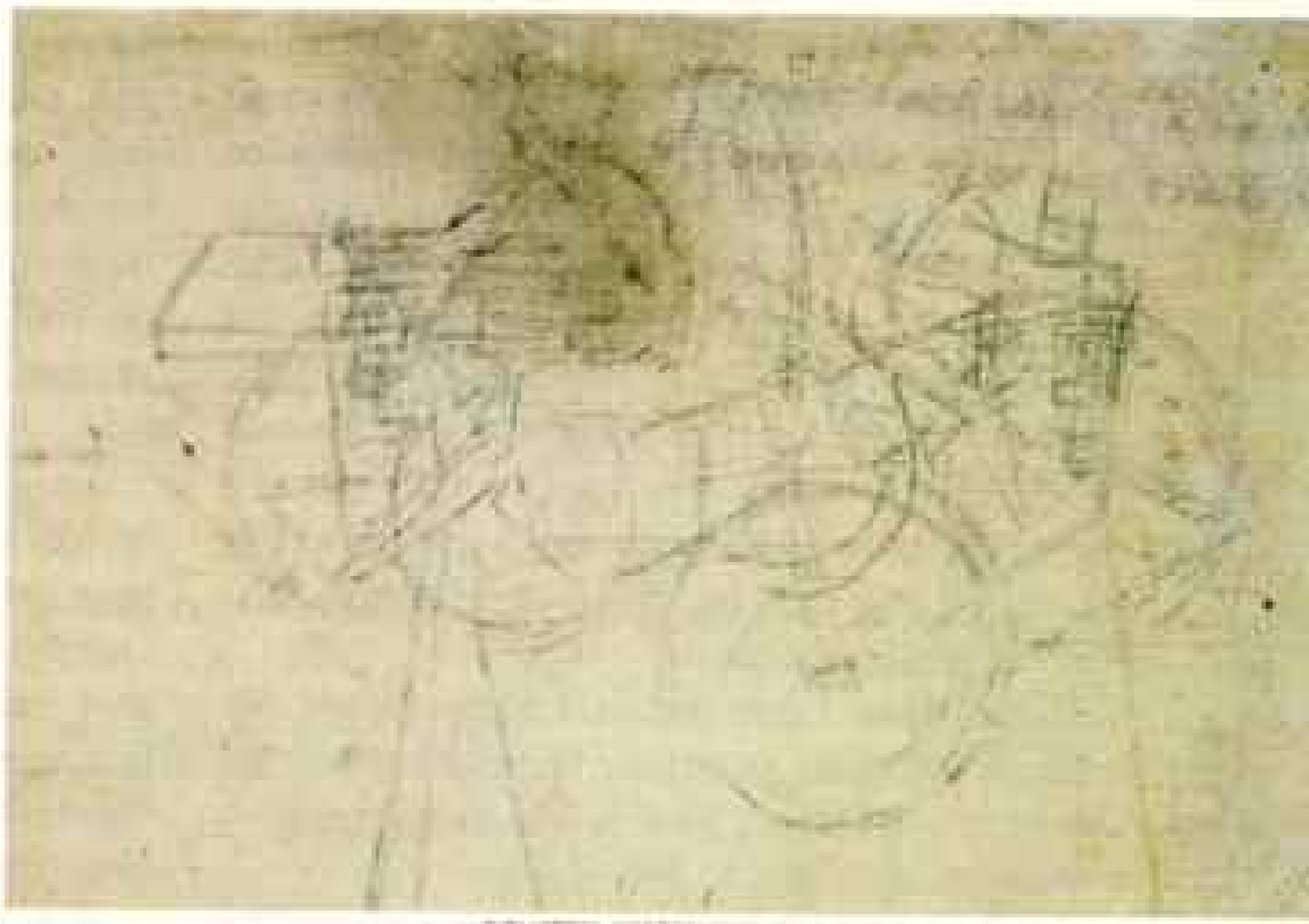
WHEREVER his imagination led, Leonardo's pen followed. He was always jotting ideas on scraps of paper, inspired by what he saw in foundries and flour mills, what he knew of ancient Greek inventions and contemporary engineering—and what he dreamed.

When words failed, Leonardo drew. Soon he was exploring ideas in his sketches, such as the self-propelled vehicle that used springs for power (**left**). He showed his car from the side, at top; then, slightly varied, from above. Like doodles around the vehicles, he toyed with devices for winding the springs: a gear and pinion, a windlass, a pulley, a winch.

Leonardo saved his notes with the idea of organizing them and passing on his store of knowledge. But he never published, and today much is lost. The largest collection known, 1,200 pages called the Codex Atlanticus, is being edited and annotated by Dr. Augusto Marinoni (**above,** at right) at Milan's Biblioteca Ambrosiana. Here with library director Dr. Angelo Paredi, Dr. Marinoni examines geometric designs that Leonardo drew for *Divine Proportions* by Pacioli, a Renaissance mathematician.

As Dr. Marinoni studied the Codex Atlanticus, he thought he saw, under a smudge, the outline of another car (**middle right**), which modern artists have reconstructed (**lower right**).

Another collection of notes infinitely richer in mechanical innovations—the Madrid Codices—came to light in Spain in the mid 1960's, further attesting Leonardo's genius. Alone in his day, he analyzed the elements of mechanics and recombined them in new ways to increase the efficiency of machines. He understood friction, the use of ball bearings, and transmissions.



BIBLIOTECA AMBROSIANA, MILAN (ABOVE AND FACING PAGE)

DRAWING BY ROBERT S. HYNES, BASED ON RENDITION BY ANTONIO CALEGARI

(Continued from page 296) geometry, optics, astronomy, geology, botany, zoology, hydraulics, mechanics, anatomy.

Painting? Should not painting be first among the studies of this prodigy among the great men of art? But, he would say, painting *is* science. It is based on the rationalization of sight. A most noble science, for it enables the artist to compete with nature.

He is a driven man, this Leonardo: a multiple genius, flawed by an insatiable need to understand everything and, understanding, to change, to improve. Perhaps he is, as a biographer was to describe him centuries later, "a man who awoke too early in the darkness while the others were all still asleep." The 15th century welcomes him as an artist, but is far from ready for many of his ideas.

AND NOW one of those ideas has failed him. By his own error, he has doomed his latest work—a great mural in Florence that would have brought him the adulation he needed in his own land. The experimental paint he had devised will not dry. Looking back, he realizes that another of his great works is decaying because he has followed his own untested notions. Worse, the self-examination brought on by failure has reminded him that he, too, is destructible. His span of years is limited.

How many have passed? Fifty-three? No time to re-create or repair the ruined works. There are too many new wonders to create—wonders unknown to the world.

At the summit he swings from the saddle and strokes the horse's sweating neck with soft, well-tended hands that can catch the curve of an angel's cheek or turn two dimensions into three at the touch of a brush—or bend a horseshoe with an easy twist. Florence lies below him, long shadowed in the golden evening. The Arno glitters on its untroubled way, and villa-crowned hills cut dark designs on the haze-softened horizon.

His painter's eye catches the scene. His inventor's mind transforms it. Only that which is fine and new would he retain: The splendid dome that soars above the city, serene curves gleaming. The tall campanile and the Baptistery, its marble rich with deep green and white. The peaceful, pleasant church of Santa Maria Novella, where incense flavors the cool air and dried priests-made-saints lie gape-jawed in glass caskets.

These places are sacred to him, not because they are Christian monuments but because they are beautiful. A mathematically minded forerunner of the Age of Reason, Leonardo loves harmony and grace, and worships logic as a god.

For the rest, the artist-inventor, drawing on ideas he conceived years earlier for Milan, sees changes everywhere: The twisting streets should be as wide as the multistoried medieval mansions that line them are high. There should be efficient sewers and ventilated toilets, outside stairways and bay windows. He envisages a model brothel designed with an eye to discretion.

Industry should be arrayed outside the town along a lock-controlled canal where waterpower would run machines to do the work of many men—machines for lens grinding, needlemaking, metal drawing, file making, screw cutting, mirror making. There would be distilleries and sawmills and fulling mills. To build these, he has devised cranes, posthole diggers, dredges, portable bridges, pumps, pile drivers, and many ingenious tools (pages 306-307).

To protect his precocious dream city, he would build terrible new weapons of his own conception: explosive shells, steam-powered cannon, rapid-fire weapons, tanks, poison gas, and artillery-proof fortifications. Weaponry fascinates him. Though he has called war "bestial madness," he serves its ends and its practitioners.

But few of his plans or devices have interested the princes of the day. Now, aging, he sees his dream for what it is, and it fades. Such technology will stay undiscovered in his cabinet, to be re-created in another age.

Disconsolate, he feels that he must shake the world with a prodigious feat. Even though he recognizes his own superlative skill as an artist, this brilliant, farsighted man has never understood that his paintings alone will make him a giant among geniuses, known to hundreds of millions across uncounted centuries and in lands yet undiscovered. No, his feat must be conceived in science, based on mathematics (the only absolute truth), and realized through engineering: He will fly.

For years he has studied the flight of birds and the movements of the air, and has designed several flying machines (page 309).

A lost legacy haunts Villa Melzi in Vaprio d'Adda, once repository of all of Leonardo's notes. About 1508 the artist apprenticed young Francesco Melzi, and later lived with his family. In 1519 Leonardo, near death, bequeathed his works to the admiring papil, who treasured them "like relics." After Francesco died, they were dispersed.

This mural hints of Leonardo's style, says present-day Duke Melzi (**above**). But the duke's only authenticated memento is a letter of authority (**left**) from Cesare Borgia to his "highly esteemed architect."

Every facet of his multiple being—artist, scientist, aesthete, observer—yearns for this superhuman adventure. Longing for success, he suddenly assumes in a rush of premature triumph that it will be his.

As daylight dims on the top of Monte Ceceri—Swan Mountain—he writes in a notebook filled with phrases and sketches: "the great bird will take its first flight upon the back of the great swan, filling the whole world with amazement and filling all records with its fame; and it will bring eternal glory to the nest where it was born."

For a moment, before leaving, he watches with passionate longing the slow circling of hawks and the swallows' supple turning.

A legend says that in this time, around 1505, the great bird rose from Swan Mountain and flew. The artist's loquacious notes tell us nothing; no other witness deposes. But some 50 years later an acquaintance wrote: "Leonardo *(Continued on page 307)*

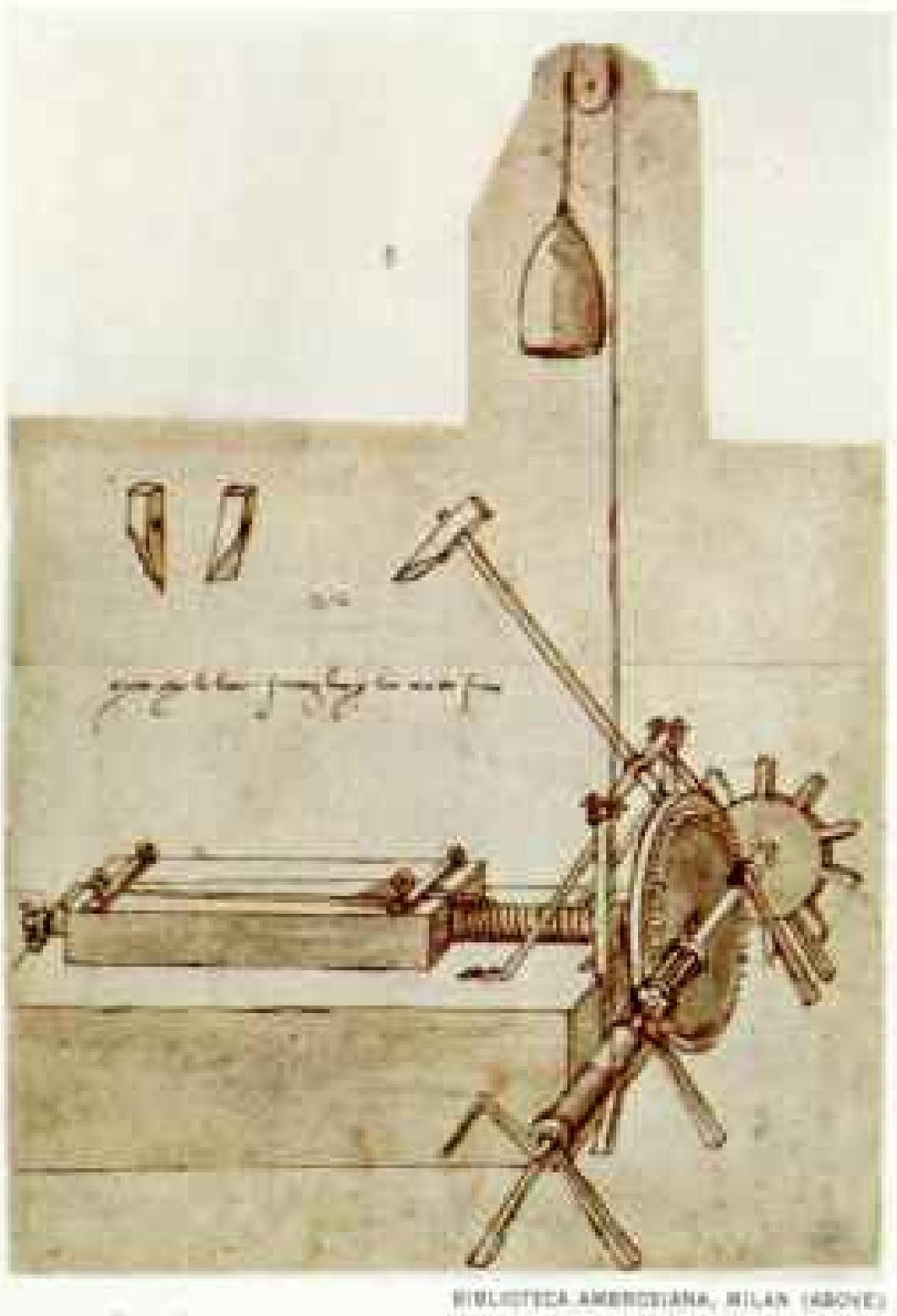
"**Nothing is beyond the powers** of the Florentines," ran a Renaissance boast. It was Leonardo who made it so. As a teenager he arrived in the city on the Arno (**above**), home of soaring intellects and backbiting politicians. He learned to produce art on order as apprentice to Andrea del Verrocchio, whose workshop turned out Madonnas for the church, portraits for bankers, sculptures for the ruling Medici, and decorations such as the gilded copper sphere that still surmounts the Duomo, or cathedral, at right. When Verrocchio was painting the "Baptism of Christ," he assigned Leonardo an angel. The young artist portrayed a curly-headed boy, his back to the viewer, his face a luminous vision (**right**). There is a story that the superiority of the student's work caused Verrocchio to vow "never again to touch colors." The Florentine apprentice tradition continues in the studio of sculptor Antonio Berti (**far right**).

SCALA, COURTESY UFFIZI GALLERY, FLORENCE

da Vinci also attempted to fly, but failed. He was an excellent painter."

To call Leonardo an excellent painter is like labeling Shakespeare a clever wordsmith. He was a true genius, recognized in his own time and idolized in ours. His paintings are as secret and seductive as himself, done with the hand of an angel, the intellect of a scientist, and the soul of a romantic. His drawings —some of them—are among the most beautiful ever made. As an engineer, he could think in four dimensions, visualizing not only the shapes of mechanical parts but also their interrelated motions—and create things that no one yet wanted.

In some ways the first modern, Leonardo was in many more the personification of his own incomparable time. Like the spirit of the Renaissance itself, the mind of this man destined to become its living symbol was fashioned in the quickening spring of the Western world's awakening from the shriveling darkness of the Middle Ages. He was free, as few human beings have ever been free, to become whatever his gifts might make of him.



BIBLIOTECA AMBROSIANA, MILAN (ABOVE)

Search for automation—machines that run themselves—fascinated Leonardo. To make the cutting ridges of a metal file, the inventor set a descending weight that repeatedly tripped a hammer to strike the blank bar (**above**). Such drawings are so precise they inspired models at Milan's National Museum of Science and Technology (**left**). The file maker, at lower right, rests beside a waterpowered saw with automatic feed, and, clockwise, a screw-cutting lathe, a pile driver, and a windlass.

BORN IN 1452, love child of a peasant girl named Caterina and the respected notary Piero da Vinci, Leonardo lived at first with his mother in a three-room stone house, astraddle a hill just outside the village of Vinci (pages 298-9), where Ser Piero settled down with a legitimate wife. In that enchanted Tuscan countryside began the youngster's lifelong love of nature, of all that moved or grew or was—the deepest love he would ever know.

Towheaded, blue-eyed, open-faced, driven by a curiosity that brought him often to the edge of fear, he roamed the tamed, terraced slopes, where lizards rustled in warm leaves under the laden vines and gusts turned olive groves to rippling silver. There were forbidding forests on the high peaks, and everywhere cypresses, like single brushstrokes, marked the mild horizon.

Ser Piero's wife having proved barren, and his bastard beautiful, he took the boy from Caterina and installed him in his own house. Here Leonardo acquired a modest education and, on at least one occasion, a number of small dead animals, which he drew with remarkable skill as they reeked and rotted on his table. The practical Ser Piero is said to have suffered the stench and sold the painting.

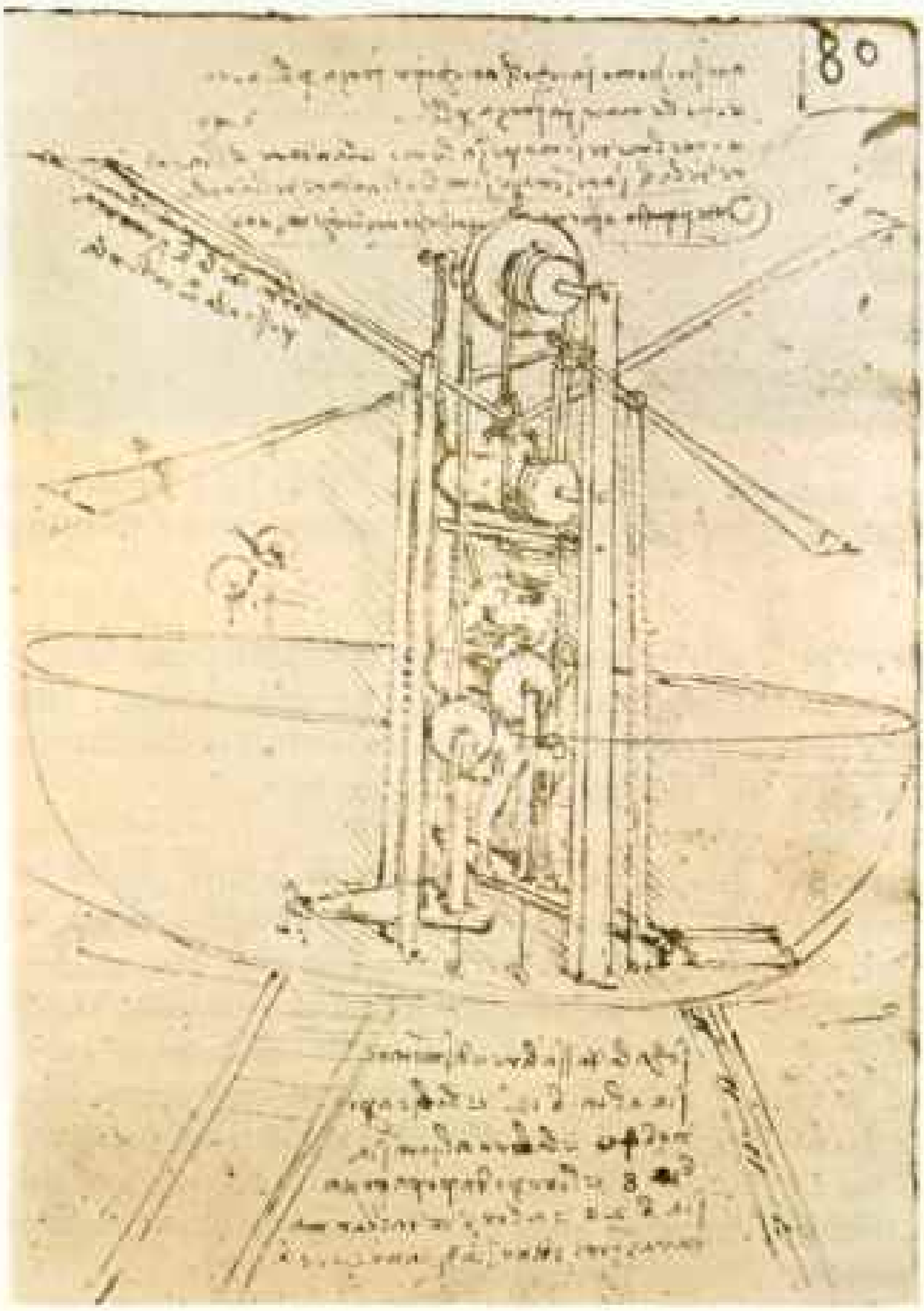
Around 1469 Leonardo's father took him to Florence, the new Athens of Europe, where the learned despot Lorenzo de' Medici was establishing an aristocracy of literate intellectuals and all arts were honored.* There were painters here—the world's best—turning at least part of their talents to the representation of things as they were rather than as the grim Gothic Church for so long had said they must be, and so making art a branch of knowledge rather than an instrument of religious expression. In the liberal land of the Medici, the princes of the church had grown

*See "The Renaissance Lives On in Tuscany," by Luis Marden, NATIONAL GEOGRAPHIC, November 1974.

To fly like a bird: That dream spurred Leonardo's ambition for a quarter of a century and still inspires Italians. In a craft designed by Professor Franco Tinarelli, his colleague Vincenzo Trussardi, buoyed by a hydrogen balloon, flaps with cloth wings across the sky near Clusone (**left**).

Leonardo failed to launch his flying machine and abandoned muscle-powered flight. Yet his achievement remains: the first scientific studies of flight. He began with birds (**right**), noting variations in lift, thrust, equilibrium, steering, and stability. After dissecting their bodies, he evaluated wing designs (**lower right**). The angular blade with net inserts would overcome air resistance, he hoped: "When the wing rises up it remains pierced through, and when it falls it is all united." He preferred the bat wing, like a "bellying sail."

BIBLIOTECA REALE, TURIN (ABOVE); BIBLIOTHÈQUE NATIONALE, PARIS



Fanciful flying saucer depended on pilot power to overcome gravity (**left**). He would move the oarlike wings by pedaling, turning a winch with his hands, and pushing with his head —all at the same time. In a practical vein, Leonardo envisioned parachutes, a helicopterlike aerial screw, and retractable landing gear. He advised would-be pilots: "If you fall, see that you strike the earth with the double bag you have under your rump."

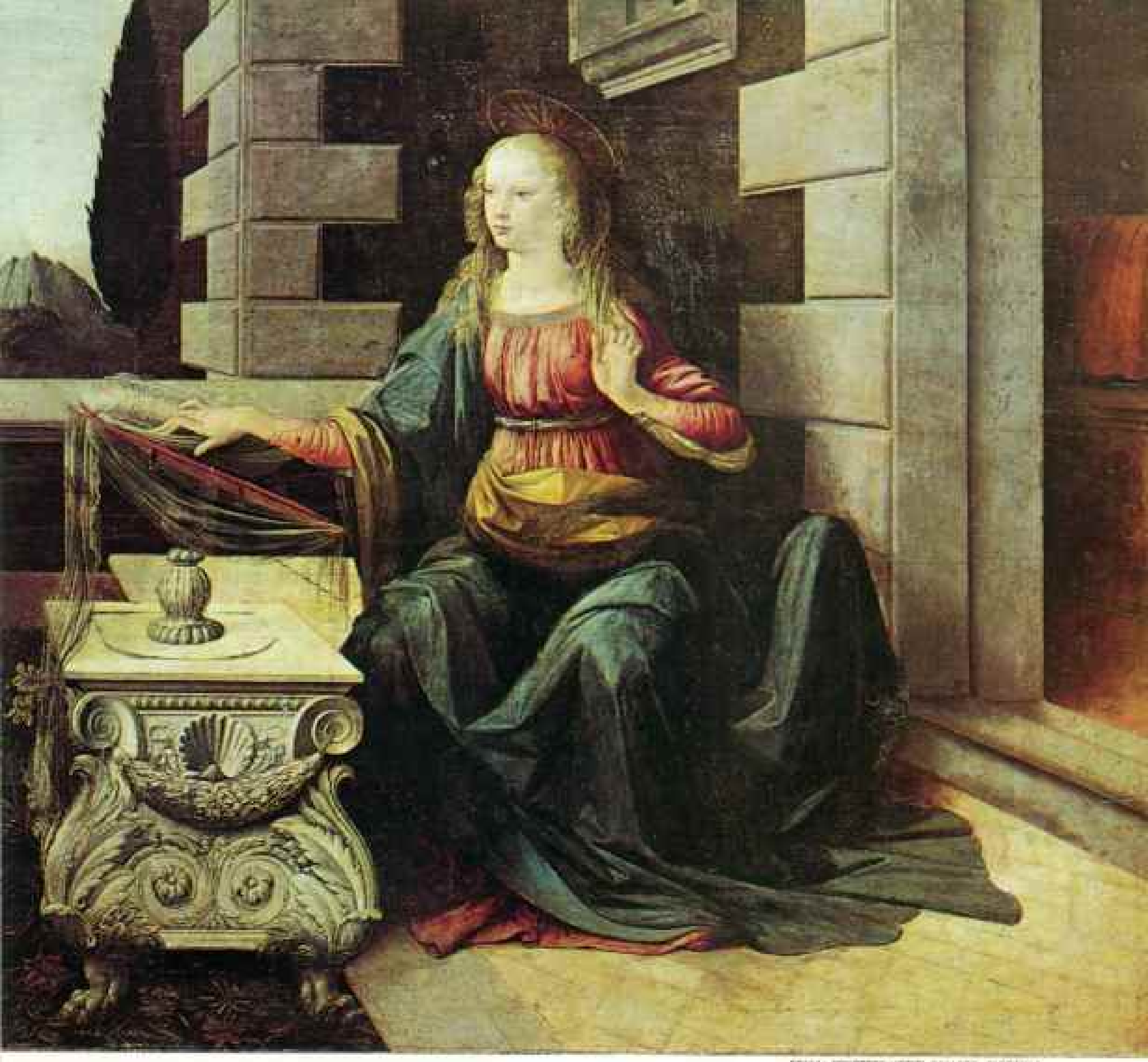
Masterpiece from a youthful hand, the "Annunciation" proves that by 1478 Leonardo had learned well the lessons of perspective and color. The dreamy landscape and the carpet of

knowledgeable and hence moderate. The threat of the Inquisition still lay decades ahead.

In the tolerant atmosphere of Florence, a man could pursue any course if he did so with grace. No society could so well have suited the gifted, undisciplined country boy; most would have destroyed him.

Leonardo was apprenticed to Andrea del Verrocchio, a kindly, competent man who ran a shop that produced anything from jewel settings to altar paintings. He stayed with him for at least six years. The boy mastered every medium and continued his studies of nature, discovering so much so fast that it seemed to him that everything must eventually be revealed to his searching mind. In his exuberant confidence, he seems to have felt no need for the religious nurture of the church or the comfort of human love.

HE OUTSHONE his fellow pupils in every skill and proved himself more able than his master with a brush. Assigned to paint the figure of a kneeling angel in a baptism of Christ by Verrocchio, he gave it a whole new dimension that seemed to draw the spectator directly into the painting, in a way that his teacher's stiff style could never do (page 304). Some say that Verrocchio never painted again.



SCALA, COURTESY UFFIZI GALLERY, FLORENCE

swirling flowers, suggesting nature's creative force, are his innovations. Such talent had qualified the apprentice by the age of 20 for admission to Florence's prestigious guild of painters.

But the boy also differed from his associates in other, less commendable ways. His master soon discovered that he was capricious, quick to boredom, and conscienceless when it came to completing a job. In 1476 Leonardo and three others were anonymously charged with being homosexuals. They were tried—twice—and acquitted. But Leonardo became withdrawn and secretive and assumed an alabaster mask of quiet courtesy through which glimmers of intense misanthropy sometimes shone. He left Verrocchio's studio to live alone, and for a time attempted no work of art.

In 1472, when he was 20, he had been accepted into the guild of painters, allowing him to seek independent commissions. But not until 1478 does the first record of such a commission appear. He contracted to paint a chapel altarpiece in the Palazzo Vecchio, probably a nativity scene, as indicated by many of his sketches that year. There is no evidence that the painting was ever begun.

But his 1478 sketches, exuberant and lively, perhaps led him to develop the idea for the "Adoration of the Magi," for which he was to receive a commission in 1481. Ambitious beyond fulfillment, it was a big picture, dark, and crowded with figures which (to quote Kenneth Clark's fine phrase) "vanish and

BOTH COURTESY TRUSTEES OF THE BRITISH MUSEUM, LONDON

Steely-eyed determination of a condottiere, leathery mercenary of 15th-century warfare, survives in Leonardo's meticulous rendering (**above**), scratched on specially prepared paper with a silver stylus. Such Roman-style armor with bat wings and lion heads was forged in Verrocchio's workshop.

Though Leonardo hated the "bestial madness" of war, he mastered military engineering and obtained work with rulers of Italy's militant city-states. In 1482 he sold his services to the Duke of Milan, himself the son of a condottiere, on the basis of nine secret "instruments of war" and, in passing, his talents as architect and artist.

These war machines were ingenious but impractical (**right**). Leonardo himself rejected the horrendous Roman-style chariot with revolving scythes as causing "no less injury to friends than to enemies." Why not, instead, horse-saving "covered chariots, safe and unattackable." The interior view of his heavy wooden tank exposes wheels geared to cranks turned by hand. Soldiers would fire breech-loading cannon from beneath the conical roof. The artist-engineer foresaw streamlined missiles with directional fins, multiple-barreled machine guns, and powder-and-turpentine grenades—much like today's Molotov cocktails.

reappear, like fish in a muddy pool." Seething with emotion and motion, a display of disciplined intelligence and a fantasy filled with creatures of his subconscious, it was a mother lode of forms and fancies from which he would draw the rest of his life.

Characteristically, Leonardo left the work unfinished. And, unfinished, uncolored, it is superb. Generations of painters, critics, and less learned admirers of art have marveled at its power and beauty.

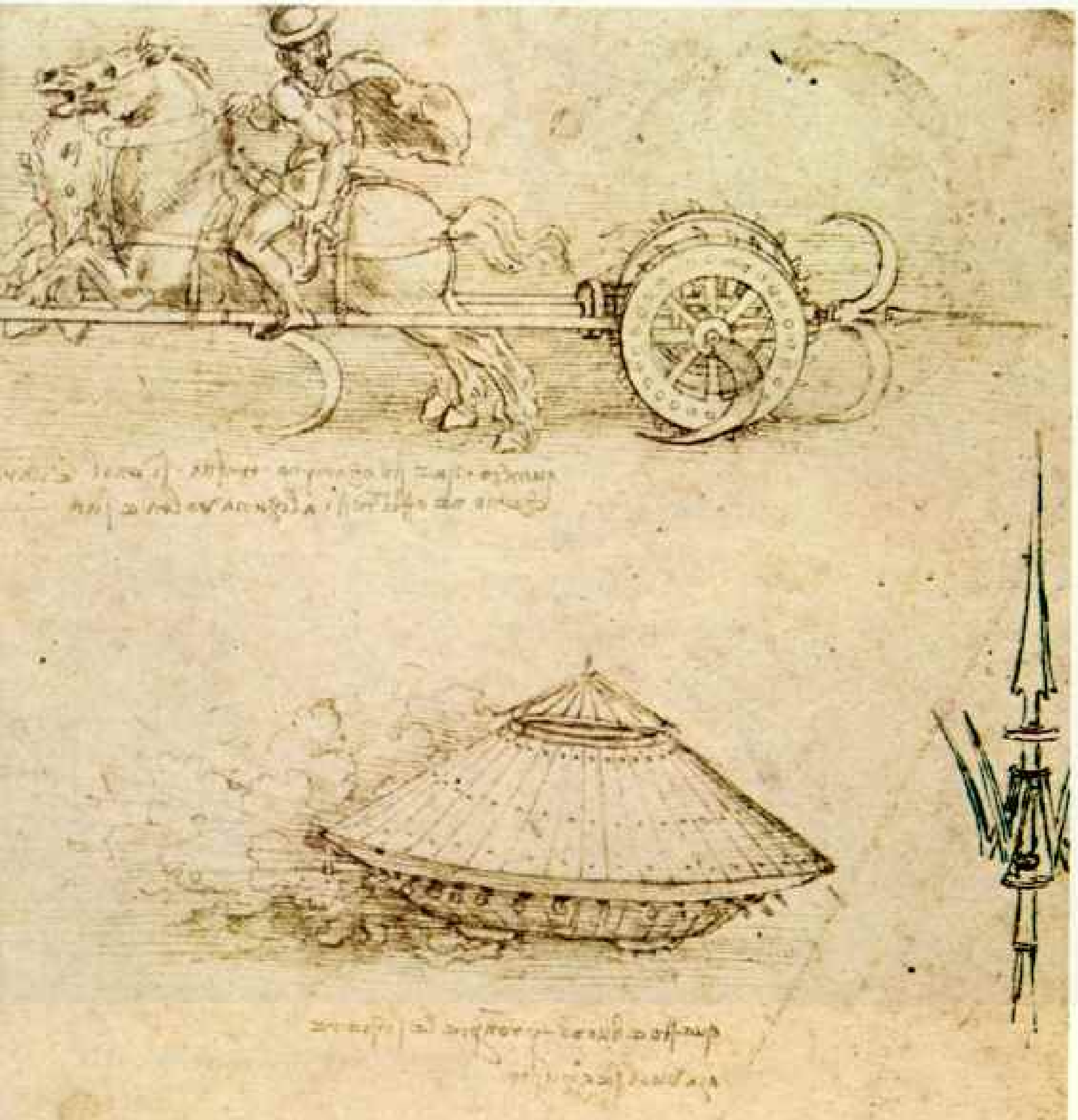
Had the young painter learned from this work the evocative force of half-expressed suggestion, he could have considered the painting finished and become more prolific. But his scientific bent, evident in this extraordinary painting, required that a completed work must present total detail within

a mathematically computed perspective. To finish the "Adoration" in such a way could have taken a lifetime.

Perhaps as late as 1478, the young artist was still collaborating with Verrocchio. For a Pistoia Cathedral altarpiece commissioned that year, Leonardo may have painted the "Annunciation" on the pedestal, similar to a large painting that now hangs in the Uffizi Gallery (pages 310-11). The Uffizi work long was considered to be his earliest painting, dating from 1472, but recent scholarship has redated it six years later.* It, too, is an ambitious painting, rendered in intense, clear colors, with a perspective stressed beyond mathematical correctness. The twilight background and the flowering foreground are surely labors of love—the young artist's tribute to the natural world. Virgin and angel have the lifeless look of mythical creatures become standard symbols.

*A principal consultant for this article was Carlo Pedretti, professor of art history at UCLA, whose extensive scholarship on Leonardo includes special attention to dating his works.

LEONARDO left Florence in 1482 at the age of 30. He stayed away for 18 years. The young Florentine hoped to find the glory he wanted in the sumptuous court of Lodovico Sforza, usurper of Milan. A practical city, Milan cared more for knowledge than for the arts. It housed no great artists but counted many learned men. Leonardo came as a musician, bringing as a gift from Lorenzo de' Medici *(Continued on page 317)*



CZARTORYSKI MUSEUM, KRAKOW, POLAND

National Geographic, September 1977

MORE REAL THAN REALITY

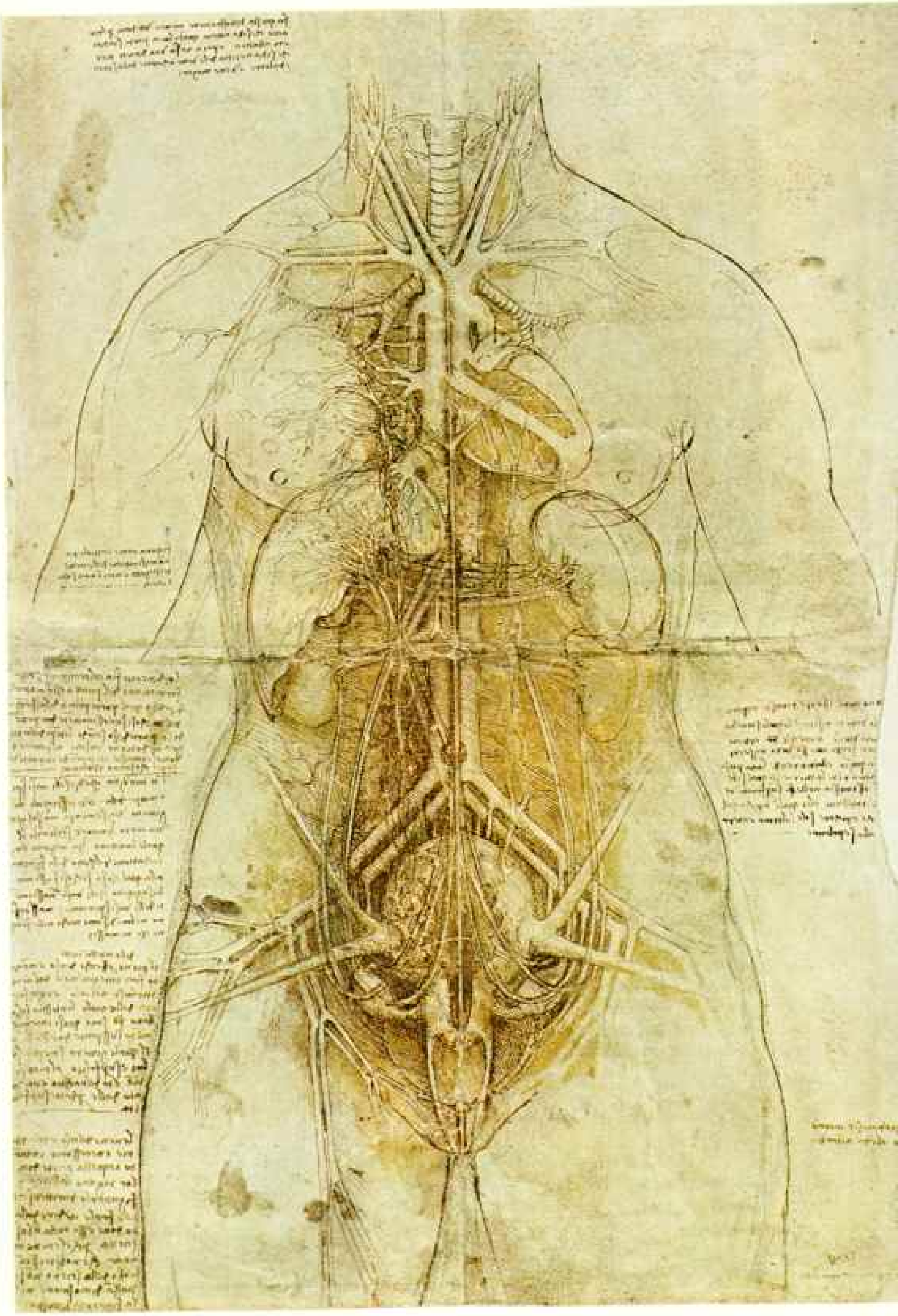
"PAINTING seems . . . miraculous," Leonardo wrote, "making things intangible seem tangible." He captured inner moods of women even in trial sketches such as the Leda, a mythological figure (**upper right**). Nothing is known about his pensive model, but the coiffure was a wig, he noted, to be "removed and replaced without spoiling."

Leonardo's artistry in oil was built on his scientific observations of light, reflection, and shadow. He posed subjects in twilight to lend "more grace to faces." The flesh glows in the portrait of Ginevra Benci, even through her transparent bodice (**right**).

A smile hovers on the lips of Cecilia Gallerani (**left**), mistress of Leonardo's Milan patron, Lodovico Sforza. Here in 1484 she cradles an ermine, Sforza's heraldic figure—and a symbol of virtue.

A Florentine woman, Lisa del Gioconda is generally credited with the smile that made Leonardo's portrait the most famous in the world (**above**). Even in his day, it was recognized as "more divine than human." The artist kept the "Mona Lisa" with him, on the excuse that it was incomplete, until the day he died.

LOUVRE, PARIS (TOP LEFT); ROYAL LIBRARY, WINDSOR (TOP RIGHT); NATIONAL GALLERY OF ART, WASHINGTON, D.C.



a silver lyre of the artist's own design. He also presented himself as an engineer, describing in a long boastful letter his inventiveness in the field of weapons. Almost as a postscript he prudently added, "also I can do in painting whatever may be done, as well as any other, whoever he may be."

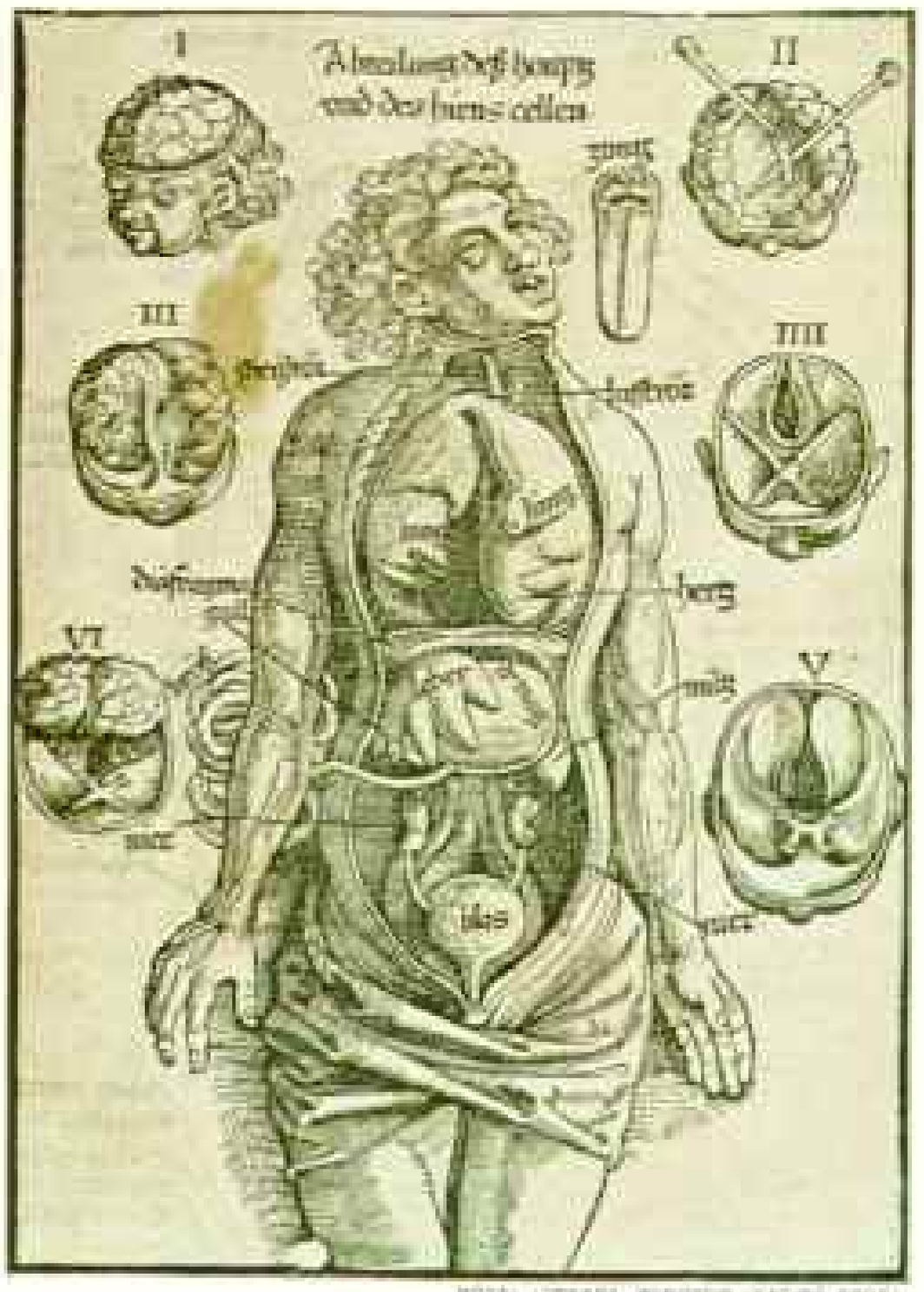
It was as an artist that Leonardo was accepted. He established an art factory much like Verrocchio's shop in Florence and at once accepted assignments. One, an altarpiece for a convent, was still unfinished and still the subject of a lawsuit 20 years later. This was his "Virgin of the Rocks," begun in 1483 and now in the Louvre. It is a work that retains a Florentine sense of brilliant color and alluring expression, with a Lombard quality of light in a background of rocks, water, and vegetation. A more rewarding commission, a portrait of Lodovico's beautiful and learned mistress, Cecilia Gallerani (page 314), he completed with commendable speed, as he did the likeness of a musician.

A GRACIOUS PERSON, pleasing if not loving, a singer, versifier, maker of marvelous illusions, he was both performer and showman. He devised puzzles and games, and jokes that made people "roar with laughter." He won the friendship of dukes and kings. Admirers called him "the Divine Leonardo" and said he could do anything.

Around 1485 he began his notebooks. These are voluminous, cryptic compilations of material on everything that took his fickle fancy: geology, geometry, anatomy, astronomy, architecture, flight, studies for paintings, personal accounts, platitudes, word puzzles, all interwoven and superimposed as one burning interest gave way to the next. His notes are written left-handed from right to left, and there are sketches everywhere that complement his forceful and articulate prose. His discussions were addressed to himself, and so he has left us an extraordinary record of the movements of his mind.

A decade later he taught himself Latin, a second language to the learned classes but not part of the curriculum of young artisans—which included painters. His later notebooks reflect the recorded wisdom of Greece and Rome, as well as of the Middle Ages.

The duality of Leonardo's nature grew more pronounced in the indolent atmosphere



ROYAL LIBRARY, WINDSOR (FACING PAGE); NATIONAL LIBRARY OF MEDICINE, BETHESDA, MARYLAND

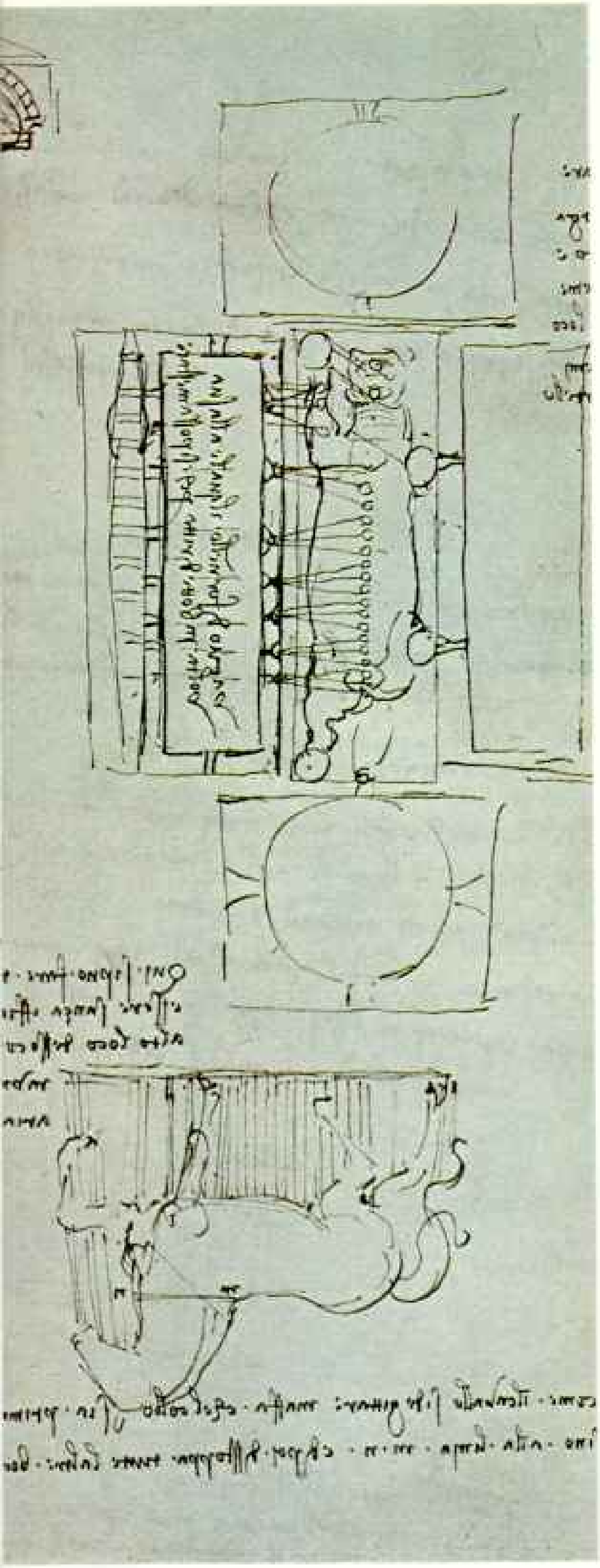
With a zeal for accuracy, Leonardo based anatomical drawings on his dissections. This female of 1508 emphasizes the vascular system and principal organs (**facing page**). In contrast, an Austrian text (**above**) showed a many-lobed *leber,* or liver, based on that of a baboon. An Arabic schematic (**below**) vaguely located the organs of a pregnant woman.

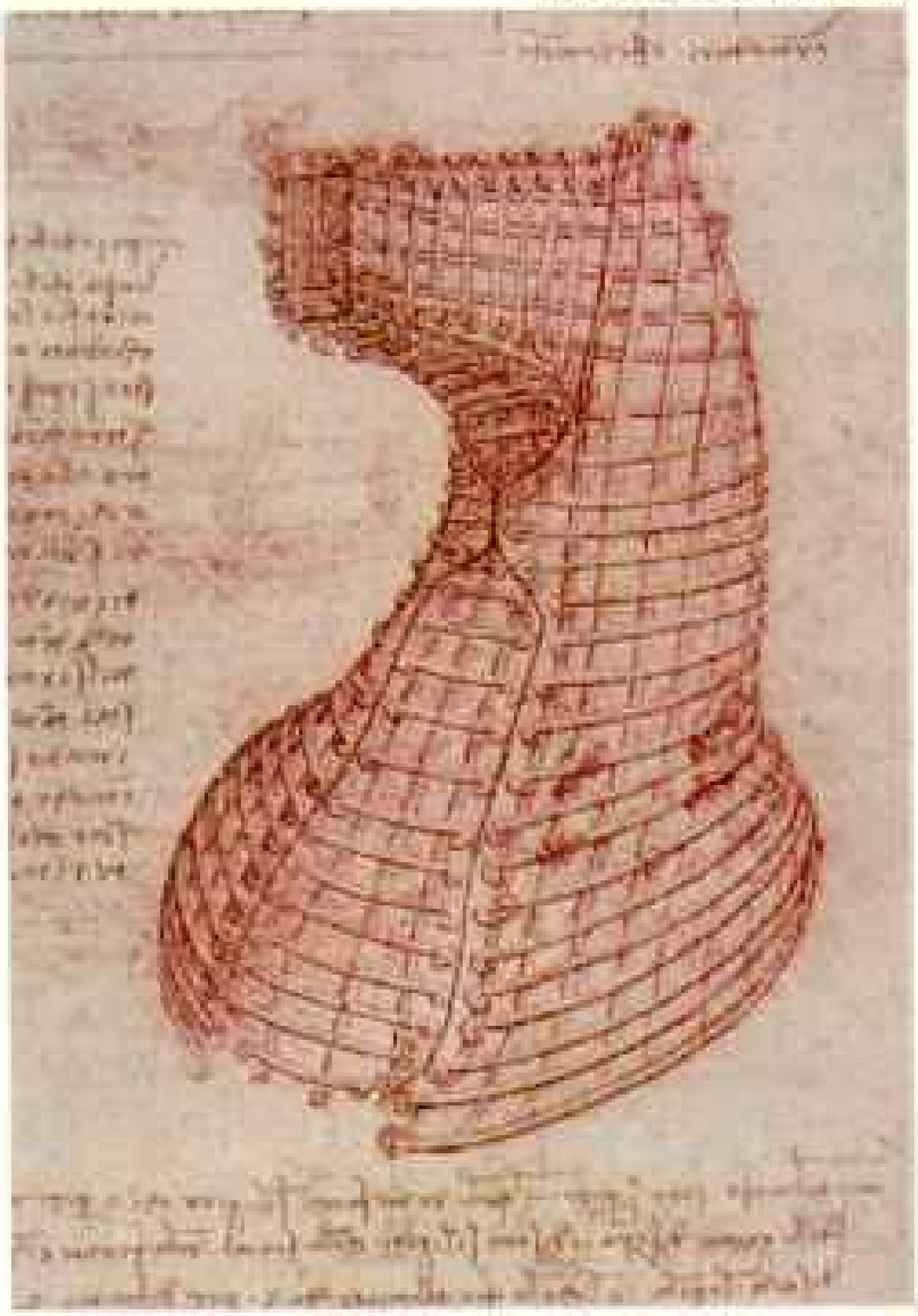
THE HORSE THAT NEVER WAS

LEONARDO'S Milan patron, Lodovico Sforza, demanded the world's largest statue, a 23-foot-high bronze horse with rider, to be placed in a courtyard of his castle in Milan (**right**). With meticulous attention to detail, Leonardo sketched animals in the Sforza stables, then constructed a huge clay model, and finally devised a radically new process to cast the horse in a single operation. Iron framing (**below**) held the plaster mold for the head.

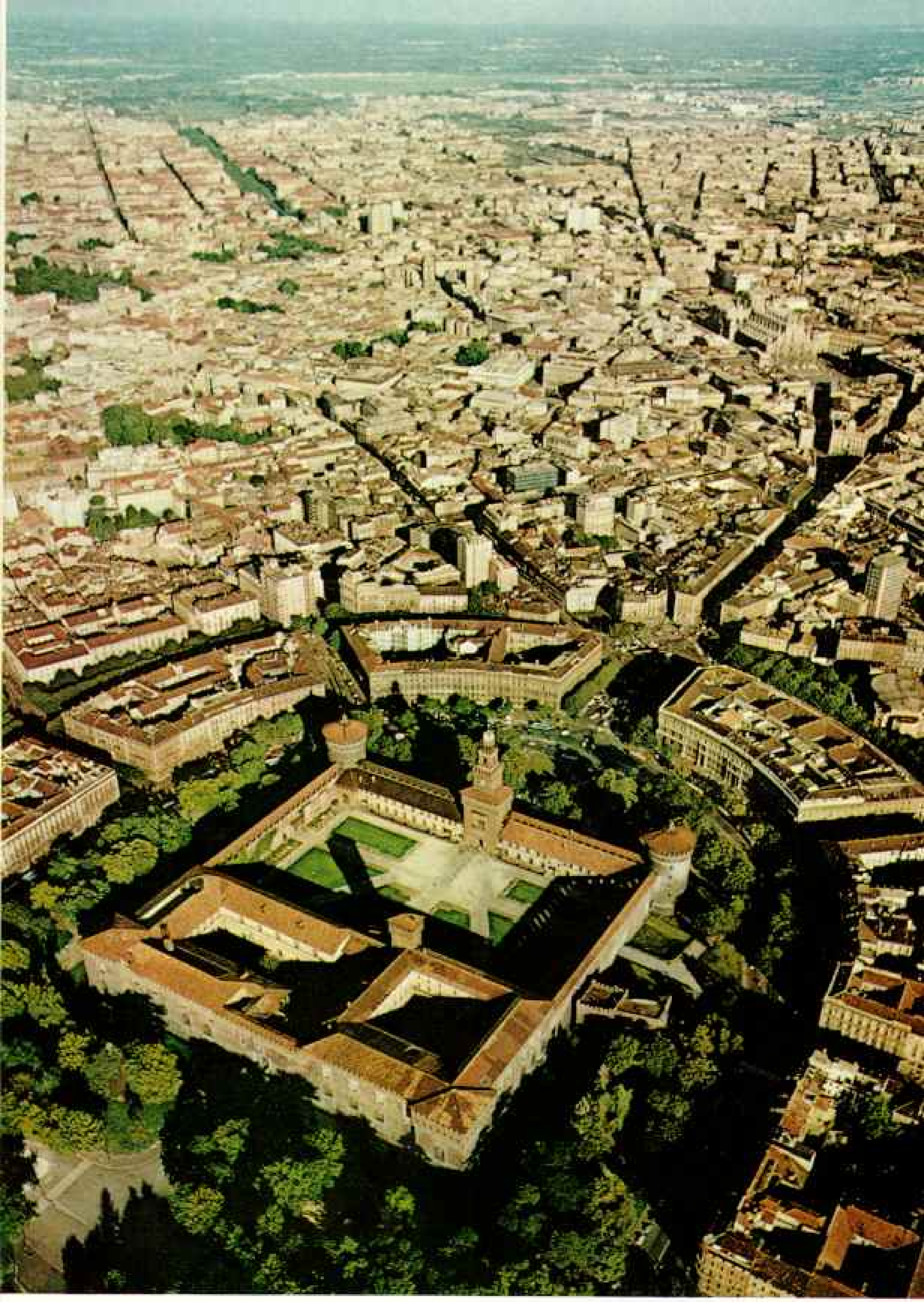
The molds were to be buried upside down, between circular ovens (**left**). Molten bronze —an incredible 79 tons—would pour through tubes into the molds (**lower left**).

Before casting could proceed, however, war intervened. Lodovico took the bronze to make cannon; in 1490 he lost to French armies, who occupied the castle and used the clay horse for archery practice. Just 200 years later French designers fashioned an equestrian statue of Louis XIV. Smaller but similar to Leonardo's design, it employed his casting technique. The method is still used.





GUSTI DRAWINGS: BIBLIOTECA NACIONAL, MADRID; TED SPIEGEL, BLACK STAR (RIGHT)



BIBLIOTECA AMBROSIANA, MILAN

"**Method of walking on water,**" reads the note beside this figure. The idea was revived recently and translated into Water Walkers, popular polystyrene toys (**below**). Much of Leonardo's nautical gear—submarine, water walkers, diving suit with a "wineskin to hold air," and webbed swim gloves—was designed for naval warfare and based on concepts of fellow engineer Francesco di Giorgio Martini. Leonardo, as usual, went further, seeking principles behind the motion of water and air.

of Milan. He spoke scathingly of war, but offered to serve it with imaginative ideas for murderous devices. He treated friends with kindness, but enjoyed drawing hideous grotesques. He declaimed against the taking of life, but watched hangings and sketched the wry-necked victims. In architecture he played with city planning, but worked on fortresses or on the evanescent decor of festivals. But perhaps more frustrating to the man himself was the conflict between his intensely powerful intellect, which drove him to mind-wasting exercises in geometry (and held that nothing that is not mathematically demonstrable could be true), and his fanciful, imaginative genius, which found truth in beauty.

Anatomy became a passion. Quite naturally he wanted to explore the human body in order to represent it perfectly. Other Renaissance painters studied corpses to perfect their depictions of the human form. But Leonardo's scientific bent led him beyond mere art to a reveling in the exquisite mechanics of muscle-articulated bone.

IN MILAN, Salai, a lovely lad with curly blond hair and the disposition of a weasel, became part of Leonardo's household. The artist took the child in as servant and pupil, clothed, fed, pampered, and drew him. Salai's pretty features appear in the languid, androgynous faces of boyish virgins and girlish saints. As usual, where personal matters are concerned, Leonardo's profuse prose reveals nothing of his feelings. "Salai stole the money," he writes coldly. And, "thievish, lying, obstinate, glutton." Again his pictures are his only statements of emotion; he drew Salai with love.

Along with his varied duties at court, which ranged from portraiture to plumbing, two great works mark Leonardo's years with Sforza. One was to be a bronze statue of the duke's late father as a conquering hero astride a charger. The other, ordered by Sforza for his favorite church, was a "Last Supper." They were banal themes, like most commissions of princes and priors, but if the subjects lacked originality, their treatment did not.

The horse was to be colossal, in a pose full of motion and life. The concept was so bold, so ambitious, that it brought the artist the praise he craved, but his contemporaries, including Michelangelo, thought it could not

National Geographic, September 1977

be cast. But Leonardo, an expert foundryman, had devised workable plans (page 318) that came to light in a collection of notes known as the Madrid Codices, found only a decade ago. Before his project could be executed, war broke out and bronze destined for the horse became cannon instead.

He did turn out a full-scale clay model of a riderless horse. It survived until 1499, says biographer Giorgio Vasari, when the French soldiers who occupied the city after Lodovico's defeat "broke it all to pieces."

The "Last Supper," too, was presented as never before. Where other painters portrayed the Apostles in pensive mood, deployed as individuals around the table with Judas generally on the near side, Leonardo interrelated the 13 figures in a brilliant composition reflecting the terrible moment following the words, "One of you shall betray me." He endowed them with deep emotions, varying according to their natures, and he observed to perfection his own admonition to show by motion the intention of each subject's soul.

Like the horse, the "Last Supper" had begun to deteriorate alarmingly in Leonardo's own lifetime because of a curious lack of foresight. Leonardo hated deadlines and fixed schedules. Painting alfresco (that is, on freshly prepared plaster) imposed both. So he worked with oil mixtures, which could be applied whenever the mood struck him. A contemporary description tells much about that mood.

"I have seen Leonardo go early in the morning to work on . . . the Last Supper . . . there he would stay from sunrise to darkness, never laying down the brush, but continuing to paint without eating or drinking. Then three or four days would pass without his touching the work, yet each day he would spend several hours examining it and criticizing the figures. . . . I have also seen him . . . leave the Corte Vecchia when he was at work on the stupendous horse . . . and go straight to the Grazie. There . . . he would take a brush and give a few touches to one of the figures: and then suddenly he would leave. . . ."

The technique suited the artist, but not the wall. The paint soon blistered and began to scale from the damp surface (following pages). Within a few decades retouchers were at work, compounding the damage of decay.

With his doomed masterworks behind him, Leonardo turned to defense planning as Louis XII and his French army approached Milan. The defenses were inadequate. Lodovico fled, but later was captured and died in prison. Concerning his patron of 18 years, the court painter noted, "the Duke has lost his state, his possessions, and his liberty, and he has seen none of his works finished." Leonardo shed no tear but, putting patron above patriotism, set out to win the friendship of yesterday's enemies—today's friends—the French. This done, he left Milan. In the spring of 1500 he was back in Florence.

LEONARDO CAME HOME a famous man. No one knew or cared much about his science and his inventions, but everyone had heard of his horse and his "Last Supper." Still, in a Florence turned republican and pious in the wake of intellectual Medici rule, he could not be the pampered prince of painters he had been in Milan. He would have to compete to prove himself again.

His competition had dwindled. Many of the fine old hands had died or gone to Rome. His most serious rival was Michelangelo Buonarroti, 23 years his junior, surly, pious, ambitious, and a great painter. The two Florentines hated each other wholeheartedly.

As if to gain local credit, Leonardo accepted a commission from the Servite Brothers and soon produced a cartoon, or preliminary sketch, "which not only filled every artist with wonder, but . . . men and women, young and old, flocked to see it for two days, as if it had been a festival, and they marveled exceedingly."

With good reason. It was a serene and enchanting picture of St. Anne with the Virgin and Child (page 327), basis for a later painting considered one of the artist's greatest works. With its subtly heretical suggestion of pagan goddesses and its intrinsic beauty, it was also a slap at the followers of the hate-poisoned monk Savonarola, whose perverted preaching of divine vengeance had roused the city's rabble to stone works of art, distrust beauty, and fear what it could not understand. Leonardo considered God a creator rather than a destroyer.

His reputation reestablished, the master resumed his dilatory ways. He did not render the masterpiece in color or transfer it to the altar panel for which it had been made, but returned to his studies. An acquaintance

wrote: "... he is entirely wrapped up in geometry and can't stand the sight of a brush."

Restless again, perhaps longing for the protection of a powerful prince, Leonardo joined Cesare Borgia, the arch-criminal of the age, as a military engineer and cartographer. His maps were not only numerous and beautiful but, because he based them on modern surveying methods, among the most accurate then known. He produced one of the first world maps making reference to America.

Cesare Borgia, perjured priest and son of a priest, was an intelligent, treacherous killer with a pragmatist's interest in things that work. The effete artist found him fascinating. That Cesare served his father, the Pope (and his own ruthless greed), sadistically and without honor, that his senseless campaign posed a potential threat to Florence, bothered Leonardo not at all.

AFTER SEVERAL stimulating months Leonardo came home to Florence, reduced once more to the role of artist by Borgia's defeat. Perhaps a little guiltily he plunged into unaccustomed productivity, mostly planning and correcting the work of younger painters. Once again two great works drew most of his artistic effort. One was a huge mural for the Council Chamber depicting the "Battle of Anghiari" (pages 324–5), militarily a foolish little fracas in

SCALA

which one man was killed falling off his horse, but politically an important victory for Florence. The other was a life-size portrait of a middle-class woman a bit past her prime.

Some say the lady is Lisa, wife of Florentine merchant Francesco del Giocondo. Others suggest different identities. Perhaps she is no one of this earth, but a creature formed in fascination and fear in Leonardo's mysterious mind. He worked on the picture for most of four years, and it was with him always. Surely anyone who had commissioned the work would have taken and treasured it.

It may have pleased Leonardo to start with an inauspicious subject once again and make the ordinary extraordinary. The Anghiari

Sense of alarm animates the Apostles (**above**) after Christ announces, "One of you shall betray me." Leonardo's precedent-shattering "Last Supper" appears but an extension of its setting, the refectory of the Dominican monastery in Milan (**left**). Beside the serene Christ, in this detail, Thomas, James the Less, and Philip respond as individuals, showing the "motions of the mind by gestures." All Italy acclaimed the painter "whom none of the ancients or moderns has surpassed," in the words of patron Lodovico. But Leonardo's use of an oil mixture rather than the time-tested fresco technique doomed his work to the ravages of moisture.

MUSEUM OF FINE ARTS, BUDAPEST

ROYAL LIBRARY, WINDSOR

skirmish would be *war* with all the bestial frenzy he had observed along Borgia's bloody trail. The quiet lady would be as enigmatic as he himself. Her picture would be *the* portrait, capturing in paint a living or imagined individual in a perfect likeness. He worked on the two paintings alternately.

The battle scene thrust Leonardo into an artistic feud with Michelangelo, who was to paint another wall of the same chamber. The younger man's picture of male bathers interrupted by a call to arms was as captivating as Leonardo's cavalry confrontation, and he used a Renaissance beefcake style that Leonardo despised, putting tensely bulging muscles on every figure—recumbent or active.

The rivals did their cartoons in separate quarters. Both were magnificent in their way. Benvenuto Cellini, who saw them both, wrote that, while these two cartoons were intact, "they were the school of the world."

The portrait offered Leonardo pleasant relief from the subject and circumstances of the battle. Surrounding his sitter with lutists, singers, and jesters "to keep her merry, and remove that melancholy which painting usually gives to portraits," the maestro worked comfortably and carefully to make a picture that would appear to live.

It is said that in its original state it did. It is a dark picture, a disturbing mirror of an unfathomable mind and a cool heart. But it presented a form of perfection, founded a dynasty of portraitists, and became the most famous painting in the world (page 315). It hangs in the Louvre, glass shrouded and

SEEKING A LOST LEONARDO

FEROCITY OF WAR fought face-to-face lives on in the "Battle of Anghiari," a Florentine victory scene that has come to symbolize all battles. We now know Leonardo's brilliant composition from copies such as this by Peter Paul Rubens (**left**).

Leonardo's preliminary drawings (**upper left**) attest his careful observation of men and horses; both display rage in similar expressions. The warrior at far left grips the battle standard in a vise-like hold, creating a visual lever around which the battle swirls as in a vortex.

Leonardo began to paint the scene life-size in Florence's Palazzo Vecchio in 1505 but was called to Milan. In the mid-1500's, Giorgio Vasari painted murals over Leonardo's work—a loss long mourned by the art world.

Scientific sleuths, sponsored by art patron Dr. Armand Hammer, search for the concealed masterpiece with electronic devices. John Asmus and Maurizio Seracini "look" behind the Vasari mural with ultrasonic probes (**below**). Infrared scanners indicate a painting or drawing about the size of the missing mural. If they find additional evidence, they hope to gain permission from Italian authorities to uncover the lost treasure.

LOUVRE, PARIS (LEFT); GIANNI TORTOLI

guarded. Its colors have suffered a strange change as if bathed in undersea light, but the lady still glows with an inner radiance. She is both troubling and serene—ultimate proof of her creator's ability to work near miracles by rivaling nature, his own definition of the artist's goal, the capturing of a beauty, as 19th-century critic Walter Pater described it, "wrought out from within upon the flesh . . ."

IN THIS TIME Leonardo also made many sketches for a painting, since lost, of Leda nestling naked in the swan's curved wing with a coyly bent body and a smile of secret complicity. It is a curious theme for a man without any apparent sexual interest in women, beautifully executed, but chilling in its lack of sensuality.

Michelangelo never transferred his cartoon to the Council Chamber wall. Leonardo did, or at least, he began to. Forgetting the fate of his "Last Supper" (or perhaps not yet aware of it), he again used an oil paint for greater freedom and brighter hues. It is said that he was inspired by a painting method described by Pliny the Elder more than 14 centuries before. Leonardo's use of oil worked well enough on the trial panel—the small original painting—but on the wall itself the paint soon began to flake and run. The work was doomed, another masterpiece lost.

Heartsick, beaten, he did what he usually did in the face of defeat: He turned from art to one of his many other fields of interest. In this case, his old love—flight—once more seized his fancy. His knowledge grew beyond the limits of his time and approached the understanding that much later gave men wings. There is the single reference to an attempt that failed. Be that as it may, his efforts brought him no satisfaction, only the certainty that he himself would never fly or witness manned flight.

One great failure had followed another. Leonardo could not bear to remain on the scene of his humiliation. With the Florentine Council's permission, he left to spend three months in Milan, entering the service of the French governor. He took the "Mona Lisa" with him, and his notebooks, and Salai.

The French treated Leonardo with more consideration than had his compatriots. With the help of the king's regent and later the French king himself, he extended his three-month stay to seven years, during which he returned only briefly to Florence and did nothing whatever to complete the "Battle of Anghiari" (for which he had received payments). The city of the Renaissance had little left to offer the man of the Renaissance who had been its child and its champion.

In Milan he joined Ambrogio de Predis to produce a second version of the "Virgin of the Rocks." Then the master turned his brooding mind to studies so profound as to answer questions yet unasked. He became even more engrossed in his anatomical studies, viewing man as a machine and a work of art. He would disclose all the secrets of the body by combining science and art to create a work beyond the capacity of any other human being. The treatise would be the greatest accomplishment of his life.

SOME OF HIS DRAWINGS were both beautiful and precise and did, indeed, present new knowledge. Then, he turned to the stars and from their lofty perspective looked down with disdain upon the mortal mechanism that is man. In his celestial enchantment he came to question the Biblical age of the earth, the account of the Flood, and to view the earth as a living organism, likening its rivers to the flow of blood.

This was dangerous thinking, challenging the church's concept of man as the center of all things and the result of recent and special creation. In an age in which such ponderings might fall under the definition of heresy, Leonardo confided them only to his notebooks. So he lived on—a sage, skillful old man—tolerated and sometimes applauded. When Rome attacked in 1513 and drove out his friends the French, he left, too—for Rome.

Even a preliminary design reflects the glory of Leonardo's talents. In this "Virgin and Child with St. Anne," without the use of color, he achieved an arresting three-dimensional effect by employing chalk and tempera shading, or sfumato. In other versions he tried balancing the figures in different ways. In the final painting, now in the Louvre, the Christ Child reaches toward a lamb, a design praised by hard-to-please Florentine contemporaries.

NATIONAL GALLERY, LONDON

There was a new Pope now, Leo X, a Medici and a decent, intelligent man. There were plenty of commissions for great artists, and Michelangelo and young Raphael were doing very well filling the Vatican with pictures. Leonardo got no major commissions but perhaps found time to apply the finishing touches to a painting begun years before in Milan: a beautifully rendered, disagreeable picture of St. John the Baptist—that tough old desert wanderer—as a doe-eyed hermaphrodite.

He was well housed, thanks to Pope Leo's brother Giuliano, with whom he devised all sorts of bizarre experiments and odd fantasies. Few of his colleagues came to see him, and the Pope's German artisans insulted him. Three years later Giuliano died, and Leonardo set out on the last journey of his homeless life.

Once again his reputation had done for him what his talents could not always do. Young Francis I, France's new king, regarded Leonardo as a legendary figure and wanted him nearby whether he painted or not. He was housed in the cheerful small Château of Cloux in a pastel landscape near the quiet Loire. Still the maestro, Leonardo had with him Salai, who soon left, the devoted Francesco Melzi (a pupil from the Milanese years), an old serving woman, and three pictures. On one or another he painted occasionally or

Honored by kings and cardinals, yet melancholy with the fleeting years, Leonardo moved to Amboise, France, in 1517, as guest of Francis I. The artist's home overlooked the ruler's chapel (**left**). Leonardo continued to plan—a palace, flood control for the Loire. And he kept drawing—visions of the cosmos and this sketch, possibly of himself near death, which came in 1519. Despite his achievements, he is reported to have sought God's forgiveness for "not using all the resources of his spirit and his art."

ROYAL LIBRARY, WINDSOR

directed the work of other artists. He gave increasing attention to architectural planning and the king's idea of a new royal residence at Romorantin, which embodied many concepts that would appear at Versailles a century later. For the rest, the old gentleman did little but talk with Francis, who galloped up often and unannounced to ask advice, for he thought Leonardo the wisest of men.

In his heart Leonardo felt defeat. He sensed the coming of death with desperation, knowing that now he would never finish the works on which he was engaged or, more important, carry out the many wondrous projects that forever filled his extraordinary mind—that his consuming thirst for understanding would never be quenched. In his distress he would think back on a philosophical doodle, a row of blocks, each pushing the next down, whereon he had written: "By these square blocks are meant the life and the states of men."

Dying, his greatest works crumbling, his great knowledge undisclosed, he grieved for what might have been. No spark of the old arrogance returned to suggest to him that the few magnificent works he left would alone suffice to make his name immortal. And so the universal man—symbol of his time and anticipator of ours—passed with unaccustomed humility into eternal fame. □

CALIFORNIA'S NORTH COAST

Redwoods, Rain, and Lots of Room

By JUDITH and NEIL MORGAN

Photographs by DEWITT JONES

Bone-weary after hours of wielding ax and saw, logger Charles Charleston savors the hush of a redwood forest. Felling these giant trees for half of his 40 years, the logger typifies the hardy breed of people who inhabit California's wild and isolated northern coast. Long overshadowed by the sunnier and more developed parts of the state, the north coast unfolds a panorama of redwood forests draped in fog, farms nestled in fertile valleys, and rocky, wave-lashed shores. Whether loggers, ranchers, fishermen, or artists, its people are drawn to the challenge of a place that takes a pioneer's will to survive and an adventurer's heart to enjoy.

OUT OF THE NORTHWEST the wind wailed, landbound at last and moist with fragrances from off the vast Pacific. It eddied around rock stacks that rose from the surf like drunken greeters, then clanged the rusty doors of an old lighthouse high on Cape Mendocino, the apogee of this northern California coast.

Seeking shelter, we hurried toward a white ranch house that hunkered low beside the sea. Waves shuddered on the shore, tumbling rock on rock in a throaty clatter. Sprays of gravel blew up the path like tumbleweeds.

On the porch a sturdy, graying man stood rooted in welcome. He was Joe Russ III, whose grandfather had exchanged a hard life on the Maine coast for a hard one here in 1850. Joe laughed at the wind as we followed him into California's westernmost house.

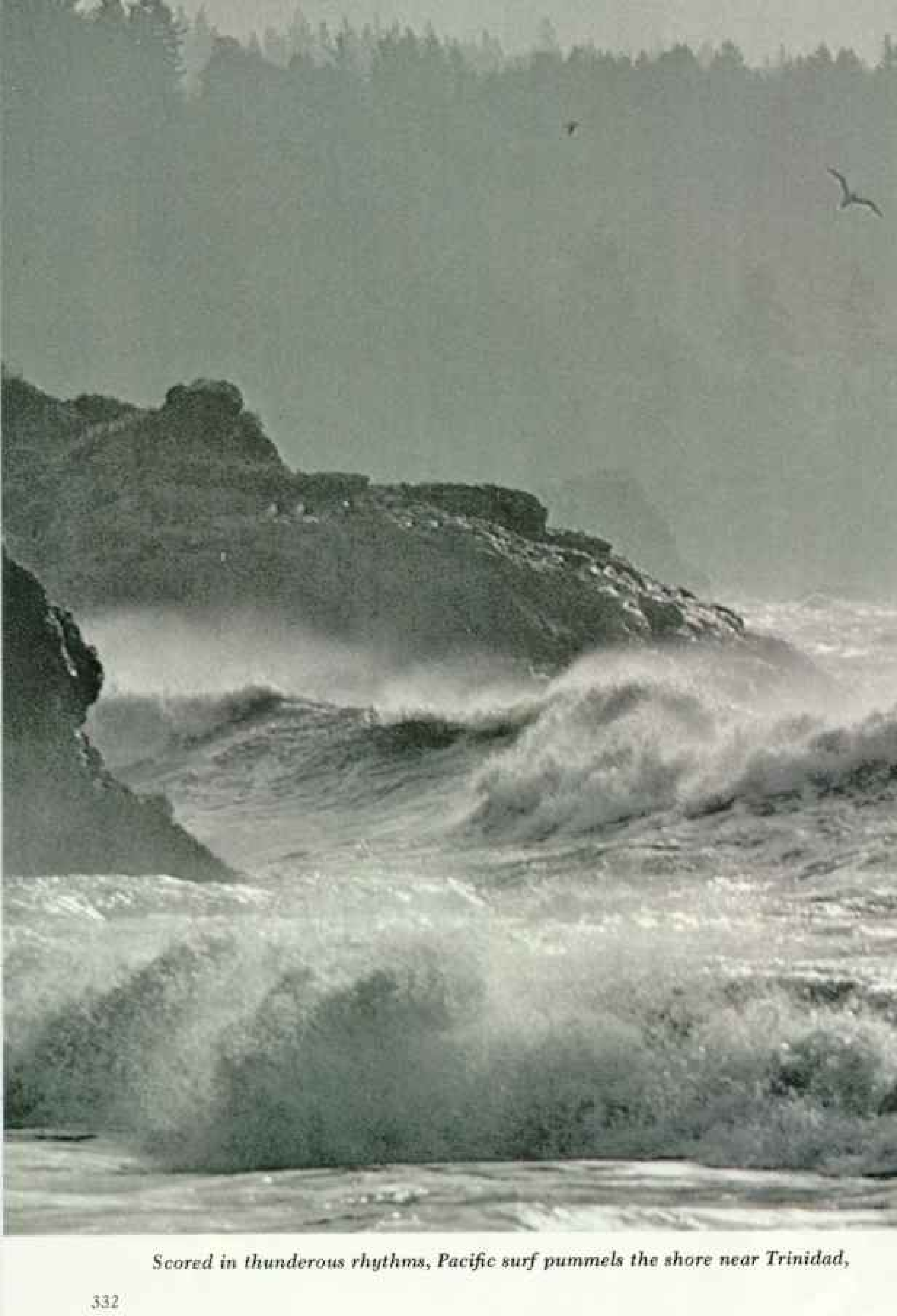
"It's worse up there at the lighthouse," he said. "Back when it was manned, they sometimes got around better on their hands and knees. They had a gauge for a while, but one day the wind got up to 90 miles an hour and blew the thing apart."

Joe has always lived near this cape, raising cattle and sheep and another generation of Russes. North and south from his spread the shoreline is primitive for most of 50 miles. Majestic in its isolation, it has been called California's lost coast.

"Maybe *some*body lost it," Joe told us. "But *we* never did. My grandfather came around the Horn to be a merchant for the gold hunters. Then he found all this grass, and we've been here ever since. People don't realize there's more up here than redwood trees. We get some weather, all right, but I wouldn't be anyplace else."

Before Joe's grandfather, only Indians walked this cape. But four centuries ago lookouts on Spanish galleons from Manila were straining to sight this landfall, a signal to turn south on the run to Acapulco. In 1579 Sir Francis Drake also sailed along the coast, writing in his log of "most vile, thicke and stinking fogges."

On headlands that seemed more Scottish than Californian, Joe showed us some of his sheep, hazy blurs behind gray rail fences. At 68, he strode firmly across his land, confident of it and himself. Such grit is a hallmark of those who inhabit the sparsely settled coast that begins north of San Francisco's suburban



Scored in thunderous rhythms, Pacific surf pummels the shore near Trinidad,

California. Some 15 state parks and beaches line the spectacular north coast.

sprawl and continues for more than 400 miles to the Oregon border (map, page 336).

North of the Golden Gate the sun is duller, the sea more demanding. Salt winds skew pines and cypresses into arthritic silhouettes. Remnants of redwood forests haunt the southern ridges; virgin groves stand as parkland in the north. The San Andreas Fault follows the coast conspicuously, traced in ominous sinks and scarps.*

Though California has become the most populous state in the country, only four towns on this long coast have grown beyond 2,000 residents. Eureka, with 24,250, is the metropolis. Isolated by history, foul weather, and a precipitous shoreline, descendants of pioneers live alongside idealistic newcomers, who learn quickly that nature drives a hard bargain for its bounty.

A Side Arm Can Come In Handy

South of Joe Russ's spread one bleak morning we drove our high-bed vehicle into the King Range, a mountain wall thick with fir and madrone trees, soaring abruptly from the surf to more than 4,000 feet. We had seen no one for hours and had taken to foot when the sound of an ax echoed up Bear Creek. Outside his cabin, chopping firewood, was a small, unsmiling man in a red-plaid shirt. In a hip holster he wore a revolver.

"Is that for varmints or strangers?" we asked him.

"Anything that comes after me," he said pleasantly. "My wife and I don't see many people up here, but we get lots of rattlesnakes. Also poison oak and rain, 12 feet of it some years."

He was Lester Bellinger, a retired federal worker. He seemed proud as he talked of the torments of nature here. It was our first brush with the obduracy that has led some of these backwoods Californians to call themselves "poison-oakers."

Twelve miles away, in the lee of the King Range, is a crossroads store and post office called Honeydew. On a rare sunny afternoon we found Leonard Meland, who operated the store and post office for 29 years before retiring in 1976. He was sitting on a bench out front, enjoying a can of beer.

*"California's San Andreas Fault," by Thomas V. Canby, appeared in the January 1973 issue of NATIONAL GEOGRAPHIC.

"The more the merrier" could serve as a rallying cry when salmon start running the Klamath River. Hundreds of fishermen gather at its mouth in late summer (**above**). Lines tangle, motors drone, and hard hats are often donned to prevent injury from flying hooks and sinkers. Somehow fish are caught before campers return to their "aluminum tents," where walking the dog (**left**) is a daily ritual for many.

"One of the wettest places in the 48 states," he said, when we persuaded him to bring out his rain charts. "Only reason anybody ever heard of Honeydew.

"Part of my work here was monitoring the rain gauge. Clouds ride in off the ocean over that King Range like a roller coaster, then dump on us at Honeydew. In the winter of 1957-58 we got a record here, 174 inches," he said happily. "In November 1973 we got more than 46 inches in one month. Ain't that terrible?" He was beaming.

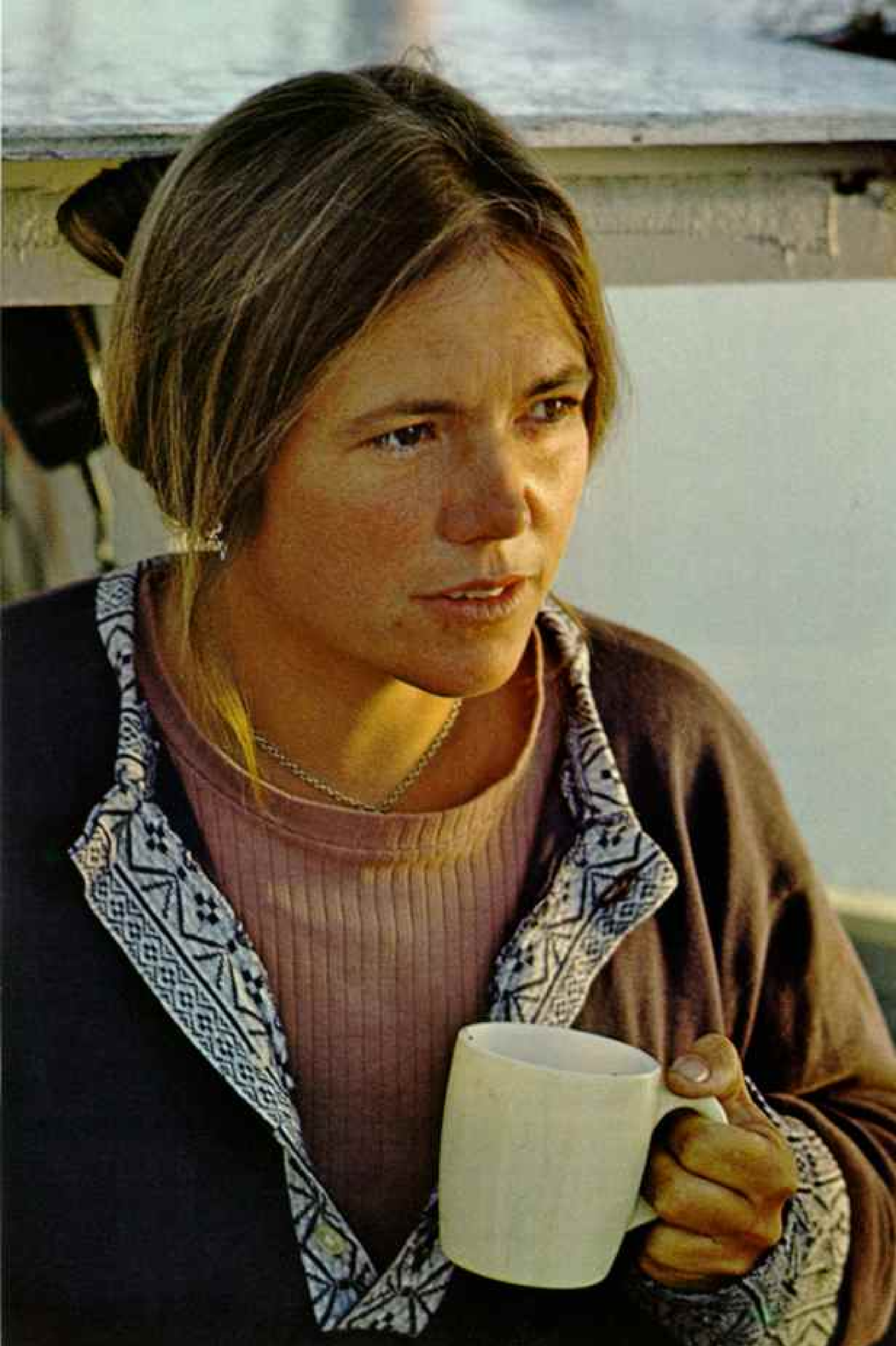
"Things have been tough here. By 1966 it was just my wife and me and the dog," Leonard said, "and we were ready to close down Honeydew. But times are changing. Ten cars came through here yesterday; three people just this week were talking about land."

Development Prompted Backlash

Broken dreams have helped to hide this coast. The hamlet of Petrolia is a huddle of wooden houses where California's first producing oil wells were drilled in 1861 and soon abandoned. From near King Peak we had seen the skeleton of another town, a network of almost empty streets called Shelter Cove. There in 1965 developers had sought to open this lost coast at $6,000 a lot. Ensuing outrage helped to make California's thousand-mile shore a testing ground for environmental law. By some reckonings, thousands of shoreline homes in more populous areas have been prevented because Shelter Cove became a rallying cry for conservationists.

On most road maps the coast of California is a blank for more than 20 miles north and south of Shelter Cove. Near the dispirited village of Whitethorn to the south, all paving ends. The only people in sight when we stopped there one morning were two old men in the general store, who disagreed about

Too forbidding for early European settlers, the north coast harbored chiefly Indians and fur traders until 1848, when gold was discovered in the Trinity River. Yet it was "red gold" from the redwoods that supplied newcomers with fortunes. An enterprising spirit still persists. Sally Bailey (**right**), who helped outfit a boat with money made from a television commercial, quit city life and now trolls for salmon out of Bodega Bay.



where the dirt road south of town might lead, if anywhere, and whether it was passable.

We followed it anyhow, past a Trappist monastery, and then paused at a commune of young people along the Mattole River. They regarded us with some hostility, and we recalled hearing of drug busts along this coast.

Women in flour-sack dresses and bearded young men were cultivating rows of vegetables as naked toddlers squatted in the dirt. One serious young man, who said he was from New York City, was milking a goat.

"I never knew goats got mastitis," he said dolefully. "It's been a real problem."

Then for almost 15 miles, completely alone, we wound down the coast on a one-track trail. Silent forests of fir and redwood closed around and above us, screening the sea that roared as much as 1,800 feet below.

After two hours we emerged in a pasture and rattled over a cattle guard onto California Highway 1. Astonished, we looked back. There was no sign to suggest that a road exists along this piece of pristine coastline.

Later we sought out Henry Franks, a Mendocino County roads official, to learn where we had been.

"You found the Usal Road and came past Bear Harbor over Jackass Ridge," he said, startled. "That's real lonely country. That land hasn't been cut in a long, long time."

Nor is it likely to be. Early in 1977 the State of California acquired eight miles of our route as coastal parkland, and was negotiating for more.

Treacherous Seas Take Their Toll

As we traveled this long north coast, its seas bewitched us with their cunning and violence. Although the region's last manned lighthouse, at Point Arena, was automated early in 1977, the U. S. Coast Guard is highly visible. At Crescent City one gray December morning we boarded the cutter *Cape Carter* to visit the site of California's worst maritime disaster, the wreck of the side-wheel steamer *Brother Jonathan*. More than two hundred persons drowned when the vessel grounded on St. George Reef in 1865. In 1891, after eight harrowing years of construction, a lighthouse went into service atop this reef, nine miles off Crescent City.

In heavy fog as we approached the reef, the cutter came to a dead stop, its foghorn

bellowing. Ahead of us we saw nothing. Then the bow lookout cried, "Sir! Look above!"

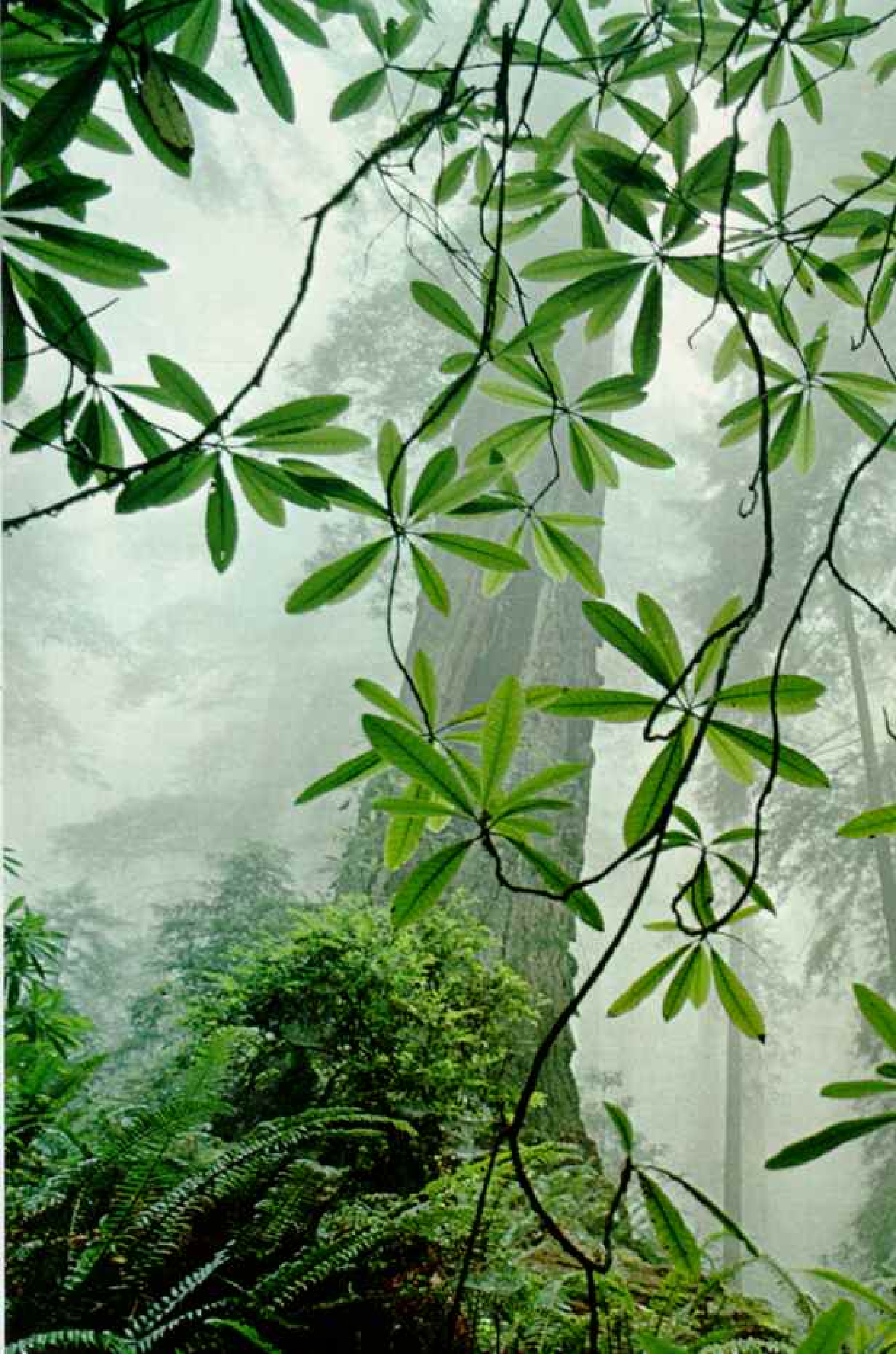
Through a rift in the fog a granite ghost like a chess player's castle loomed over us, 13 stories high. Its concrete base gripped a reef over which waves careened in deadly confusion. Chief Boatswain's Mate Robert Passot, once in charge of the St. George Reef Light here, pointed 70 feet up to where waves once tore the enginehouse from its foundation.

"See that boom?" he asked. A gray shadow extended out from the lighthouse far above us. "We went up and came down in a rope basket from that boom. You only had one chance to jump out. I never landed on my feet once. Several men died over the years, getting on and off St. George."

Back in port we saw a jetty topped with 25-ton concrete tetrapods, like tumbled jacks, which the residents of Crescent City hope will fend off any future disaster like the seismic sea waves that left 11 dead on March 28, 1964. The waves were triggered by the previous day's earthquake near Anchorage, Alaska. Oceanographers estimated that the fourth and worst wave was 30 feet high when it left Anchorage and moved at almost 500

Tossed like playthings, crab boats in Trinidad Bay strain at their anchors during a squall. Quick, violent storms and harbors mined with rocks often spell trouble on the coast. California's worst shipwreck occurred at St. George Reef to the north in 1865, when the side-wheeler *Brother Jonathan* collided with rocks, drowning more than 200.

As if to embrace the sky, coast redwoods soar 350 feet or more in Redwood National Park. Logging has stripped most of the virgin stands in the narrow fog belt along the northern California coast. Nevertheless, parklands now preserve some 68,000 acres of the world's tallest trees. Conservationists and timber interests disagree over the question: Should more acreage be protected?



miles an hour, striking Crescent City with deadly aim at a height of 21 feet.

We sought out Bill Parker, who directed civil-defense work that night. "The ocean picked up half the town and set it down crazy," he said. "One old couple's house floated three blocks down the street and stopped in a field. They were still in bed, dazed, when we rescued them the next day."

The highest wave of record on this coast damaged no more than a lighthouse keeper's disposition. We climbed above the little harbor of Trinidad to that beacon with Ralph Hunter, the white-haired grandson of Fred Harrington, whose log entry for December 13, 1913, remains one of the most astonishing in Coast Guard annals. He reported a wave that "struck the bluff and shot over the level of the lantern." Trinidad Head Light, then as now, is 196 feet above mean low tide.

Ralph led us around Trinidad Head as he told the story:

"Granddad was wiping salt off the lighthouse windows when it hit. He just hung on the railing, soaking wet. The air must have been blue, knowing him, but it was too noisy to hear what he said. The shock of the wave smashed the mantle of the kerosine lamp, and it was half an hour before he could get the light back on and come in to change clothes."

Even the rivers of this coast, with their abrupt names—Elk, Eel, Mad, Noyo, Klamath, Smith—can be violent. For most of the year they are subdued streams, but their banks are scarred with reminders of their force. In the fall of 1964, Indian women

"I wanted to work with my hands," declares Tom D'Onofrio, Methodist minister and former student activist at Berkeley, who retreated to the country north of San Francisco to become an expert woodworker. He took five years to carve this rosewood dragon table. Tom now promotes the quiet revolution of self-sufficiency; he founded the Baulines Craftsmen Guild, where apprentices study under master artisans.

warned of a hard winter. Tiny green frogs appeared high in trees, as they had before heavy floods in 1955. Snow fell early. On December 18 fierce rains began and continued for six days. At Alderpoint, where the Eel is two feet deep in summer, it rose above 90 feet. Logs washed from lumberyards and formed miles-wide jams at sea. The towns of Klamath and Pepperwood were destroyed.

In the Eel Valley near Ferndale, on the farms of dairymen of Swiss, Danish, and Portuguese descent, high-water marks still stain the sides of farmhouses. Nearly 5,000 cattle were drowned here.

"My brother and I gave up dairying after that flood," Frank Moranda told us at his farm near the mouth of the Eel. The son of Swiss immigrants, he has lived here all his 92 years with his brother, Julius, who is 96.

"The water was four feet above the top of this porch. But we love this land. We stay on."

In Ferndale, a village of Victorian steeples and gables (pages 348-9), we sipped coffee in a café and scanned an admirable volume of town history. It had been researched and written by the 53 members of the high-school class of 1977.

"I helped write the chapter on what Main Street used to be like," our waitress told us. "It was really something in those days."

We asked her to autograph it. She blushed and circled her face in the class picture and wrote "Monica Mansfield." For us it is a reminder of a quiet place where young people look back in wonder and respect.

Majestic Giants Dominate Coastline

The coast redwood, tallest of trees, grows in a fog belt close to the Pacific Ocean. Virgin forests once extended from south of San Francisco northward into Oregon. But logging, sweeping northward during the past century, has taken nine-tenths of the virgin trees. Less than 200,000 acres remain, with 68,000 of these in parkland.

Late one afternoon, with low shards of sunlight piercing the daylong shade, we walked among shoulder-high ferns to touch the trunks of massive redwoods in the Rockefeller Forest along Bull Creek. All was silent except for the chirp of a winter wren and the creak of some great limb stirring ten or twenty stories above. The redwood is imperturbable, epic in its indifference to fire, parasites, and disease. On the north coast it is the prime source of both jobs and controversy.

In a redwood forest near Smith River we struggled at daybreak to keep pace with John Green, a 66-year-old Tolowa-Chetco Indian logging for Simonson Lumber Company. He bounded up the mountainside with his tools slung over his shoulder like toys: a 54-inch power saw that weighed 40 pounds, an iron knockout bar, and an ax.

"We'll fell a good-size one," he said in a voice as gentle as a child's. We stopped beside a tree about seven feet thick that rose a hundred feet before its first branches appeared, more than two hundred feet in all.

Last Rites for a $15,000 Tree

John revved up his saw and drove it into the tree at elbow level. Sawdust spurted like flecks of dried blood and buried his boots. Musty smells of bark and soil hung in the damp air. As John put long slashes around the tree, a Caterpillar cleared a soft, hummocked grave as long as our tree was high.

"He's making the lay," John said. "Those mounds of earth keep the tree from shattering when it hits."

With his bar John knocked out a slab of trunk called the back cut. Jacks went into the gap. He moved to the other side and made the undercut, a deep wedge that left the center of the trunk as a hinge. Soon his snarling saw fell quiet, and he gazed upward. The redwood's crown stood in a halo of sunlight.

"It's ready," he said quietly. "Move back." Then the warning bellow: ". . . berrrrrr!"

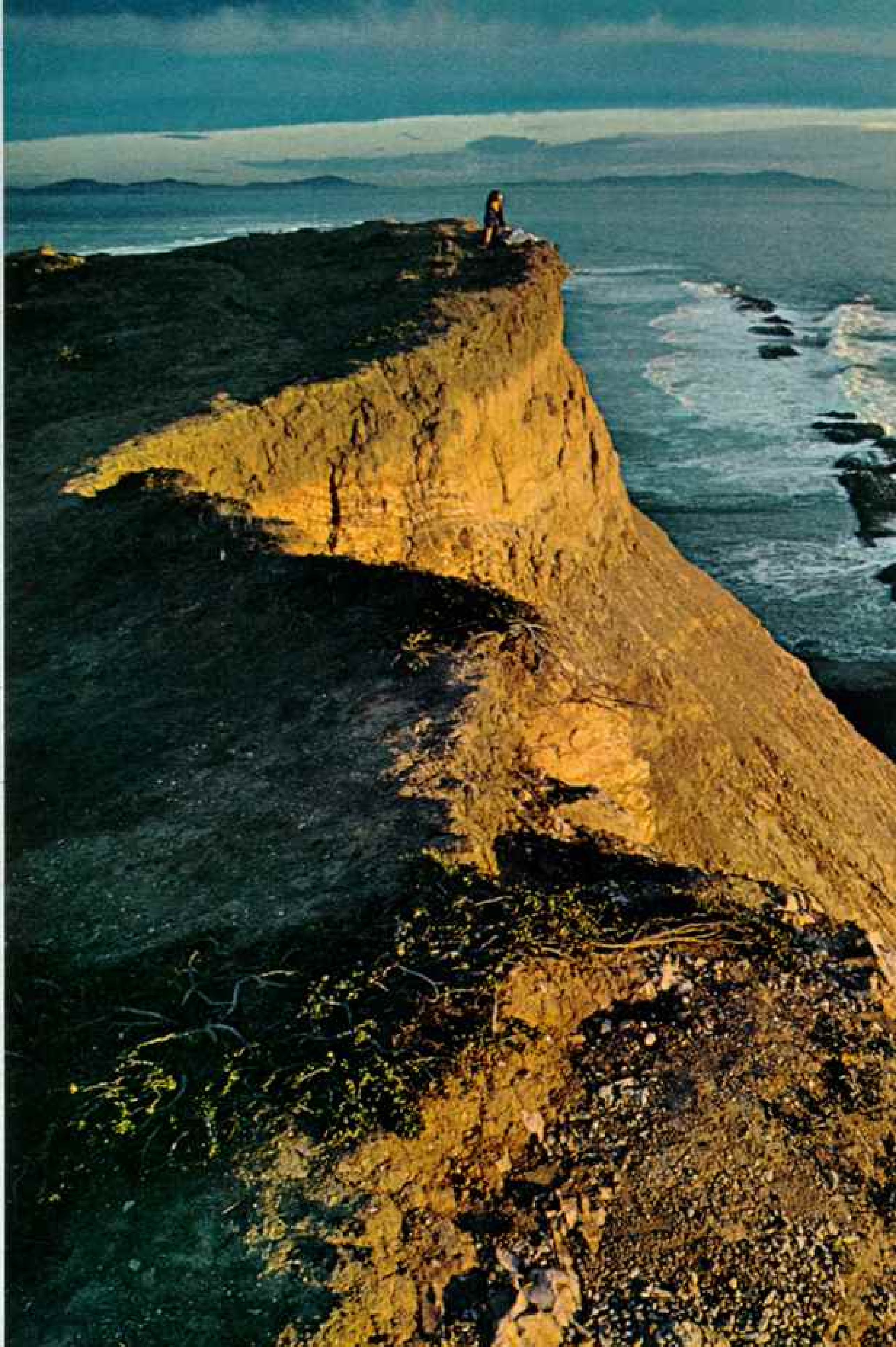
The tree shuddered, began to lean, hesitated. With a wrenching crack the trunk snapped. The tree gained speed, leaped outward, and struck its bed with a thunder that shook our spines. The sky seemed empty.

John climbed up on the stump and studied the rings. "I thought it was older," he said. "It's about 540 years."

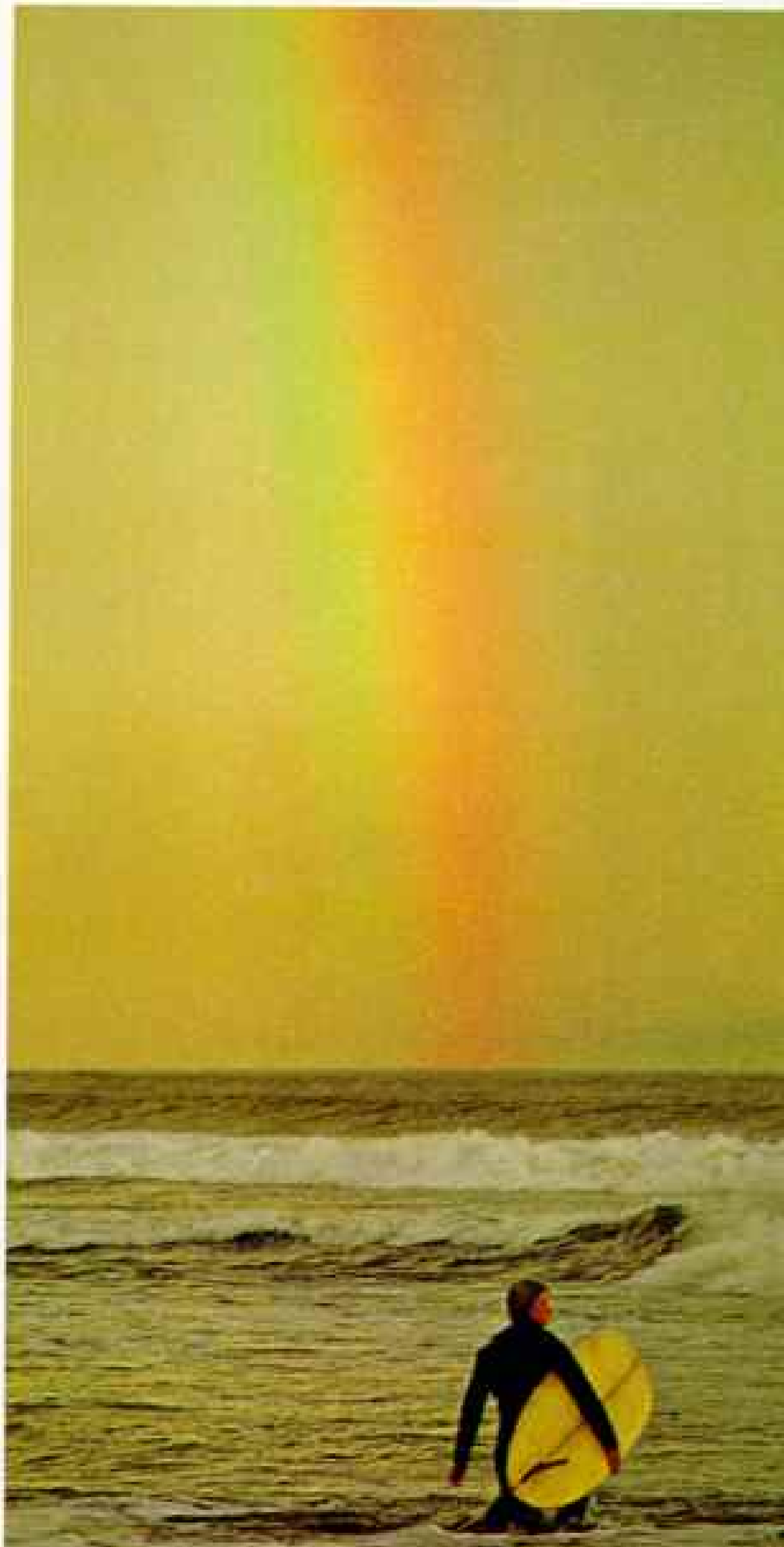
He paced atop the fallen tree, sawing it through in 20-foot lengths. Cut into first-grade lumber and dried, he guessed, the tree could yield about $15,000 at retail and build a couple of houses.

John picked up his tools and moved up the slope. It was not yet ten in the morning.

Lee Simonson, whose family holdings include a forest along eight miles of the Oregon-California border, drove us up Rowdy Creek



Thoughts may wander as deep as the ocean when one is perched on a cliff over the Pacific at sunset (**left**). Of some 400 miles of northern coastline, nearly a third is public land. Uses range from beachcombing to surfing, frequently under a rainbow (**below**). The state's newly established coastal commission will regulate development and promote conservation within a shoreline corridor stretching along the entire California seafront.



to meet a loner named Frank Thomas. A wiry man with a cavernous face, Frank was thinning second-growth redwoods with the help of two splendid Belgian-Percheron horses.

"It's slow and expensive," Lee explained, "but when we cut here in 15 years, the trees that are left should be healthier and bigger. And horses don't scar trees in passing, the way machines do."

A spirited mare named Clara was Frank's pet. She tossed her head high, turning to watch as he backed her into position and chained three logs behind her. Pawing the ground, she awaited his command and then trotted briskly down the hillside alone, eyes wide, mane and tail flying, pulling a ton of logs as if they were a king's sleigh.

"This Clara," Frank said later, "would rather work than anything. A guy offered me a couple thousand for her. We just laughed, didn't we, girl?"

Conservationists Raise Loggers' Hackles

In forest and town we heard bitter criticism of conservationists who seek to halt further cutting of virgin redwood, especially on Redwood Creek near the three tallest known trees. Each more than 360 feet, these trees were discovered in 1963 by Dr. Paul A. Zahl of the National Geographic Society.* They stand in what is called "the worm," a wriggly protrusion at the south end of Redwood National Park. Established in 1968, the park is a ragged corridor that sweeps along 33 miles of coast and encompasses three state parks.

The Sierra Club is among those organizations urging Congress to extend park acreage by purchase and thus reduce the threat to these trees (pages 360-61). Nearby logging has already increased erosion and silting and has widened Redwood Creek, cutting into the bank near the tallest trees.

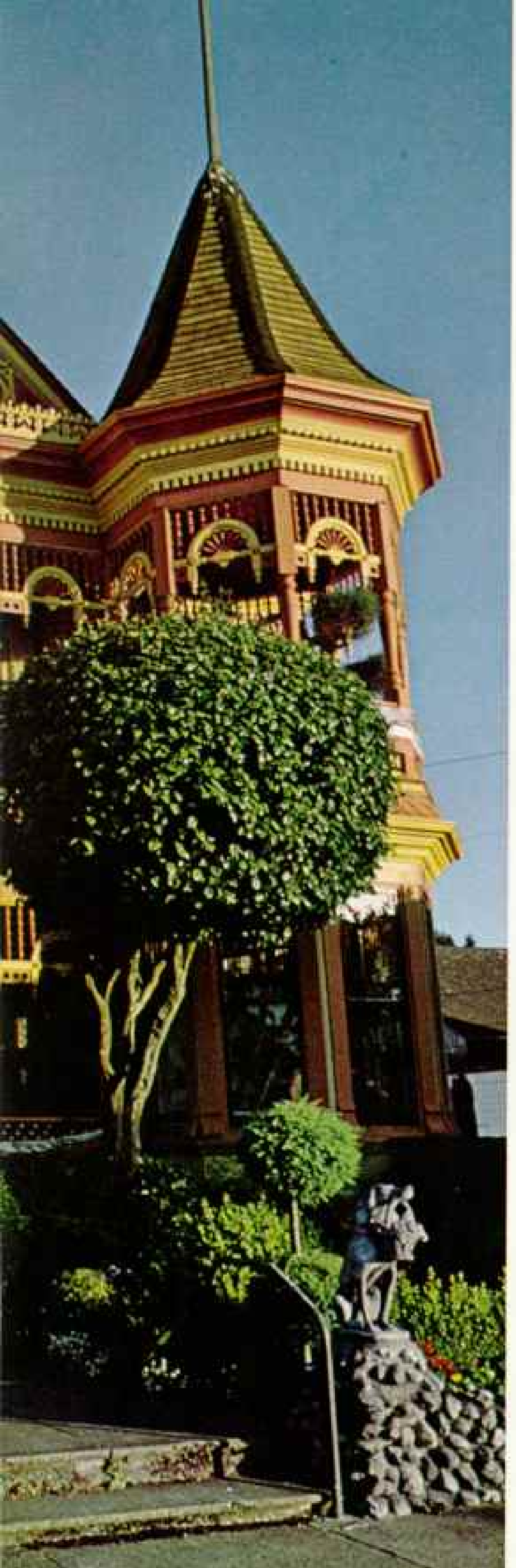
Park Superintendent George Von der Lippe told us of other problems. "We are a pawn in this conflict between loggers and environmentalists," he said, "perhaps the most controversial of all national parks."

Because of high acquisition costs, Redwood is already much the most expensive national park, but it lacks trails and visitor centers that Von der Lippe believes it needs.

"We're proud of our park," Andy Flynn told us. A civic leader in Crescent City, he

*See NATIONAL GEOGRAPHIC, July 1964.

Where there's timber, "State of Mainers" gather, and in Mendocino in the late 1800's it was no different. Settlers from Maine built houses here, embellished with gables and corniced doorways (**facing page**). Artists and craftsmen revived the town in the late 1950's. Tourists, urban escapees, and nomadic youths followed in such numbers that the town was made a historic site to prevent incompatible development. Old-timer Herman Fayal, 84, built a town model (**above**) to remind visitors of earlier days. Nannie Escola, 91 (**below**), accepts newcomers if "they don't tell me what to do."



Refurbished grandeur: Fourth of July bunting pales beside the sunny facade of the Gingerbread Mansion (**left**), one of many Victorian homes receiving face-lifts in Ferndale. Built in 1894, the building passed from doctor's house to hospital to aging apartments before two Bay Area men bought the 30-room structure in 1965; they restored it and designed more spacious apartments. A reproduction of a ship's figurehead (**above**) serves as a scarecrow in an Annapolis garden.

seems to state the majority position among residents. "But we don't want it enlarged. If we don't cut trees, we don't eat."

The controversy flared in the spring of 1977 as three lumber companies declined a suggested moratorium on logging in forests close to the worm. Interior Secretary Cecil D. Andrus proposed to Congress a 359-million-dollar, 48,000-acre expansion of the park. Loggers responded that unemployment in the area, already at 14 percent, would rise to 17 percent if that acreage were excluded from logging. They dramatized their case with caravans of logging trucks carrying protestors to San Francisco and Washington.

Howard Pentoney, a burly Eureka attorney, pleads a middle course: "Why can't they leave a screen of old-growth redwoods along the roads and rivers?" he asked. "Stumps! All we see is stumps!"

The redwoods stood unharmed through centuries when this coast was inhabited only by Indians. At their peak there were perhaps 70,000 Indians. Most Athapaskan tribes lived in the mountains, taking salmon from the rivers. Algonquian tribes—Yuroks and Wiyots—established an advanced society along the coast, with redwood canoes, plank houses, obsidian blades, and cultivated tobacco.

Fishing Rights Spark a Controversy

Into this setting in 1828 marched the fur trapper Jedediah Smith, first of the American pioneers to reach California overland. In crossing the Klamath River, he was aided by Indians. Lately there has been tension between their descendants and sport fishermen, because only the Indians, who hold subsistence fishing rights along the lower 40 miles of the Klamath, are permitted to use gill nets. Sport anglers feel the Indians are depleting the fish stock. The latest legal issue is whether "subsistence" rights limit the Indians' catch to the fish they consume or if those rights allow them to sell commercially any excess catch—as they have begun doing in violation of state law. As reservation Indians, are they subject to state restrictions? The courts are trying to decide.

"Our people have always fished the rivers," Betty Green explained. "Why make us outlaws?" A Tolowa-Yurok, she is compiling a textbook on the Tolowa language, literature, and culture.

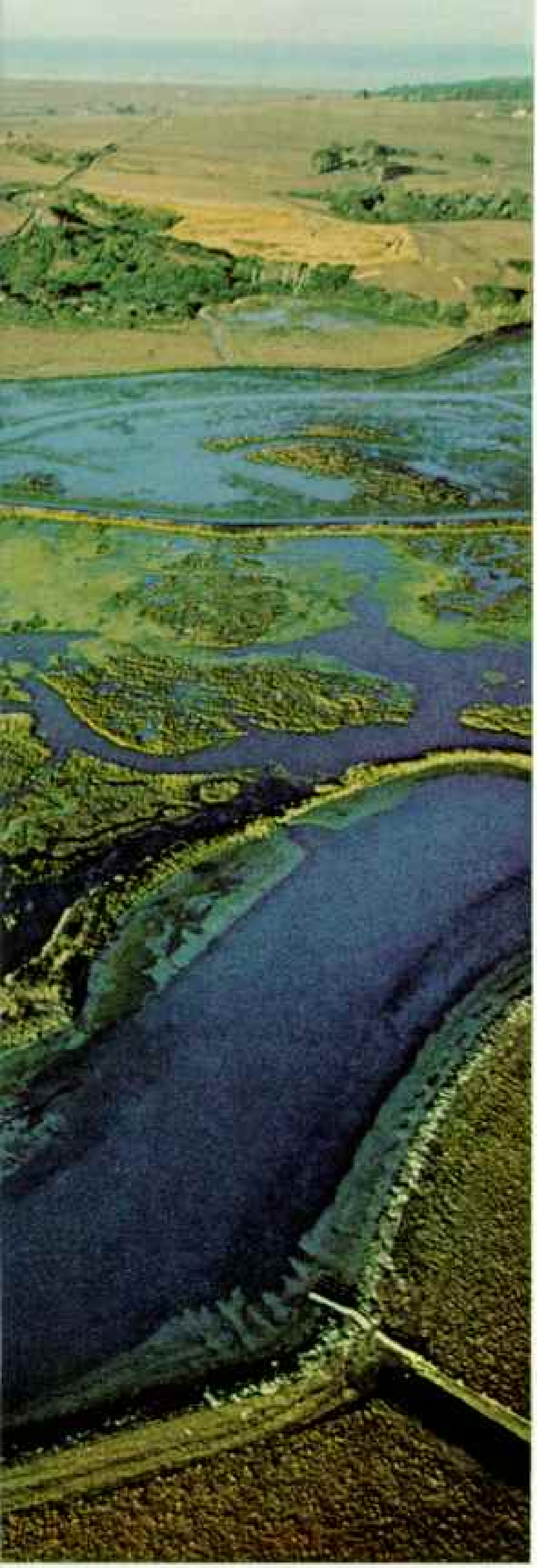
"There are thoughts that cannot be expressed but in our own way. Our language is a part of me I cannot give up," she says.

When white settlers massacred Indians in 1860, an outraged young reporter at Union Town published a vigorous protest and was hounded out of town. Bret Harte then went to San Francisco and launched his literary career. Union became Arcata, a lumber town that today is the focal point of change along this coast. Humboldt State, once a quiet teachers college, has given impetus to young people, who now dominate town government.

Mayor Alexandra Fairless was one of the two youngest members of the city council when she was elected as a 32-year-old student in 1972. By 1977, in her second term as mayor, she had become the oldest.

MICKEY PFLEGER

Knack for the different marks the doings of Alexandra Fairless, whether she's building a retreat atop a redwood stump (**left**) or representing Arcata as its first woman mayor. Popular with students, who form a major voting bloc, she runs afoul of lumbermen for not opposing expansion of Redwood National Park. "Expansion is inevitable, so why not try instead for job replacement and diversity of industry," she exhorts publicly (**above**). Despite this rift, she has quieted much local misgiving. "At first people thought, 'Oh no! We're in trouble.' But they have seen what I do, and now I am accepted."



Wearing the seasons on his face, hired hand Mel Pelascini (**above**) pauses for a smoke after "scratching up a potato field" on a ranch near Loleta. Wary of city living, like many other northern Californians, Mel, 49, has worked outdoors most of his life, going from logging camps to dairy farms. "You may think it monotonous riding back and forth on a tractor all day, but there ain't two fields alike," he explains.

Much rich grazing and farming land exists where redwoods once stood. One farmer protects his land by repairing dikes built more than 50 years ago to keep salt water from marshes near Humboldt Bay (**left**). Land now going underwater, at center, probably will become a state wildfowl preserve.

"I was the first woman to run," she said. "That really surprised me."

With long brown hair and piercing eyes, she is a persuasive political leader. Like a majority of the 7,600 students, she is not native to this coast. Born in Chicago, she worked in San Francisco and then went to Humboldt State to finish college.

"Everything here used to seem closed," she said. "The old-time lumber people used to oppose any new industries coming in. A newcomer could only meet other newcomers. All that has changed."

WCTU Water Ploy Short-lived

Driving through Arcata, Mayor Fairless paused at ornate redwood homes that have been recently restored, their owners encouraged by mounting public interest in preservation and by inflated prices that have made home construction more costly. Then she led us to the central square. A dusty plaque marked a fountain erected in 1912 by the Woman's Christian Temperance Union.

"The ladies were hoping the men would drink water," she said. "The fountain hasn't worked for years. The other day the Woman's Club asked the council to restore it. But we were afraid we might ruin it if we tried.

"They say that Ulysses S. Grant didn't start drinking until he was banished to Fort Humboldt here as a captain," Mayor Fairless continued. "Let's go in one of these bars and have a drink to him."

Arcata lies at the north end of a 14-mile-long natural harbor, Humboldt Bay. Farther south, near the harbor entrance, is Eureka, the most populous town on the northern California coast. On a spit of land at the harbor mouth rise the tall stacks of the largest pulp mills. Lumber dominates the economy, but tourism has surpassed fishing as a distant second source of income.

Although Eureka was settled as a port for northern gold mines, it soon boomed with lumber. Its fortunes rose and fell in cadence with the home-building industry's. Then, about 1970, urban escapists began arriving

Disguised as Tomales Bay, the San Andreas Fault carves a path between Point Reyes peninsula, right, and the California mainland. Constant reminder of an earthquake threat,

to marvel at its charm. Now it is bright with fresh paint, much of it provided by grants for community restoration. The shops and saloons of Two Street, as locals call Second Street, are being restored in dusky pastels, with brick crosswalks and iron lamps.

Big Men for Big-tree Country

The scene is best from the cupola atop the Carson Mansion at the head of Two Street. It is an indelibly American baroque showplace, completed in 1886 by lumber baron William Carson. From it he looked down on his mill and watched lumber schooners. Today it is the sanctum of the Ingomar Club, a private social club whose 250 male members make it the most visible redoubt of machismo in this Bunyanesque land.

"It really *is* Paul Bunyan country," Coast Guard Lt. Tom Allan III told us. "People are *big!* Back East I'd walk into a restaurant and be the tallest person in the place. Out here, I swear, you walk into a bar and everybody's six-foot-six!"

We felt the same way one stormy winter night when we walked, hungry and tired, to the Eureka waterfront. Under floodlights brawny fishermen cast sprawling shadows as they unloaded boxes of Dungeness crabs. There was much coming and going at a café called Vista Del Mar, and we joined the crowd. Five amiable strangers crowded their chairs together to make room for us at their table. A waitress brought pitchers of beer and vast platters of crabs.

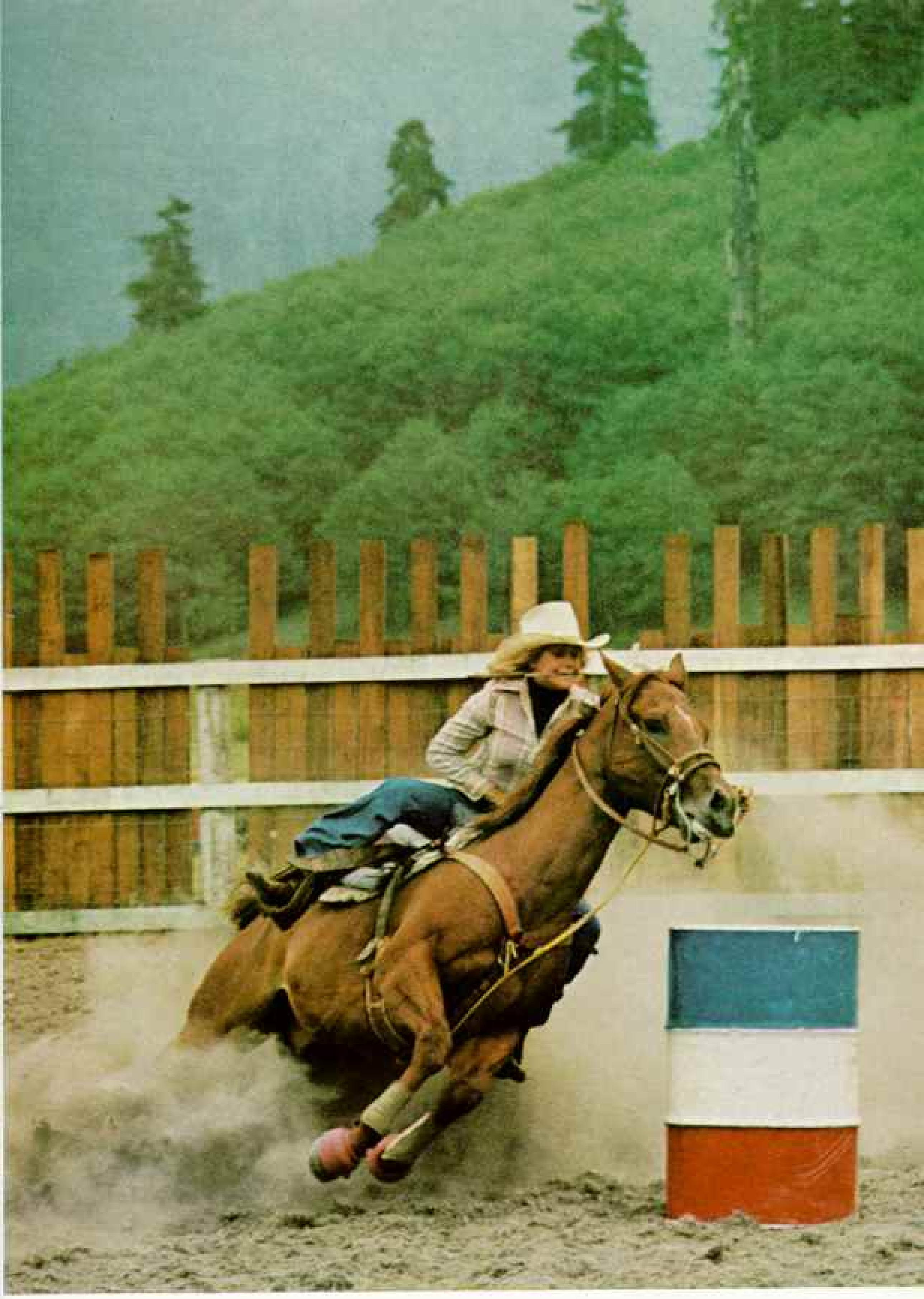
"On the house," she said. "The coleslaw is gone, but there's no way we'll run out of crab."

Above the din one bearded giant explained: "It's been a good winter for crabbers. This is the night they say thank you."

The prime fishing grounds of the northern California coast are reached from the ports of Crescent City, Eureka, Noyo, and Bodega Bay. Fishermen also throng sandbars at the mouths of rivers, seeking salmon and steelhead trout.

A fly fisherman we met on the Klamath River talked of the hazards. "This is a tough,

the fault line follows the northern coast for about 175 miles. During the San Francisco earthquake of 1906, few buildings along this coast were spared a sobering jolt.



rough country," he said. "A sneak wave can turn over a 65-foot boat. Strong swimmers drown. Fishermen go crazy. One man was fishing in his waders here at the mouth of the Klamath. He snagged a king salmon with a gaff hook and wouldn't let go. It dragged him off the bar into the surf, and he drowned."

From a dock at Bodega Bay, where as many as 500 boats crowd into port during fishing season in summer, we watched a handsome young couple, their faces flat with fatigue, unloading their salmon catch. They were Bruce Eby, a southern Californian who abandoned an academic career for a 30-foot fishing boat named *Jo-Jo*, and his partner, Stephanie Berquist.

"It's long, hard, dirty work," he said later as they rested. "The glamour fades in the first hour. Reel in a salmon, club it to death, clean it. The boat's a little slaughterhouse. I get spiritually weary of killing salmon. It's a noble fish that can travel thousands of miles in its lifetime."

But salmon fishing pays. They had caught 65 king salmon on a two-day trip that would net them a thousand dollars.

People: How Many Is Enough?

Many urban expatriates seek a gentler way of life along this more southerly coast. Yet the sparseness of people carries problems. Joanna McLaughlin, editor and publisher of the weekly *Independent Coast Observer*, was plaintive when we stopped by her office at Gualala: "We don't want a lot of new people, but we could sure use enough to support a bus line and medical facilities."

Big Ed Ohlson, still active in his eighties, lives nearby in a ranch house protected from the ocean winds by cypress hedges. His wife pushed forward a delicate Chinese chair, and he settled into it doubtfully.

"My three brothers and I had been in the sheep business around here since 1906," he told us. "In 1941 we took a big chance. We made the only bid in a court sale of 5,200 acres along this coast. It cost us $125,000 and there were 2,200 ewes, ready to drop about 2,000 lambs. Even then we worried, but in three years the ranch was paid for."

Then in 1964 they sold the ranch to Castle & Cooke, Inc., for $2,730,000. It became The Sea Ranch, a widely admired planned community. Its 430 modern houses of weathered cedar and redwood, on coastal shelves and forested ridges, surprise those who drive Highway 1 about 95 miles north of San Francisco.

Living With a Faulty Lawn

Many talented people have sensed the challenge in establishing modern environments on this coastline, which invites comparison with an Emily Brontë moor. That mood shaped the lives of Eve and A. B. (Abe) Crittenden when Abe quit his job with a factor in the Manhattan textile trade in 1946 and, after a few years of teaching and roaming about America, chose this coast as home.

We found them one crisp fall morning when we followed a single-lane road into a forest clearing, an old stagecoach stop called Plantation. Eve, a tall woman of commanding poise, invited us in for coffee. Abe, his stride as brisk as any commuter's, set down his wheelbarrow and joined us. We admired a grassy volleyball court that seemed oddly sunken in their front yard.

"That's the San Andreas Fault," Eve said. "The quake that hit San Francisco in 1906 made that court. It's good because you don't have to chase the ball."

The Crittendens started a summer camp at Plantation when they came here in 1952, but in the surrounding hills are descendants of pioneer landholders to whom the Crittendens, after 25 years, still seem newcomers.

"We were having dinner at one of those old ranches," Eve said, "and I heard some man say, 'These are our new neighbors.' So I turned to some strangers and said, 'How do you like it here?' Abe saved me with a whisper: 'He means us!' "

Now there are newer comers. Norman Richardson, a member of one of those first families, sold part of his ranch to a Buddhist order of Americans from Berkeley. Some of

Ride 'em cowgirl! With a pony-express rider's dash, a participant in the barrel-racing event guides her steed round an obstacle at a rodeo in Orick. The events provide good times for the many ranchers on the coast. Some of their richest grazing land lies near Fort Ross, where Russians raised crops for settlers in Alaska between 1812 and 1841.

Whittled down from a forest, 50 acres of redwood planks from company-grown trees dry in the air yard of Georgia-Pacific Corporation in Fort Bragg (**below**). Attractive and rot-resistant, redwood often ends up as siding for houses. In the planned community of The Sea Ranch, environmental architect David Wright designed his redwood house (**left**) for "passive" solar heat. Wright uses insulated shades to regulate the amount of sunlight passing through steeply angled windows. Concrete walls and brick floor store the heat, which radiates back through the house to warm living space. A wood stove is the only "active" heater.

them were transforming redwood trees into fluted columns when we visited the site. Prayer flags of protection at the corners of a vast retreat building were meant, in part, to guard against earthquakes. The house that Richardson's forebears had built in 1865 has become quarters for volunteer Buddhist workmen.

Village a Haven for Artists

Some fear the impact of those with city ways on this quiet coast. They are most vocal in the village of Mendocino, which perches on a scalloped headland, taking the northwesters over its shoulder. Clapboard houses and wooden water towers suggest a misplaced fragment of Maine. About 1,100 persons live here in a town built mostly a century ago by timbermen, many of them from the logged-out forests of New England. Before World War II the virgin redwoods here were gone, and mills closed. But Mendocino did not die; artists found its mood compatible, and with them came young city people who sought refuge among older settlers who clung to their homes.

On a winter Saturday we watched bemused visitors stroll in and out of restored hotels and shops. The music of Bach and Mozart played in service stations. Pete Cecchi stood behind his bar explaining how his father used the crosscut saw that hung on the barroom wall. On their barstools, customers reverently passed around yellowed photographs of loggers posing jauntily on stumps 18 feet wide, of tree toppers strapped to redwood trunks 300 feet above the ground, of seven-yoke ox teams and cables and skids.

Outside, pamphlets rustled on windshields,

How many redwoods should be saved? This long-debated question now awaits a new series of answers as a plan to expand Redwood National Park reaches the U. S. Congress. The Department of the Interior has requested that 48,000 acres be added to the 58,000-acre park, established in 1968. Ten years ago the Tall Trees Grove—located inside a bend of Redwood Creek—stood flanked by mountainous forest (**above**). Now clear-cutting extends to the park boundary (**upper middle** and **upper right**), threatening the 360-foot-tall trees with erosion.

Angry loggers and merchants in Eureka (**right**) fear the curtailment of timbering will hurt the area economy, despite government promises of redevelopment. Lumber firms have made improvements, such as removing logs by cables instead of tractors and replanting the land they cut. Yet logging is now destroying vistas in the park, denying visitors what a park official says is "the experience of being present in a primordial redwood forest."

JONATHAN BLAIR (THE LEFT, ABOVE) AND MICKEY PFLEGER

Rising through a blanket of morning fog, the stacks of Eureka's pulp mills cough out dense billows of steam. In accordance with tough state and county air-quality laws, the mills are among the cleanest in the country. Having long endured the vagaries of

placed by locals of all stripes who want to restrict tourism or encourage it, to make the whole town a state park or to resist it, to permit growth or to halt it.

Such enthusiasms are noted by Nannie Escola, 91, a zestful native and former teacher (page 347). Her five children, eleven grandchildren, and seven great-grandchildren all live along this coast, a display of continuity rarely found in California. We sat in the cheery kitchen of her house, surrounded by old photographs and stacks of notebooks, an archive of Mendocino's past.

"I'm not against tourists," she said, "but I am against the people who come here and want to boss us. When they first come, they think they're the first to discover the place. They think they must save us. But most of them go away in 10 or 12 years."

Nannie, whose parents moved to Mendocino from a lumber camp in 1892, calls herself the town's first hippie. Her parents had sought to discourage her from marrying her Finnish sweetheart back in 1914, but the couple had managed nicely with a rather modern solution.

weather, northern Californians must now cope with the shifting demands of government. Regulations proliferate, affecting activities from logging to house building. Yet the people will almost certainly adapt, because most of them would live nowhere else.

"My pupils gave me a surprise beach picnic after school," she recalled, "and a friend of John—that was the young man who was my husband for 35 years—came up and whispered, 'Get yourself ready, Nannie. John and the minister will be here soon.' "

Nannie went home and changed from her long corduroy skirt and blouse into a white wedding gown and slipped out of the house.

"We were married near a bonfire beside the waves, under a full moon," she said, "and the children sang 'Blest Be the Tie That Binds.' "

In late afternoon we left Nannie and walked to a wild headland that Mendocino people helped to save from subdivision. Preserved now as state parkland, it remains the town's front yard.

The old village glittered in the setting sun, but a bank of fog hung offshore. White plumes of surf climbed the cliffs, boiling and spewing, then reeling back. Beneath us wave tunnels echoed with muted thunder.

Suddenly the fog swooped in, enveloped us, and blew past. When we turned, Mendocino was gone. It was easy, at that moment, to forget that anyone had come this way. □

Norway's Reindeer Lapps

By SALLY ANDERSON
Photographs by ERIK BORG

On the icy fringes of Europe, a proud and ancient people struggle to sustain their imperiled culture. Many of Norway's 25,000 Lapps live in Finnmark County—but less than a tenth follow the twice-yearly reindeer migrations. Young Nils Johan Mienna (**facing page**) will be one of the few of his generation to continue the nomadic tradition. Another 20,000 or so Lapps are scattered across the northern reaches of Sweden, Finland, and the U.S.S.R.

SKIING DOWN THE TRACK amid twisted, leafless white birches, I held up at the edge of the valley. Below me, the village of Masi lay on a river plain wedged between the long hills of Lapland.

At three o'clock in the afternoon, what was left of the January daylight lay pink on the horizon. Despite the minus 26°C temperature, I felt warm. Chimney smoke, rising straight up in the frosty stillness, filled the valley with the sweet pungency of birch fires. The street-lights had come on, and the ski jump behind the school was illuminated. The Øvregård boy must be practicing, I thought.

From the steep trail I glided across the frozen river and headed up lower Masi's only street. An old woman trudged along, swinging a flashlight. She shone it on me as we passed—checking to see who I was.

Exhausted from a long ski excursion, I was returning to one of the scattered Lapland towns I came to know during a two-year study, funded in part by a Thomas J. Watson Fellowship, of changing life patterns among northern Norway's Lapps—Samit, they call themselves.

With its mixed population of settled and seminomadic Lapps, Masi is modern Lapland in microcosm. Here, as in other communities I visited, I found old ways seeking accommodation with the new. Now in winter, with their herds gathered in the southern grazing lands, the reindeer Lapps had reverted for several months to domesticity and a settled life-style.

Such towns as Masi are small patches of progress on the surface of a stark and brooding wilderness. Along upper Masi's two streets, snowmobiles, milk trucks, and buses speed by modest frame houses, a cozy café, a post office, and a well-stocked general store with gas pumps out front.

Yet, as with other towns of Norway's Finnmark County, Masi for its new look pays a stiff price: Long-established customs are in peril. Especially for the reindeer Lapps, those who migrate with the herds, cultural and economic forces are reshaping their way of life.

In the Masi school, for example, Lappish programs must be wedged into a full Norwegian curriculum. Teacher Mikkel J. Hetta, born in Masi, admitted me to his first-grade class. The day began with songs, some in Lappish, others in *(Continued on page 368)*

Bound for a sea journey, reindeer are herded toward Kviteberg, where a landing craft waits to ferry them to less crowded pastures down the coast. As Norway

looks increasingly to its northern frontiers for land and mineral resources, grazing land diminishes and Lapps forsake the old ways for new occupations.

Norwegian. Next came Lappish alphabet practice. (The Lapp alphabet with 31 letters is two letters longer than the Norwegian.)

"For the herders' children, getting a good start at home and at school are two different things," Mikkel told me. "At home, talk is all about reindeer and mountain life, and at school, everything is books and modern Norwegian society."

Schooling Helps Divide the Generations

Mikkel had temporary charge of the two boarding homes that housed students from outlying settlements, some 20 to 30 miles away.

"Going to school away from home is always hard on the younger ones," Mikkel said. "The village is big and full of people, the schoolrooms are big, and the corridors are so very long, with doors everywhere you look."

Then there is the generation gap. When the children finish school, they usually speak better Norwegian than their parents and know more about the outside world. At the same time, Lapp culture is not stressed in the schools, and young people often do not learn to value their own heritage.

Traditional Lapp occupations, Mikkel pointed out, can no longer support the population growth; advanced education, with a vocational emphasis, has become a necessity. Fortunately, special scholarships are available for reindeer Lapp youths.

Children of reindeer Lapps get time off from school to participate in spring and fall migrations of the herds. Youngsters learn the herders' ways and become familiar with the

Corralled in burlap amid a sea of snow, reindeer that strayed from a neighboring herd during spring migration wait to be returned. Nearby, Mikkel Skum (**top**) keeps vigil to prevent his deer from wandering. At summer's end as much as a quarter of the herd will be slaughtered and the meat sold. Wood shavings stuck on the fresh skins (**above**) preserve the hides until they can be scraped and tanned.

terrain they must know by heart if later on they choose to follow the reindeer.

In Suosjavrre (SHOOSH-yow-vrih) I met Aslak and Inga Mienna. They knew that only three, at most, of their seven children could follow the time-honored seminomadic life; the others would have to find other vocations.

Aslak Mienna's 15-year-old son, Nils Johan (page 365), got a leave from school to join his father on the spring migration. All night long the two had been moving north from Suosjavrre with the reindeer Aslak herded in common with Anders Aslak Bongo, Mikkel Bongo, and Mikkel Skum. (The Lapps use varied combinations of only a few names.) I was up ahead, traveling with Anders, and we were getting ready to set up camp. Aslak and Nils came roaring up on their snowmobile to help, anticipating hot food and rest.

Soon the *lavvo*, or light herding tent, was up, the floor covered with birch branches and then thick reindeer skins, and a bucket of snow was melting over the fire. We boiled coffee and ate our fill of bread, butter, and dried reindeer meat, roasted over hot coals. Then we sat back and waited for sleep to come.

Aslak asked me what kind of animals, fish, and trees we had in America. His speech was a mixture of Norwegian and Lappish, and Nils Johan said teasingly, "Listen to him! He can't even speak Norwegian."

Aslak countered in Lappish, "Well, you know when I went to school, the schools were very bad. And we only went three months out of the year, in the winter."

Reindeer Becoming a Cash Crop

Europe's Lapps—there are perhaps 45,000 of them—are spread among Norway, Sweden, Finland, and the U.S.S.R., with Norway counting the most (map, page 364). Of Norway's approximately 25,000 Lapps, less than 10 percent are reindeer owners. The state retains title to open reindeer grazing lands. But population pressure and resource exploitation keep encroaching on grazing privileges.

Where the herder's life once revolved entirely around the reindeer, which provided not only meat and milk but also materials for garments and tools, now the animals more and more are handled as a cash crop. Today the reindeer Lapp needs folding money to buy ever more abundant processed foods, ready-made clothing, automobiles, television sets, and radios. Each family, after the slaughterings in September and February, must have more carcasses per capita to sell. (Some animals, to be sure, still are reserved for food and for raw materials used in domestic crafts.)

Modern Lapps Accept New Roles

Overall the Lapps have proved resilient, accepting the benefits of progress while retaining ethnic identity. Many now work as doctors, dentists, educators, social workers, miners, tradesmen, and builders. Jokingly these people refer to themselves as "school Lapps," "office Lapps," or "conference Lapps," mocking the many social categories anthropologists and ethnologists assign them to.

Early in my work I listened to rumors that shortly were confirmed: Anders H. Bongo, a prosperous and respected herder, was going to slaughter his entire reindeer herd, give up the nomadic life, and take a desk job in the county assessor's office in Kautokeino, a chief town of Norwegian Lapland (page 373).

On the September day of Anders Bongo's last roundup, photographer Erik Borg and I thumbed a lift along the lonely road that runs from Alta to Skaidi, stretching over the *vidda*, or moorlike uplands. All around, the rolling hills of Arctic Norway flaunted autumn orange and red of dwarf birch, heather, and blueberry.

A road sign announced our destination—Aisaroaivve, one of Kautokeino district's largest summer settlements of reindeer Lapps. Anders Bongo had brought his herd—hundreds of animals—to the communal slaughterhouse here. To our ears came a distant jangling of bells, the barking of dogs, and an occasional ringing curse.

Autumn roundup was a combination of hard work and festivity. Within the wire-fenced corral, men and women worked side

Warm nest for nomad feet: Masters at coping with their bone-chilling winters, Lapp herdsmen shun store-bought thermal boots for traditional deerskin shoes, stuffed with sedge grass for insulation. Of obscure origin, these short, wiry people, who call themselves Samit, may have arrived in Scandinavia as recently as 2,000 years ago.

In the Arctic fastness of the *vidda*, Finnmark's great upland plateau, Lapp traditions remain strongly intact—though seasoned with up-to-date conveniences. Even the staunchest guardians of old customs, the reindeer Lapps, have modern

homes where the men live during the long winters and, increasingly, their wives live year round. At Masi, traditionally dressed townsfolk meet at their Lutheran church on confirmation day (**left**). A center of Lapp culture, Kautokeino (**above**) was rebuilt after World War II, when the Nazis burned nearly every home in Finnmark.

The author, seated, exchanges addresses with new friends (**top**) in Alta, once a marketplace for Lapp herders trading meat for supplies.

by side—lassoing and ear notching, lassoing and chasing to the slaughter chute, lassoing, swearing, and releasing (as the lasso caught the wrong pair of antlers).

The lively scene brought to mind a snatch of *juoigos*, or folk song, made popular by Nils-Aslak Valkeapää, a Lapp singer from Finland:

> *Hellishly .*
> *Bells clanging*
> *Horns crackling*
> *A blizzard of reindeer hair. . . .*

We watched Anders Bongo lasso a reindeer and dig in his heels to tighten the loop.

Anders shouted to the men near him as he struggled to control the big buck, *"Bättet vekkehit*—Come help!"

I felt a pang on seeing Anders's sturdy 5-year-old son, Mikkel, tagging along after his father. The boy trailed his own tarred rope lasso. Did Mikkel know, I wondered, that after today the family herd would no longer exist, that life would change?

Anders Bongo's slaughter of his deer was drastic action, even in these unsettled times. Although Anders at 34 years of age owned a herd that allowed him to live quite comfortably, he was dissatisfied: He wanted more—more comfort and security, more of a sense that he had control over his family's future.

Lapp small fry, awaiting their parents at a wedding reception in Kautokeino, crowd a snowmobile. Now fixtures of most households, these machines are responsible in part for turning reindeer Lapps away from self-sufficiency, as ever larger herds are needed to pay for gas and maintenance.

Like most visitors, I was captivated by Finnmark. For hard work and acceptance of nature's sway, this moody and elemental land offers in return the splendor of winter sunsets four hours long, wide horizons, skies of crystal clarity. From Alta, with its magnificent fjord, to Kautokeino, the road snakes through a river canyon, then emerges onto the open vidda, its sweeping, rounded contours sparsely wooded with twisted birch.

At first sight Kautokeino reminded me—oddly—of the seashore. A place long since stripped of trees and strewn with glacier-deposited sand, it lies at the heart of the wintering-over area for reindeer.

Kautokeino, with Tana and Karasjok to the northeast, for centuries have formed nerve centers of Lapp culture. In Kautokeino I again met Anders Bongo—he of the reindeer slaughter. Now he was sitting at his desk in the assessor's office.

What was it like, I asked Anders, to give up the free, nomadic herder's life to work all day in an office, slave to a clock? He had no regrets. He was living comfortably and still enjoyed the reindeer people's high regard. Older herders, he admitted, expressed concern about how Anders might fare in his new niche. Some envied him the courage, confidence, and talent that allowed him to make the switch.

"Sure, reindeer herding is great in many ways—it's a free life. But any herder is always financially insecure," Anders reminded me. "His entire fortune is running loose in the mountains, subject to the weather and other hazards. An average wage earner in town can put his money in a bank with guaranteed interest, or into insurable possessions."

Calves Have 50-50 Chance

Past years, Anders went on, had been very hard on the herders of the Kautokeino district—a layer of ice under the snow keeping reindeer from the lichens they feed on, then an epidemic infestation of their animals with brainworm.

"In an average year we lose through natural causes—predation by fox, wolverine, eagle, and lynx, and to disease and bad weather—just under 50 percent of all calves born," Anders continued in his deep, authoritative voice.

"I lost almost all my calves two years in a row, and it can take several years to regain the losses of just one bad winter."

Still, while some herds suffered, others thrived. Actually, the total reindeer population has increased, but the number of reindeer Lapp households has also grown.

All in all, a reindeer owner *ought* to be able to make a good living, Anders pointed out, with the price of meat what it is today. "But that doesn't take into account the snowmobile," he said, "and that's the other reason I decided to quit."

New Status Symbol: Costly Convenience

The snowmobile has indeed made herding easier. Most Lapps can buy snowmobiles with cash or through loans and discounts, but trouble comes for poorer families when they have to cover installments as well as pay for gasoline and repairs. That means selling more reindeer for quick cash, and soon the herder has too few animals to support his family. Furthermore, the snowmobile has become a status symbol, and every young boy longs to own one, the bigger and faster, the better.

Anders Bongo's uncles, the men I had joined on the spring migration from Suosjavrre, were my good friends. Now I wanted to observe the fall work as the reindeer were herded south. They shook their heads.

"It's miserable, cold and dark with wet snow," they said, "but if you want to, well, come along."

In early October, photographer Erik Borg and I accompanied these same three men, Anders Aslak Bongo, Mikkel Bongo, and their brother-in-law Mikkel Skum. Our base was a mountain cabin above Alta. Snow had come deep and early, and, laden with supplies and equipment, we spent the entire first day fighting our way to the cabin. That evening we dined on fresh reindeer stew, cooked in brook water with cabbage and potatoes on the cabin's cast-iron stove.

Mikkel Skum got up early next morning to check the herd. Erik, Anders Aslak, and I lingered over morning coffee. A few hours later we set out to find Mikkel.

On the third ridge from camp Anders stopped to survey the surrounding hills with his binoculars. Mikkel's tracks still headed south. Just as Erik, loaded with cameras, caught up with us, I thought I heard a dog bark in the distance.

"They're coming now," Anders said.

Mikkel was struggling up out of a canyon

Held in thrall by educational television, young students at Masi are taught in both Lappish and Norwegian, with an emphasis on vocational training to prepare them for contemporary life. The children of Aslak Mienna (**right**), like most Lapp students, live far from school, and must be boarded for most of the school year. Home on a three-day visit, they share family letters with their father.

with the entire herd ahead of him flowing in a great brown wave over the snow. His dog, Gab'ba, barking and running, helped him keep the reindeer moving.

We skied down to meet Mikkel, who was sitting in the snow rolling a cigarette. He looked weary and annoyed.

"I followed them to Avccanjavrre. No telling where they would have gone." I knew that Avccanjavrre was eight miles away, making Mikkel's morning ski tour about 16 miles round trip without rest or refreshment.

Anders Aslak took over the herd, and I stayed with him. Mikkel and Erik headed back to the cabin.

We stuck with the reindeer until after sunset. A herder puts his reindeer up for the night where natural boundaries tend to keep them from straying. We left them on a point of land that dropped abruptly to river canyons on two sides and to the fjord at Rafsbotn on the third.

The moon was rising, and the distant lights of Alta airport were beginning to twinkle as we turned and headed home.

"You can break trail," Anders said to me. "Your skis are better for it. See the moon?"

"Yes." The huge orange disk rested its chin on the ridge in front of us.

"Head that way, and we can't miss."

Following that lantern in the sky, we soon made our way down the last slope to the cabin, rest, and hot food.

Even here in the quiet and isolation of the high barrens, the talk could turn to politics and domestic issues.

"Have you heard about the new look for Suosjavrre?" Anders asked me facetiously.

I knew he was referring to the zoning plan drawn up for a village still without streets or running water. But the new road from Kautokeino to Karasjok was coming, and the zoning board would not be caught unprepared.

Lapps Seek Government Representation

The men mentioned the recent campaign to elect representatives to the Storting, or Norwegian Parliament, when the Lapps had put up their own candidates, called Sami-Lis'to. I recalled listening on the radio to the woman heading the slate. Edel Hetta Eriksen was the first Lapp to run for Parliament independent of a national party.

Some time later, in Kautokeino, I called on

Hobbled runaways are spirited back to their herd during migration. So, too,

Mrs. Eriksen, principal of the grade school. In her two-story frame house, a bright orange and yellow carpet reflected its warmth in Mrs. Eriksen's face.

"We want to get into government on our own premises," Mrs. Eriksen said. "Unless we can elect a candidate through the Sami-Lis'to, we may never have a representative in the Storting who can vote Lapp interests, free of party-line commitments."

In Kautokeino I also visited John Loso, himself a herder and now in charge of reindeer affairs.

"There is no doubt of it: Our land is being overgrazed," said Mr. Loso. "The range cannot support the larger reindeer herds needed by the increasing numbers of reindeer Lapp households. And all I can see for the future is even more people and less grazing land."

The state has proposed inducing amenable reindeer Lapp households to accept full change of occupation. Financial subsidy would be offered for requalifying education in the new pursuits.

The Norwegian Reindeer Lapp Association, for its part, promotes backup sources of income—handcrafts, catering to tourists, harvesting native resources such as berries and fish—to lessen dependence on herding.

Meanwhile, pasturage is being chipped away, power dams are being built, roads are opening more territory to development, geologists prospect for new mineral deposits, and all Norway is demanding more space for recreation.

Way of Life Hangs in the Balance

John Loso explained that it is very difficult, perhaps impossible, to develop new methods of herd management and range improvement without destroying the Lapps' traditional social structure and cultural values. Many Lapps feel protective toward their reindeer people, believing that they represent a conservative force—a balance wheel—which helps save a treasured language and way of life from being overwhelmed by Western civilization. Yet all concerned see clearly that the reindeer Lapps cannot be subsidized and sheltered as if they were museum pieces. They must continue to form part of the social fabric of Finnmark.

Toward the resolution of these uncertainties, there are no sure steps. □

are the reindeer Lapps being propelled, willing or not, into the 20th century.

NATIONAL GEOGRAPHIC PHOTOGRAPHER BRUCE DALE AND GREG DALE

THE ESSENCE OF LIFE

SALT

By GORDON YOUNG
SENIOR EDITORIAL STAFF

Photographs by
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FOREIGN EDITORIAL STAFF
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W. E. GARRETT, NATIONAL GEOGRAPHIC STAFF

Good as gold when scarce, cheap as dirt when abundant, salt's price—but not its value—has varied throughout history. Familiar at table (**facing page**), and little known as the gossamer threads Hopi Indians collect in the Grand Canyon for their ceremonials (**above**), it is a substance of myriad uses. Salt literally keeps man alive, and does the same for his industry as the most essential of all raw materials.

ON VIENNA visitors gaze in awe at what surely must be the ultimate salt container. Benvenuto Cellini created it more than four centuries ago for a king of France. Gold, enamel, ebony, its breathtaking craftsmanship drives home the point that salt was once a very precious commodity (page 386).

But why? Four centuries ago, as today, the oceans contained billions of tons of salt. Subterranean deposits—remnants of ancient seas—dotted this planet, then as now. Why did salt rate Cellini's genius? Why were these seemingly prosaic crystals coveted by royalty?

The answers are part of the fascinating story of salt, that humble compound which so many of us take for granted.

Even its basic makeup defies logic. Salt is a blend of sodium and chlorine—the first, a metal so unstable that it bursts into flame when exposed to water; the second, a lethal gas. When we swallow the blend, it forms hydrochloric acid in our stomachs. Suicidal? No, an absolute necessity for life.

You and I each contain about eight ounces of salt—enough to fill several shakers. Sodium is involved in muscle contraction, including heartbeats; in our nerve impulses; in the digestion of body-building protein. Salt regulates the exchange of water between our cells and their surrounding fluid, which carries food in and wastes out.

Without salt the body goes into convulsions, paralysis, death. Put blood cells in a salt-free fluid and they burst.

Fortunately we have built-in controls that regulate the body's salt content. Take in too much, and the kidneys will excrete it; ingest too little, and they will give up water but virtually no salt. Through perspiration, however, the body constantly loses both water and salt. Without replenishment the body dies.

When man, the hunter, first walked this earth, a salt supply was no special problem. Raw meat furnished the salt he needed for survival—as it does the Eskimo hunter, and as the animal blood drawn from their living cattle sustains the Masai tribesmen of Africa today. Fire came as a mixed blessing: Roasted

Prying salt from an ancient seabed, Afar tribesmen in the brutally hot Danakil Depression of Ethiopia ply their ancient monopoly and trade. After the slabs are levered out, they are cut into uniform blocks. Carried by caravans to the Ethiopian highlands

SEUNG SEBASTIAN

and beyond, the salt may eventually command thirty times the desert price. Raw and roasted meat gave early humankind a natural source of salt. With the advent of boiled meat and farming, it assumed its modern role, a necessary condiment of civilization.

meat keeps its salt, boiling leaches it out. And when man began to farm, cereals did not give him enough sodium chloride, and the great salt hunt began.

Crystals Worth Their Weight in Gold

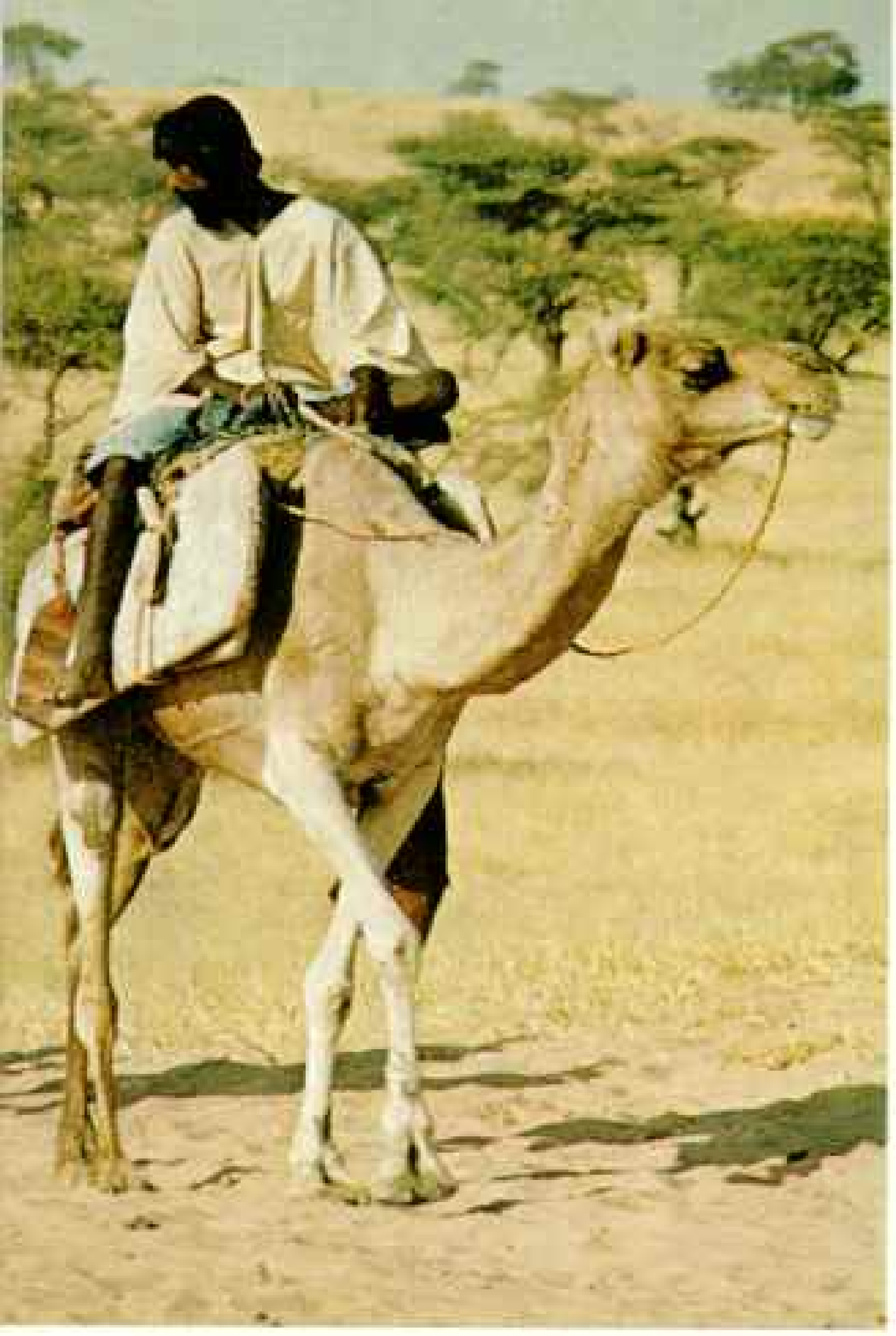
Down the ages that quest ranged the world. Where it was scarce, salt was traded ounce for ounce with gold—for as the Roman statesman Cassiodorus observed, "Some seek not gold, but there lives not a man who does not need salt." Rome's major highway was the Via Salaria (Salt Road). Over it soldiers convoyed the precious crystals up the Tiber from the salt pans at Ostia. Those "worth their salt" were paid a salary. That word comes from *salarium*, money paid soldiers to buy salt.

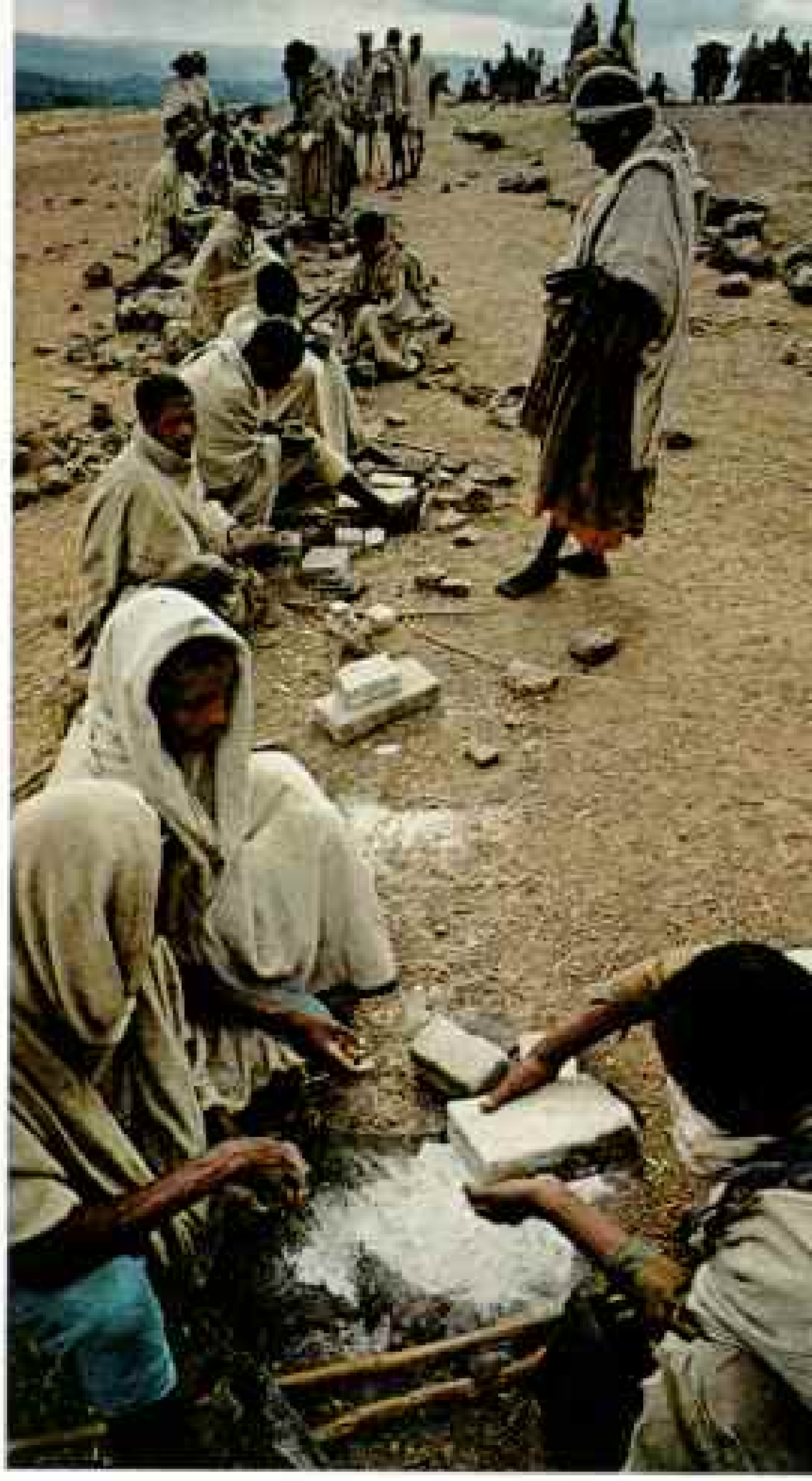
Marco Polo reported the high value in Himalayan regions of salt coins bearing the seal of the Great Khan of Cathay. Twentieth-century Ethiopia still used salt disks as money; stacks of them were salted away in the treasury. And in central Africa until the early 1900's salt could be used to buy a bride.

Throughout history, common salt has played an uncommonly large role. Rulers jealously preserved salt monopolies, decreeing death to salt smugglers, for control of the life-essential substance also gave them control of the populace. A lucrative whip hand. Under the *ancien régime* the French people had to buy salt from royal depots. When his treasury ran low, the king could simply increase the amount each family must buy.

But Frenchmen learned that salt could be a cause, too. The hated salt tax—*gabelle*—helped spark the French Revolution, which killed the tax and the king as well.

Emperor Napoleon revived it, 15 years later, in a different form. But fortune sometimes plays bitter jokes. During the grim winter of Napoleon's retreat from Moscow, salt starvation decimated his troops, lowering resistance to disease. Epidemics spread. Wounds that might otherwise have healed became fatal. Thousands died.





On the road to Timbuktu a salt caravan plods through the sere countryside of Mali (**above**). The driver keeps close watch on the fragile cargo. Vigilance at stops will also help prevent pilferage—by the salt-hungry camels (**below**). In desert Africa the flavoring remains a precious staple and can still be used as money. Buyers and sellers in an Ethiopian market (**above, right**) coolly strike their bargains. Here in the last century 120 salt slabs would buy a beautiful young girl.

COLAMAR WENTZEL (ABOVE, LEFT); GEORG GERSTER (ABOVE, RIGHT); VICTOR ENGELBERT

JAMES L. STANFIELD, KUNSTHISTORISCHES MUSEUM, VIENNA

KOLLMAN WENTZEL, COLLECTION OF ARTHUR A. PETERSON, ORLANDO, FLORIDA

From sublime to whimsical, salt containers reflect centuries of human ingenuity. Benvenuto Cellini's 16th-century masterwork (**top**) cradled salt in a golden boat. Patented shakers to crush or prevent caking (**middle**) and fanciful pieces (**bottom**) once graced tables but now delight collectors.

Men have credited salt with qualities far beyond price. It betokens wit, wisdom, virility, hospitality, sanctity. Homer dubbed it "divine"; Plato hailed it as "a substance dear to the gods." And "Ye are the salt of the earth," the Bible says.

Jews sealed covenants by exchanging salt. Bedouin traditionally will not attack a man whose salt they have eaten. In Slavic lands bread and salt, gifts of welcome, signal lifelong health and happiness to a bride and groom. Hebrews, Greeks, and Romans salted sacrifices as a sacred offering. In the Roman Catholic Church to this day, salt, symbol of purity and incorruptibility, is placed in the mouth at baptism, and holy water is salted.

To spill salt, however, is considered unlucky—though you can counteract the ill effect by tossing a pinch of it over the left shoulder. In his painting the "Last Supper" Leonardo da Vinci put an overturned saltcellar in front of the ill-fated Judas (pages 322-3).

Table Salt: A Pinch in the Bucket

Crystalline salt deposits—the residue of long-vanished seas or pinched-off gulfs—are found on every continent. Even in Antarctica scientists have found millions of tons of salt frozen on the floor of a dry valley. And the oceans contain an estimated four and a half million cubic miles of it—enough to bury the entire United States a mile deep.

Only a pinch of this—perhaps 5 percent of the world's annual salt production—ends up as seasoning on the dinner table. The vast majority, however, pours into chemical plants, where it leads the five major raw materials utilized by industry: salt, sulfur, limestone, coal, and petroleum. As salt—or separately as its component elements sodium and chlorine—it goes into gargles, textiles, and rocket fuels; cosmetics, paints, pharmaceuticals, and photography; soaps, dyes, ceramics, batteries, adhesives, and explosives. The freezing point of a saturate solution—21°C lower than that of fresh water—makes rock salt an excellent refrigerant, snow melter, and freezer of ice cream. And liquid sodium cools nuclear reactors.

Salt pickles cucumbers—and metals; helps pack meat, can vegetables, cure leather, make glass, bread, butter, cheese, rubber, wood pulp. Bleaching this magazine's paper is but one of the some 14,000 uses, more than for

any other mineral. Under the terms of an old land treaty, salt is delivered each year to the Onondaga Indians of New York State.

"One hundred bushels," that treaty reads, "to be delivered on the first day of June. . . ." But the Onondagas don't arrive in full regalia, bearing woven baskets. Instead, in blue jeans or print dresses, they park their Pintos and Mustangs in front of a frame house on the reservation and leave bearing bags of commercial salt.

New York State can afford it, for it lies on one end of the Eastern Salt Basin, a deposit extending through the Great Lakes region.

Priest Stills Troubled Waters

Salt was the product that started Syracuse. Nearby runs the Erie Canal, De Witt Clinton's "Big Ditch," which opened the Ohio country, plied by brawling, bawdy, boozing canalmen loaded down with sin and salt. Salt-tax revenues paid half the canal's cost. All this because Indians once told a Jesuit priest that their spring was contaminated by demons. Father Simon Le Moyne sipped, boiled a sample, and discovered the "demon"—salt.

Boiling is big business now. The Industrial Chemicals Division of Allied Chemical Corporation at Solvay, near Syracuse, extracts one and a half million tons of salt each year from the brine that it brings up at Tully, 20 miles away.

With superintendent Mike Slezak I toured the operation. "It's not complicated," he told me. "We pump fresh water down to the salt deposit, which it dissolves, and get it back, through a second pipe, as brine. The brine then goes by pipeline across the Onondaga Indian reservation to the Solvay plant." The giant cone-topped vacuum pans I saw there boil the brine at a lowered pressure and boiling point, hence use less fuel than the older open pans. After the concentrate is filtered, the salt goes to make soda ash, chlorine, and basic alkalies for industry.

Two days later, in Michigan, it was back to the salt mines for me. But not to the proverbial "living death" that phrase connotes. I went for a pleasant drive *under* the world's automobile capital, a quarter of which rests on pillars of salt. International Salt Company's mine there, 1,100 feet underground, extends roughly four and a half miles beneath southwest Detroit.

Plant engineer Jim MacDonald handed me familiar equipment: hard hat, respirator, and battery-powered light. I'd worn almost identical gear in the black confines of a coal mine. Mining techniques, too, are similar to those in automated coal mines.

At the working face, an oversize chain saw slashes through the salt deposit at floor level. Then, higher up the wall, holes are drilled for explosives. After the blast, diesel loaders scoop up the shattered salt and transport it to the "bottom"—the foot of the shaft where the salt chunks, graded by size, are sent to the surface by elevator.

In comfort, though, coal mines and salt mines are as different as black and white. Jim and I rode in a diesel-powered car through white tunnels 50 feet wide and 20 feet high—cool, airy, well lighted.

Each working day, 2,500 to 3,000 tons of salt reach the surface from the mine. In winter, three-quarters of it goes to highway departments to melt snow on roads. Surely, with a market that size, salt-company officials must greet the season's first snowfall with the elation of ski buffs.

Highway people will salt roads if there's an inch or two. If it's deeper, they let the snowplows come through before salting. But car owners mourn their corroded fenders, and environmentalists lament that salt runoff kills roadside vegetation and contaminates water sources.

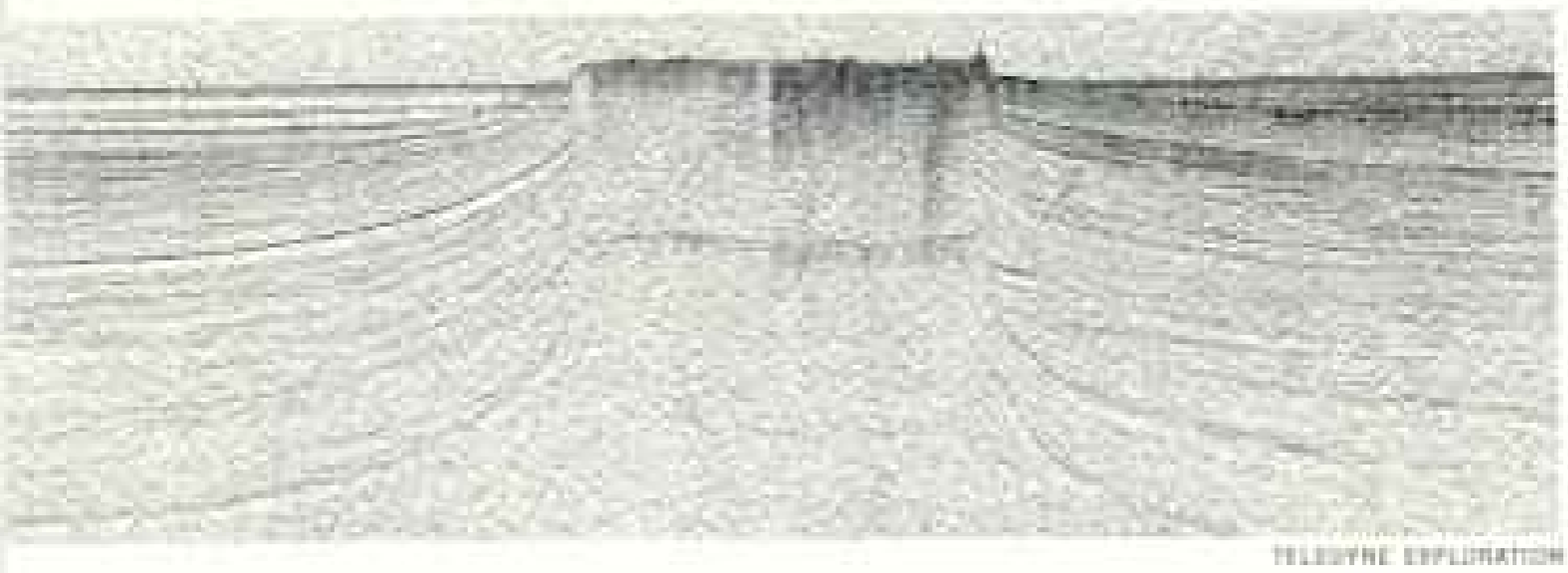
An Ingredient of Life . . . and Death

Salt's reputation as a killer has ancient roots. One need only think of the Dead Sea, so salty that no fish can live in it—and of Rome's ultimate vengeance on her mortal enemy, Carthage. Romans razed that city of Hannibal and sowed it with salt. Ironically, Carthage rose from that "desert." Refounded a century later by Julius Caesar, it again became a great North African city.

Salt bears the seeds of both life and death. In herbicides, insecticides, and fertilizers, it gives gardeners green thumbs. It purifies and softens water. Yet I heard no praise of salt from the lips of a Dutchman I went to see in The Hague.

Mr. H. M. Oudshoorn, chief engineer-director of Rijkswaterstaat, the Netherlands' Department of Water Management, bisected an outline map of the country with a diagonal

Enormous gallery of rooms has been hewn within a salt dome at International Salt Company's Avery Island, Louisiana, mine (**above**). Though easily soluble in water, salt's structural strength when dry allows for the safe excavation of large volumes. Such domes, seen in a graph made by geological instruments (**left**), are vast upwellings in the Gulf of Mexico.



TELEDYNE EXPLORATION

A plan has been devised to excavate other domes and pump in petroleum—a way to stockpile massive quantities of a dwindling resource for emergency use.

At the time of the Civil War the area around Syracuse, New York, was the country's salt capital, its product shipped on the Erie Canal, "the ditch that salt built." Salt from brine was stored in huge warehouses; here in the 1890's a crew (**right**) takes a break from shoveling a white mountain.

VULKMAR WENTZEL AND NELSON H. BROWN (ABOVE) | THE SALT MUSEUM, LIVERPOOL, NEW YORK

line. "The northern half is below sea level. Dikes keep ocean water off the surface, but underneath, the water table is highly salted. And there is continual seepage upward. The only practical way we can battle that salt is constantly to flush our canals with water from the Rhine."

There's the catch. The Rhine, by the time it ends its five-nation course in the Netherlands, is a salt-poisoned river. "And it is getting saltier each year." Mr. Oudshoorn gave a wry half-smile. "It is difficult to flush the salt out of a canal with salt water."

There is irony in the fact that lifesaving salt often becomes a threat. A pollutant, after all, is simply too much of something in the wrong place. But in the United States, scientists hope to seal the ultimate pollutant—radioactive wastes—in salt beds deep in the earth. Their dryness, ability to withstand earthquakes, and 800°C melting point (higher than radioactive wastes) make salt deposits the safest nuclear graveyards, they say.

Mine Safeguards Fragile Treasures

Near Hutchinson, Kansas, I toured the world's largest warehouse—invisible unless you are inside it. The Underground Vaults and Storage Company spreads its 300 acres of storage bays 650 feet down in the worked-out portion of a salt mine.

A seed company sends down a bag or two of each new strain it develops, so no surface blight may annihilate the strain. Corporations store vital papers, microfilm documents, product formulas. One also keeps folding cots and a food supply, for use in the event of a nuclear war.

I found old friends down there, sleeping in their flat tin boxes. Classic MGM films such as *Gone With the Wind* and Buster Keaton silents. Even earlier efforts: *Girl Without a Soul. Polly of the Circus. Camille.* More than 100,000 reels in all.

Other treasures include Bibles, furs, paintings, stamp and coin collections. And wedding dresses. "For a flat fee," said executive Michael Gingerich, "we'll store a bride's wedding gown for 21 years. The salt air will preserve it—perennial 50 percent humidity and 68 degree temperature. Her daughter can get married in it. Then, who knows, it may go underground again for the next generation."

Why bother digging holes in the ground for salt when the sea contains so much of it? Why not just fill a pond with seawater and let solar energy do the work? It is not that simple, I discovered.

Flying into San Francisco, I gazed down at 40 square miles of multicolored ponds along the bay shores. More than a million tons of salt come from there annually—but each ton is five years in the making.

Seawater (which contains about a quarter of a pound of salt per gallon) is pumped from pond to pond, while sun and wind evaporate the water. Careful monitoring is the key to success. At a certain point, calcium sulfate—gypsum—precipitates out. The brine then moves on to a crystallizing pond. There, a crust of almost pure salt will form on the bottom. But, if the brine stays too long, bitter compounds of magnesium and potassium will drop out to mix with the salt.

"Worthless" Goo Hampered Search for Salt

With salt among the earth's most abundant minerals and priced today at pennies per pound, why was it once so precious?

Ancient man had only limited access to it: brine that bubbled up, surface deposits, some bay salt. Rising sea levels—ten feet in the first millennia B.C. and A.D.—drowned coasts and solar salt pans, causing salt famines. Drilling—55 percent of U.S. production comes from brine wells 750 to 7,000 feet deep—had to wait for technology. Even then it was unpredictable. To their disgust, early salt drillers sometimes brought up nasty-smelling, sticky black stuff "of no conceivable use whatever"—oil.

Thus, salt commanded memorable prices.

In the vast Sudan, for example, certain tribes had gold, but no salt. North, in the Sahara, lay salt deposits. Between the two lay Timbuktu, fabled origin of medieval gold caravans to the Mediterranean.

Led to a secret trading place many days beyond Timbuktu, Moorish merchants with an army of bearers, each with a slab of salt on his head, halted by a riverbank, beating drums to signal their arrival. Each merchant stacked his salt, then all withdrew.

Emerging from pits where they dug for alluvial gold, the tribesmen placed gold next to each salt pile and withdrew in their turn.

"Then returneth the Moor," runs one report; "if he like *(Continued on page 398)*

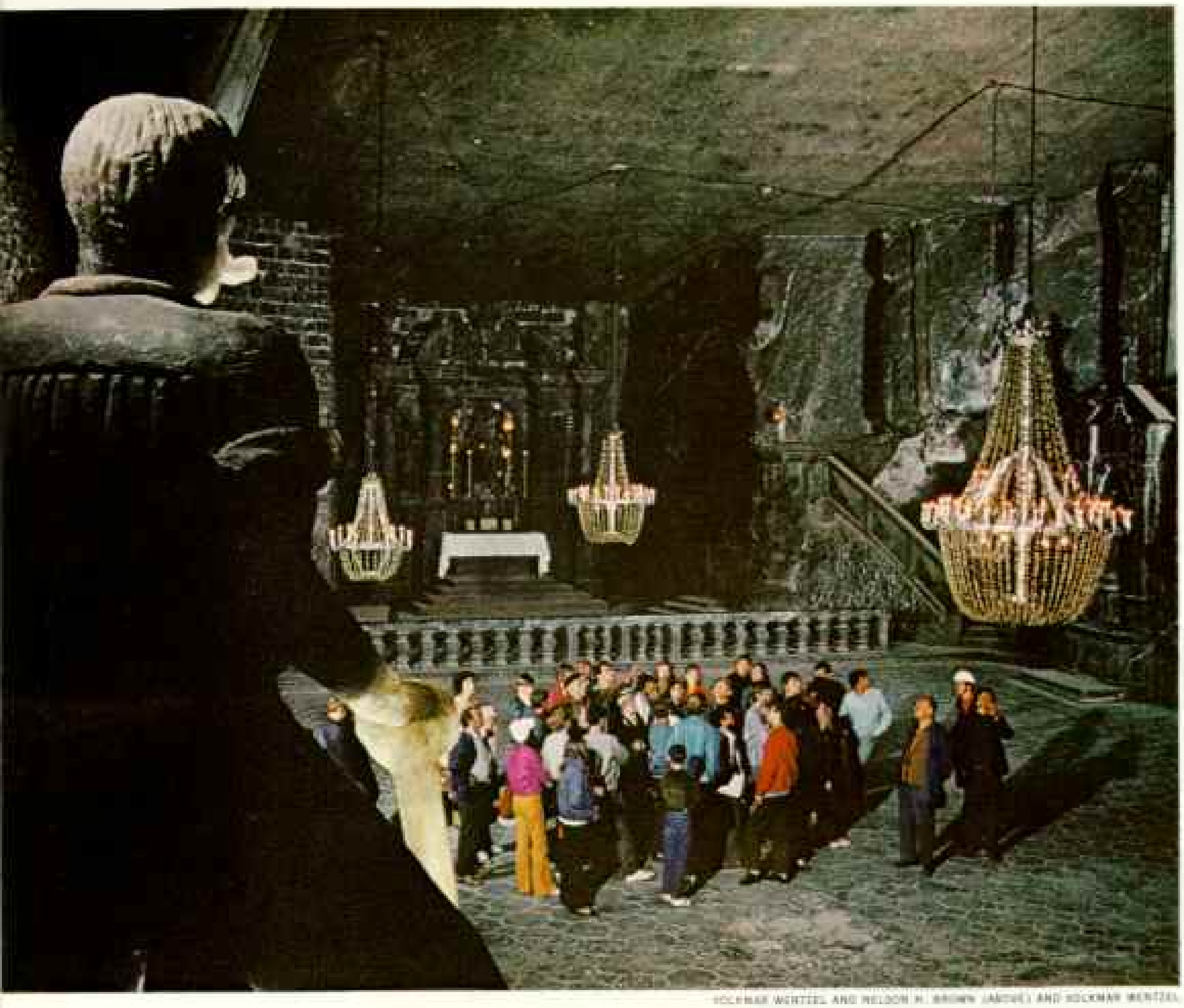
SALINENMUSEUM, HALLEIN, AUSTRIA

VOLKMAR WENTZEL AND NELSON H. BROWN

Husky Austrian miners pick away at rock salt (**above**) in a 17th-century painting. Slow backbreaking labor sufficed when salt was used mainly for seasoning and preservation of food. Now more than 70 percent of the demand comes from industry. Salt or its derivatives go into everything from plastics to mouthwash, and from aspirin to dynamite.

VOLKMAR WENTZEL, HALLSTATT MUSEUM, HALLSTATT, AUSTRIA

In the heart of Austria's Alps at Hallstatt, miners of the first millennium B.C. cut salt slabs that left behind distinctive shapes (**above**). The harvest became a commodity by which the Celts spread their culture. Some clothing and tools (**right**) were preserved in the mine; the bronze pick is nearly identical to those wielded 2,000 years later.



HOLKHAR WORTEL AND NELSON H. BROWN (ABOVE) AND HOLKHAR WORTEL

Mine, museum, sanatorium, national showplace, Poland's Wieliczka works have produced salt continuously for ten centuries. Sometime in the 17th century miners began to see salt as poor man's marble, and over the years have carved chamber after chamber of untutored native art. In Queen Kinga's chapel (**above**) the statuary, altar, railings, candlesticks—even the crystals of the chandeliers—are fashioned of salt. A ring lost by the good queen (**right**), so the story goes, turned up in the first chunk of salt brought to the surface.

Working with maul and chisel, miner Miezsyslaw Kluzek (**left**) continues the tradition of sculpturing statuary.

Part of Wieliczka has been made into a sanatorium where patients with respiratory problems can find relief in a pollutant-free atmosphere of constant temperature and humidity.

Artistic illusions, salt pans the world over resemble painters' palettes when seen from the air. Along the southern coast of Brittany (**above left**) impounded seawater is colored by algae that flourish at various degrees of salinity. Once so highly prized that pirates waylaid ships carrying it to northern Europe, the French salt made here smells faintly like violets.

In Ethiopia, ponds reflect a spectrum of earth hues (**top right**). From the edge into the vortex, brine flows in the spiral of the "Snail" (**above**) near Lake Texcoco, Mexico. After a journey of six months, the now concentrated brine is pumped to a plant that produces both salt and soda ash.

Aimless as a finger painting, donkey and truck tracks swirl across the bed of Maharlu Lake in Iran (**right**), dry during the salt harvest season.

ALL BY GEORG GERSTER

Salt—The Essence of Life

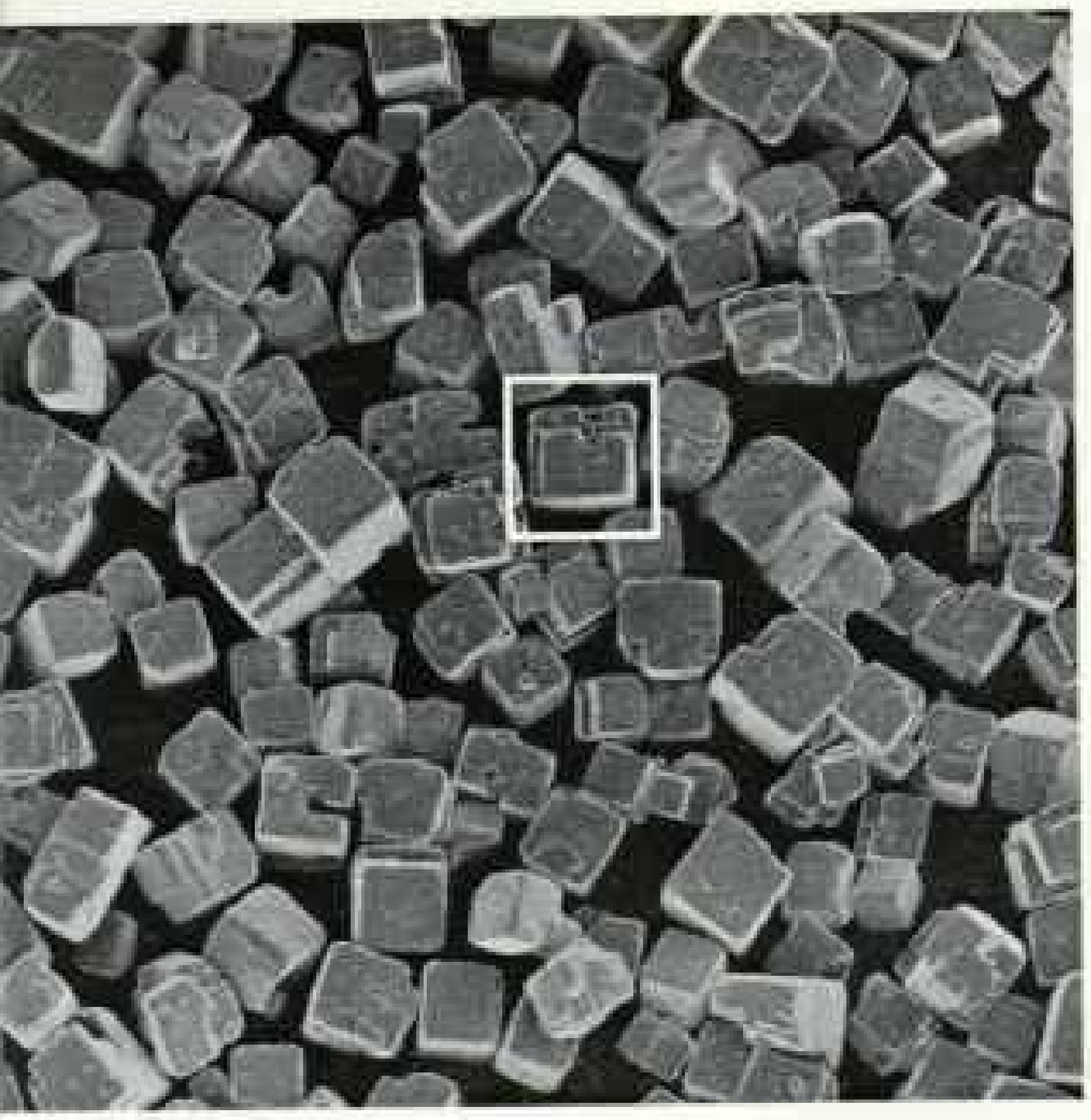
Zigzagging down a crater wall, a switchback trail plunges a thousand feet into a volcano's caldera in southern Ethiopia (**above**). Erosion washes salt down into the brine pool, where Borana tribesmen gather it. They thrust twigs into the brine, then air dry them to form seed crystals. They shake these back

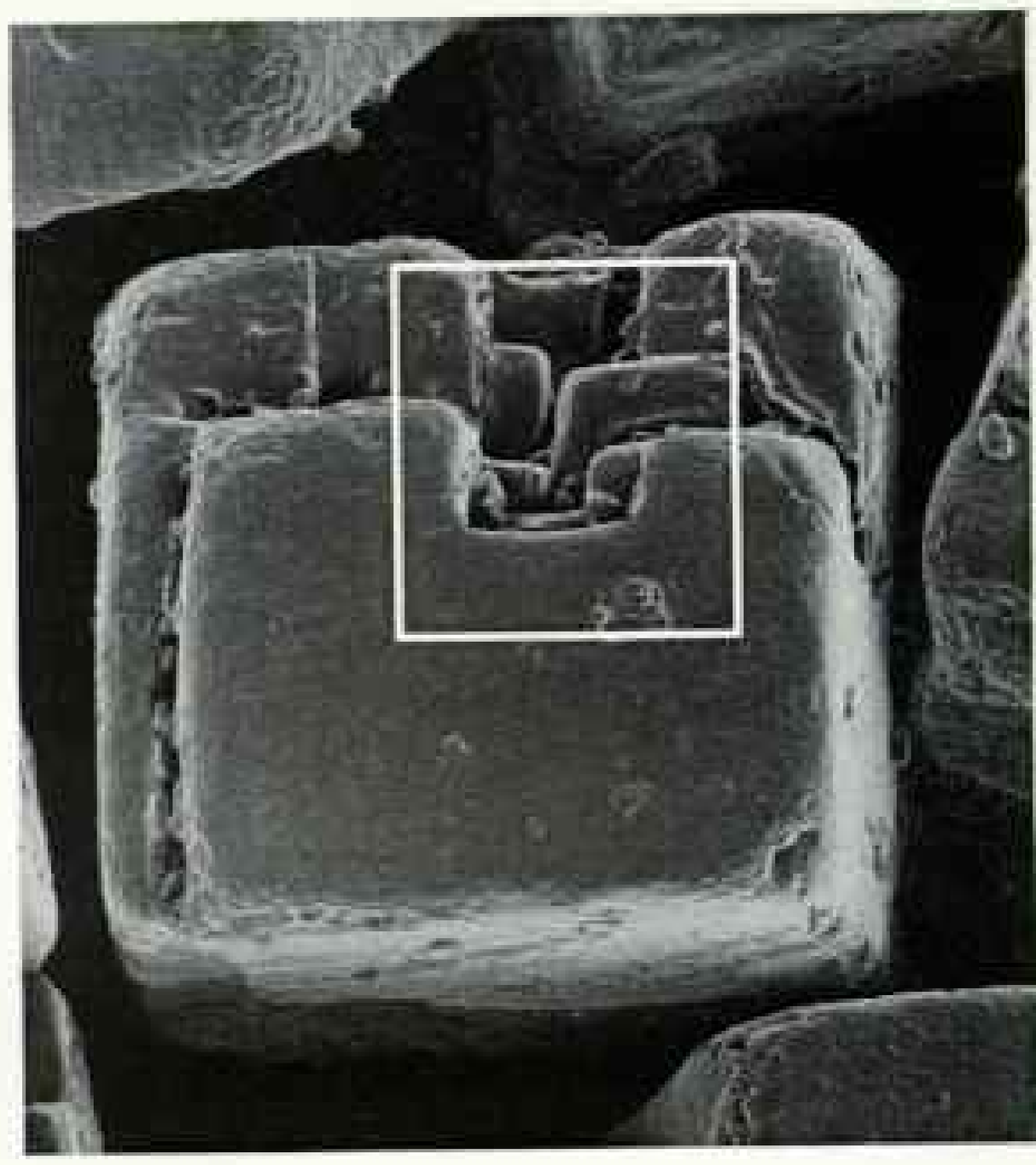
ALL BY GEORG GERSTER

into the brine, and larger crystals blossom. At harvest a worker wades into the pool (**top right**). Caked with salt (**lower right**), harvesters often suffer from salt-induced sores. If they seek wives, bachelors must work especially hard, since prospective in-laws will demand a bride-price paid in salt.

Looking into a salt crystal

COLORLESS, CUBIC, a compound comprised of sodium and chloride ions: in a word, salt, in its pure crystalline form. Here, table salt is shown in scanning electron microscope views of increasing





(Continued from page 390) the gold, taketh it away; if not, detracteth so much from his heap." This went on, back and forth, neither group seeing or speaking to the other, until the merchants, banging drums to signal that trading was over, loaded the gold and departed.

French Architect Planned Salty Utopia

In the forested foothills of France's Jura Mountains, I came upon another curiosity: an 18th-century industrial utopia whose one product was pure white salt. Built by Claude-Nicolas Ledoux, an architect unfettered by convention, the royal saltworks of Arc et Senans were to be the nucleus of his ideal city. Here workers would be ennobled by their environment.

Through a symbolic grotto, I entered a grouping of brooding stone buildings. Across spacious lawns living quarters face the dramatically columned director's house, flanked by two great salt-drying pavilions. Studying Ledoux's sketches, I wished he could have completed that ellipse and the garden city to be grouped about it. And he planned a Temple of Memory to the Glory of Women, with four sculptured towers portraying hundreds of heroines. The necropolis was to cluster tiers of catacombs about a huge, hollow sphere, symbol of infinity. There were to be two houses of pleasure, designed in phallic shape. The House of Peace would adjoin the smelter, where cannons would be forged.

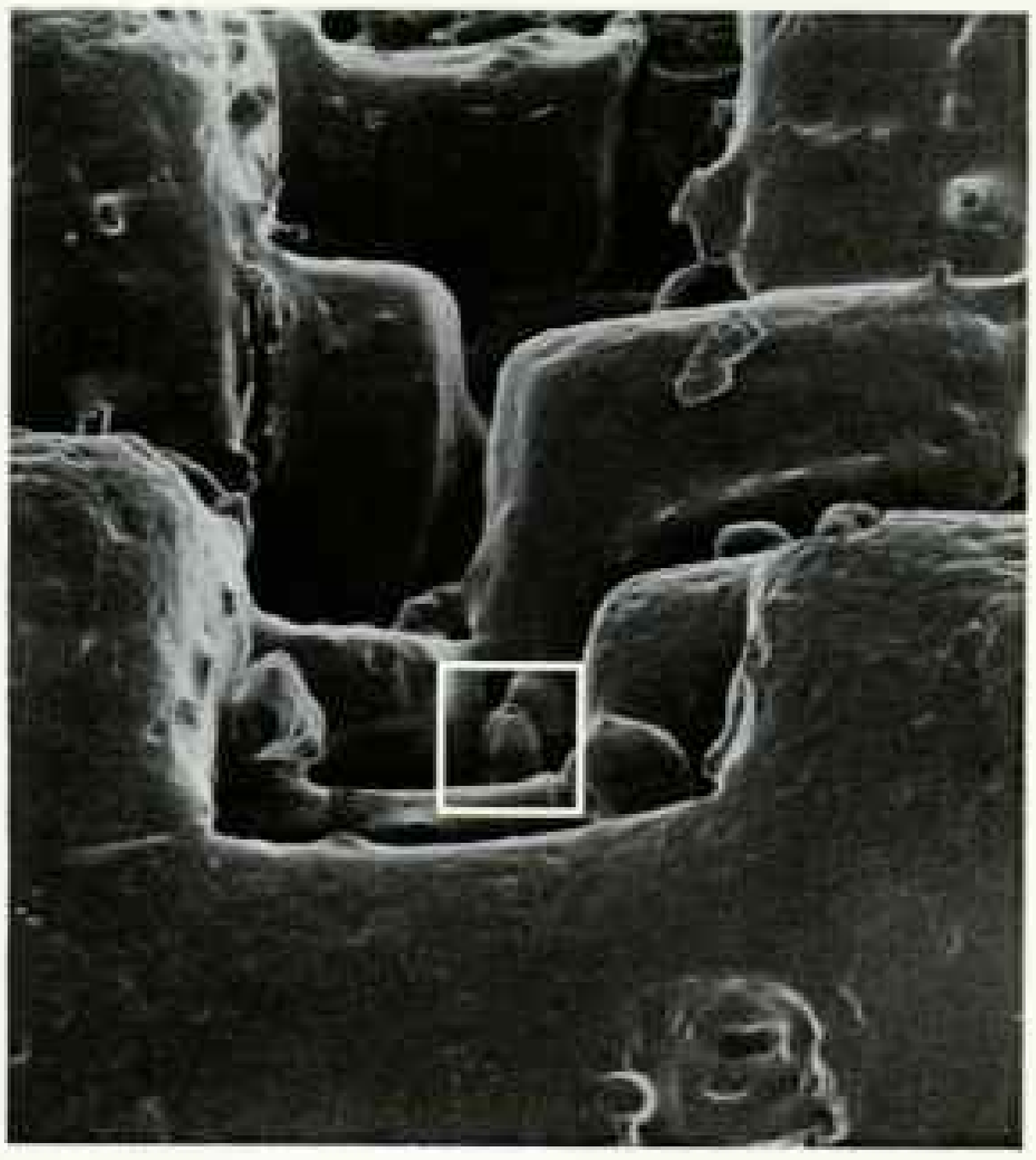
With Louis XVI as patron, he was lucky to have escaped the guillotine, though jailed during the revolution. To the end he defended his grandiose concepts against critics. "The luxury of the forms that I am imposing upon the vulgar world," he wrote, "has nothing at all to do with their cost."

But there was nothing visionary about his salt-producing ideas. He piped brine ten miles from a spring in the town of Salins to Arc et Senans, where forests could meet the insatiable demands of wood fires beneath the evaporation kettles. Ledoux's brainchild operated for a century.

I traveled on to Poland's Wieliczka salt mine, near Kraków (pages 392-3). People from the world over come to behold its salt sculptures, or to ease their respiratory ailments in its subterranean sanatorium.

Salt has been coming from the ground here for more than a thousand years, first from a

magnification from left to right. In the early 1900's, the theory of atomic structures was first proved experimentally by X-ray examination of halite—rock salt. Modern chemists have studied salt with a success denied the alchemists of the Middle Ages, who hoped that this basic substance might hold the answer to their futile quest —to turn lead into gold.



ALL BY DAVID SCHARF | MAGNIFIED FROM LEFT: 63 X, 333 X, 1,109 X, 10,000 X

saline spring. As the water level receded, the spring became a well. Continually deepened, it finally became a dry shaft through which miners descended with their picks.

More than 400 feet down, in the third of nine levels, I examined giant windlasses, ingenious water hoists, and air pumps in the museum. All were of wood, and very old.

"Salt air can destroy metal, but it preserves wood," the curator explained. "It would be most unusual to find metal equipment hundreds of years old down here."

Mining methods have gone full circle: Brine is once more the salt medium, I learned from technical director Aleksander Batko. "We carve and blast new tunnels, then flood them. The brine, piped to the saltworks, arrives better than when it started. Regulating the pipeline speed settles out impurities."

Friendly Ghost Protects Believers

For a memorable half day I strolled from cavern to cavern, admiring Wieliczka's famed sculptures, the work of untutored miners. Their medium: rock salt with the gray look of granite and the consistency of sandstone.

Copernicus, the celebrated astronomer, dominates one simple chamber. More elaborate chambers form chapels, or commemorate legends. One memorializes Skarbnik, the tall, bearded ghost called the "Treasurer" because he guards the earth's riches. He is said to walk the passages by lantern light, protecting those who believe in him. Even today he finds few doubters among the miners.

An empty crate stood on a concrete floor in a large cavern. This, too, told a story. In World War II, the Nazi occupiers of Poland set up an aircraft-engine factory here, out of reach of Allied bombers.

From one tableau, I learned of good Queen Kinga. In the 13th century she came from Hungary to marry a Polish king. Before leaving home, she dropped her golden ring into a salt spring. Magically, the ring came to light in the first salt brought up from Wieliczka's mine, while she was passing through.

Her good fortune attends the subterranean Sanatorium Kinga. The man who originated and still directs it, Dr. Mieczyslaw Skulimowski, was the mine's physician two decades ago. He noted the miners were unusually resistant to respiratory ailments. He began assigning surface workers with asthmatic

WILFORD TAYLOR

With an endless supply of sun and buckets of seawater, a Balinese worker produces salt by evaporation. Other of earth's commodities may one day be exhausted, but salt will never be among them. The oceans contain enough to make a dazzling white continent.

conditions to mine work. Almost all improved.

For the past 13 years, he has maintained a therapeutic center on the fifth level, some 700 feet down, away from day or night, heat or cold, summer or winter. It was doubling in size, the day I talked with him. Miners were blasting their way into another cavern to be added to his facility.

"The eventual goal is 800 beds," the doctor said, "with a kitchen, library, recreation room, physical-therapy area, movie theater, and whatever else is needed for patients' comfort during their 24-day convalescence in the regenerative salt air down here."

Iron Age Mine Still Producing

I crossed northern Austria to visit one of the oldest enterprises on earth, the Hallstatt mine (page 391), high above a gorgeous Alpine lake 50 miles from Salzburg—Salt Town. Except for a time in the Middle Ages, salt has been mined at Hallstatt at least since the early Iron Age. And there's still a lot left from those deposits laid down 180 million years ago in a shallow sea between Bohemia and the Alps. Titanic forces thrust salt up as a plug, 2,000 feet wide and 2,500 feet deep, inside a mountain.

Today, like the Wieliczka mine, Hallstatt's is a brine operation, and a tourist magnet as well. Lifted by cable car up the mountainside, I joined a tour group sampling the 25 miles of galleries that honeycomb the Salzberg—Salt Mountain. From one chamber a pair of polished wooden poles angled down into darkness. We straddled the "banisters" and zoomed down to a lower chamber, trailing youngsters' squeals of nervous delight.

Life was more serious here 2,500 years ago. Miners hewed heart-shaped chunks of rock salt (page 391), then backpacked the precious commodity out to daylight, where it entered the trade channels of Celtic Europe.*

Salt, in those distant days, filled a vital need as a preservative. It drew moisture from meat, dehydrating it to delay spoilage. Until the advent of refrigeration, most flesh in Europe's diet was salted. Shortage of winter feed meant that most livestock had to be slaughtered and salted down in autumn.

The Hanseatic League rose to wealth on the back of salted fish, staple food on the meatless days of Roman Catholic Europe. Baltic herring, cured in salt from Lüneburg, a North German member city of the medieval mercantile league, entered the trade for Bordeaux wines, English wool, Flemish cloth, Pomeranian grain, Swedish iron, Russian furs.

Ironically, salt may have hastened the league's decline. Early in the 16th century the great shoals of herring ceased to go to the Baltic to spawn, perhaps because of a decrease in its salinity. Taking over the herring fishery, now in the North Sea, the Dutch rose to maritime supremacy.

Even after the Reformation, England outdid Catholic nations in consumption of salted fish. Elizabeth I required her subjects to eat fish on Wednesdays as well as on Fridays, holy days, and during Lent—thus strengthening her fishing fleet, a training ground for salts who defeated the Spanish Armada.

Salted provisions enabled early explorers such as Columbus, da Gama, and Magellan to make long voyages and discover new lands.

In 1583, a quarter of a century before the founding of Jamestown, Sir Humphrey Gilbert, half brother of Sir Walter Raleigh, claimed land for England in North America at St. John's, Newfoundland. He sought control of the Grand Banks cod fisheries, worked by Basques, Bretons, and Bristol mariners. The Portuguese had already been coming for 80 years. They still do.

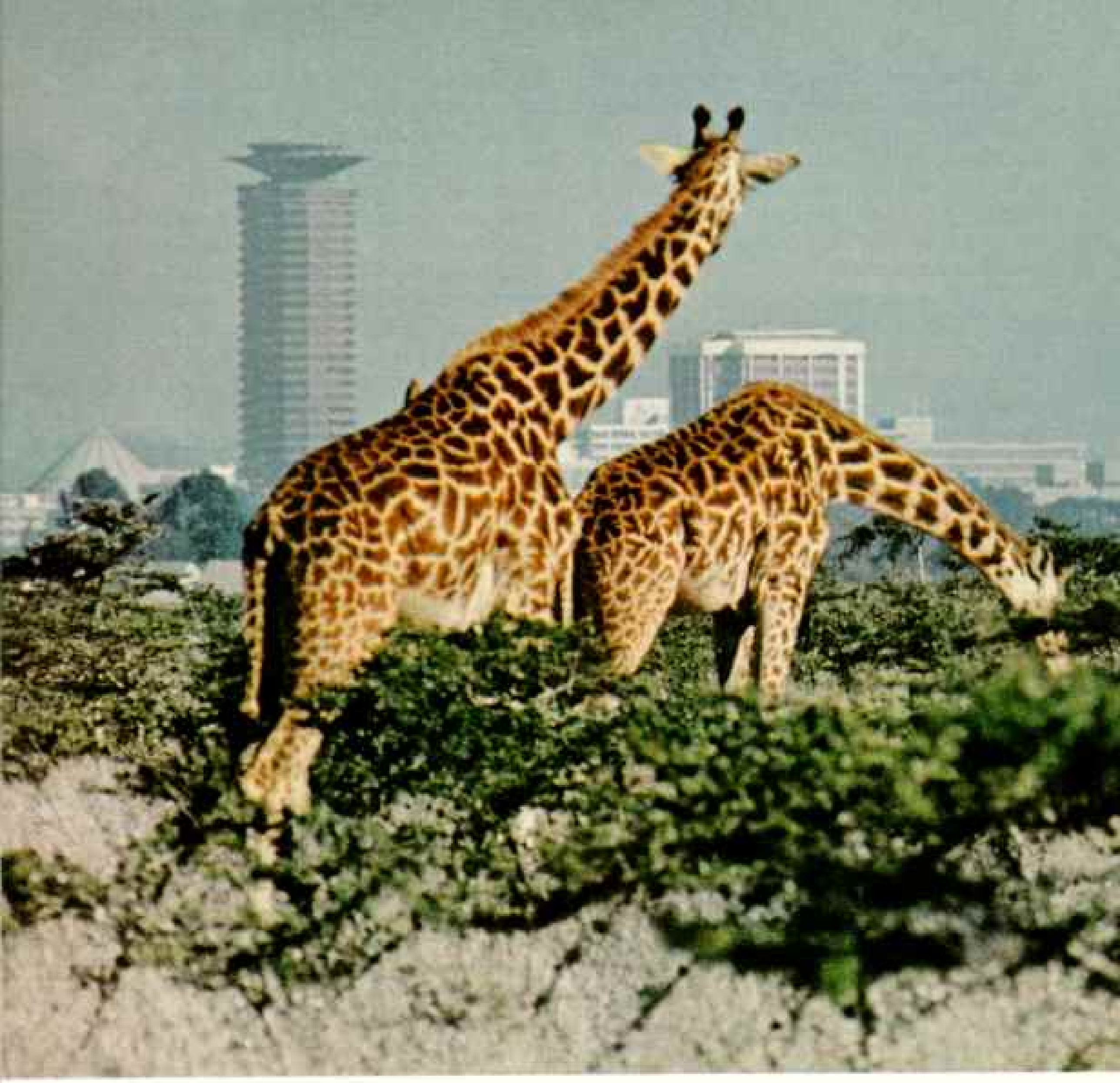
Portugal's fishing schooners, which in season line the wharves of St. John's, are salty ships indeed. Tons of salt lie in their holds to preserve the catch.

Salt Makes Possible Human Existence

By weight you and I are 70 percent fluid—the same percentage of the earth's surface that is covered by ocean. The sea within us has the same saltiness as the Precambrian seas of three billion years ago. We all spend our first months in a sac of saline solution; the fetus even passes through an early stage with gill-like ridges and tail. From cells in our brains and bones to customs that spice our language and history, salt penetrates every aspect of our existence.

Tonight at dinner, cast a more appreciative eye on that humble saltshaker. Your life and mine depend upon those little white crystals. Our blood, sweat, tears—the very beating of our hearts—all attest to that. □

*See "The Celts" by Merle Severy, NATIONAL GEOGRAPHIC, May 1977.

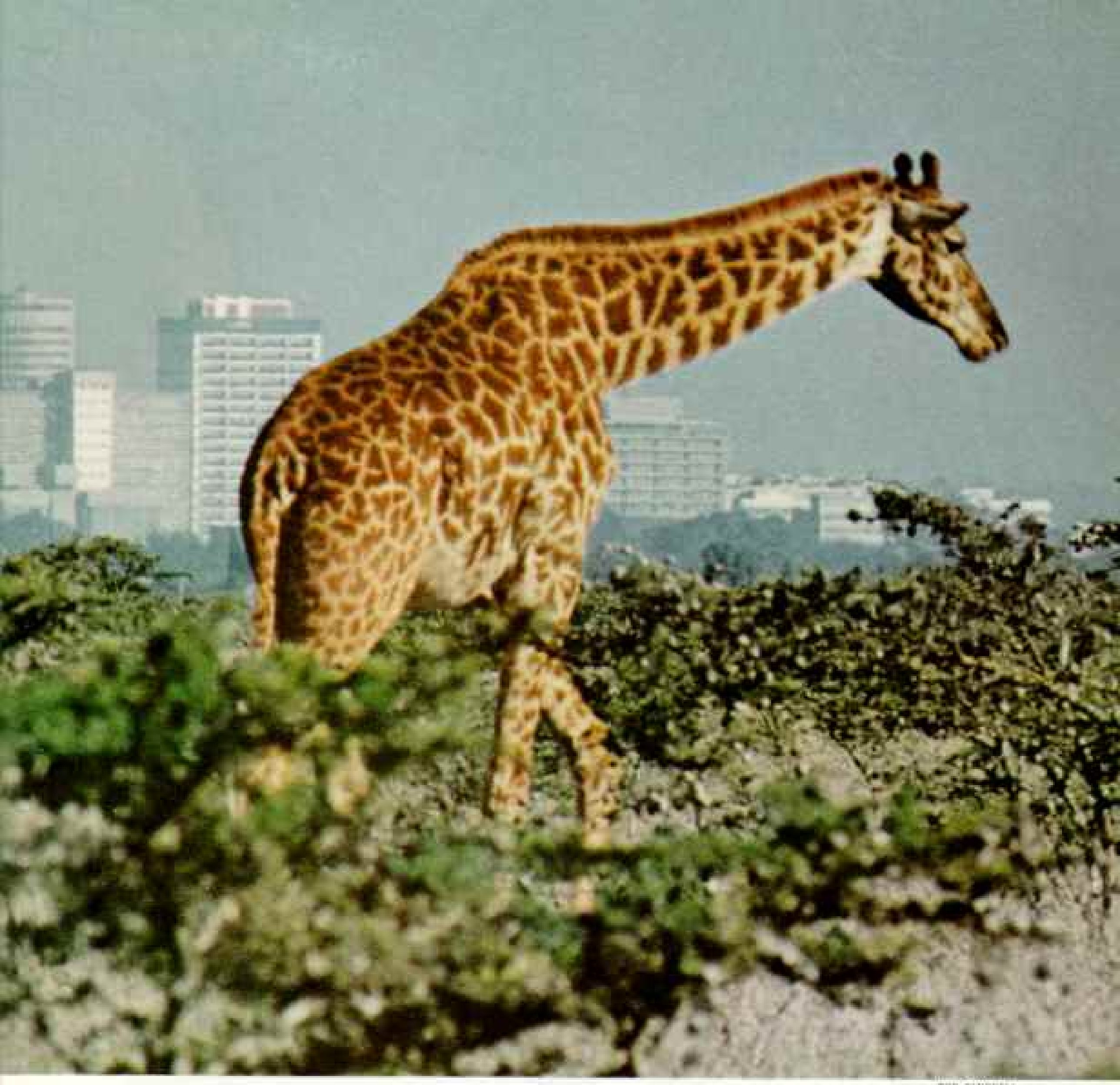


Living skyscrapers, earth's tallest creatures browse in the protection of

Africa's Gentle Giants

By BRISTOL FOSTER, Ph.D.

Photographs by BOB CAMPBELL and THOMAS NEBBIA



BOB CAMPBELL

Nairobi National Park. Beyond loom the high-rise buildings of Kenya's capital.

THE SPEEDOMETER registered ten miles an hour, yet old George, just ambling along, easily kept up. Sitting at the wheel of the Land-Rover, I could hear the thud of his great hooves as he strode across the grassy plains of Kenya.

A huge male giraffe, George accepted my presence without the slightest show of fear. I drove within six feet of him as he walked, swinging his immense legs forward, first the two on one side, and then the other two, in the typical pacing stride of the species. We were so close I could lean out the driver's window, look straight up, and see one of the animal's liquid brown eyes peering down.

George, a favorite among the giraffes I was studying in East Africa, had given away his advanced age when his face popped up on a postcard. Riffling through cards in a stationery shop in Nairobi, Kenya, to find a giraffe picture to send home, I suddenly recognized an old friend with a haughty expression. It was George!

Then on another card I identified a stately animal that I had been observing just the day before hardly five miles away. I noted the brown blotch slashed by taffy-colored streaks and the big, blurred capital "C." The hair

Prolibytherium
stood seven feet tall;
it roamed Libya
20 million years ago.

Zarafa,
a six-footer, lived
in Libya 20
million years ago.

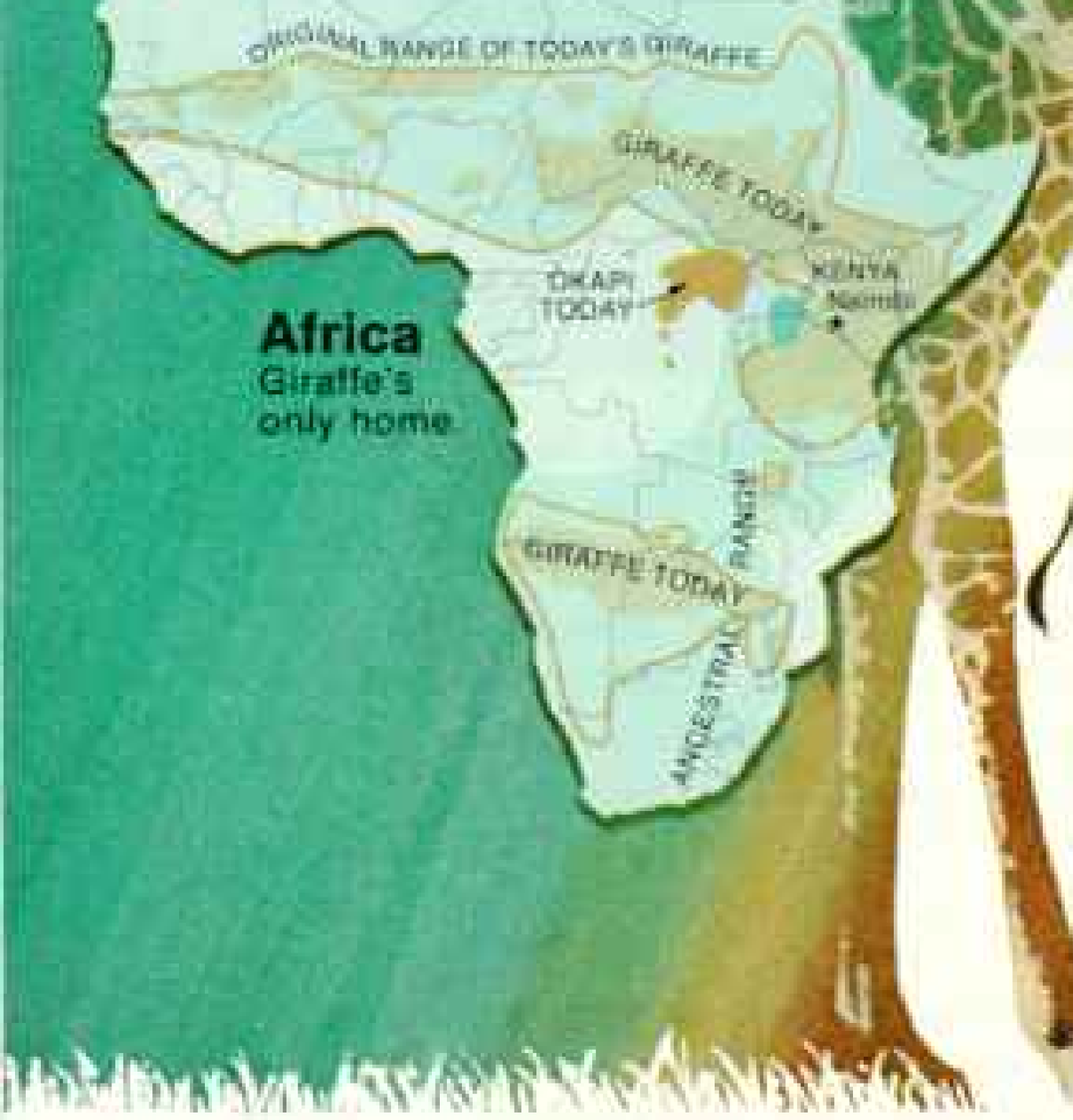
Palaeotragus,
6 to 13 feet high,
ranged over
Europe and Asia as
well as Africa 15
million years ago.

Long-necked giraffe and short-necked man share the same number of cervical vertebrae—seven.

Large body surface permits great heat tolerance; keen eyesight and hearing guard against predators.

Sivatherium,
a 16-footer, appeared
in Africa and southern
Asia five million
years ago.

Giraffe stands
14 to 17 feet high,
permitting it to
browse on foliage
unreachable by
other animals.



Okapi at six feet
is the same size as
the ancestor it
resembles—the
smallest species of
Palaeotragus.

PAINTING BY WILLIAM H. BUNT
NATIONAL GEOGRAPHIC ART DIVISION

A neck ahead in the race to live

ANCESTORS of the long-necked modern giraffe, *Giraffa camelopardalis*, and of the related okapi probably originated in Africa but spread some 15 million years ago into Asia and Europe. Now restricted again to Africa, nine giraffe subspecies are differentiated largely by their spot patterns.

pattern of every giraffe is different, as unmistakable as a fingerprint. This one clearly was Miss Prim, an animal coded in my field notebooks as F47.

Searching further among the postcards, I came upon two more giraffe acquaintances. All were among the scores of giraffes I had been studying and photographing in Nairobi National Park, the 44-square-mile wildlife reserve just south of Kenya's capital city.

"I'll take these four. We've been living together for years," I said to the clerk, who regarded me a bit oddly.

I looked up the local photographer who had made the pictures—some of them many years earlier—and he told me when each had been taken. This allowed me to estimate minimum ages, which established that George was at least 25 years old.

Soon I was looking at the giraffe pictures of all the local wildlife photographers. One showed an adult snapped nearly twenty years earlier that was another of my current study subjects—and, like George, probably near the end of his life. There were pictures of other animals that had survived equally long. These "historic" photographs supplemented the camera record I'd been making of every giraffe observed in Nairobi Park.

Long-term, Long-neck Research

On behalf of the Canadian Government, I had come to Kenya to set up a graduate program in wildlife ecology at the University of Nairobi.* I decided to study the giraffe, an animal that had obvious advantages as a research subject. The hundred or so animals in Nairobi Park at any one time were a manageable number, easy to find. Furthermore, they are just plain fascinating creatures. The giraffe is the world's tallest animal; a newborn calf may stand six feet in height and grow nine inches in a single week. Though awkward looking, the giraffe is swift and graceful; though gentle, it can deal a deadly kick with six-foot legs.

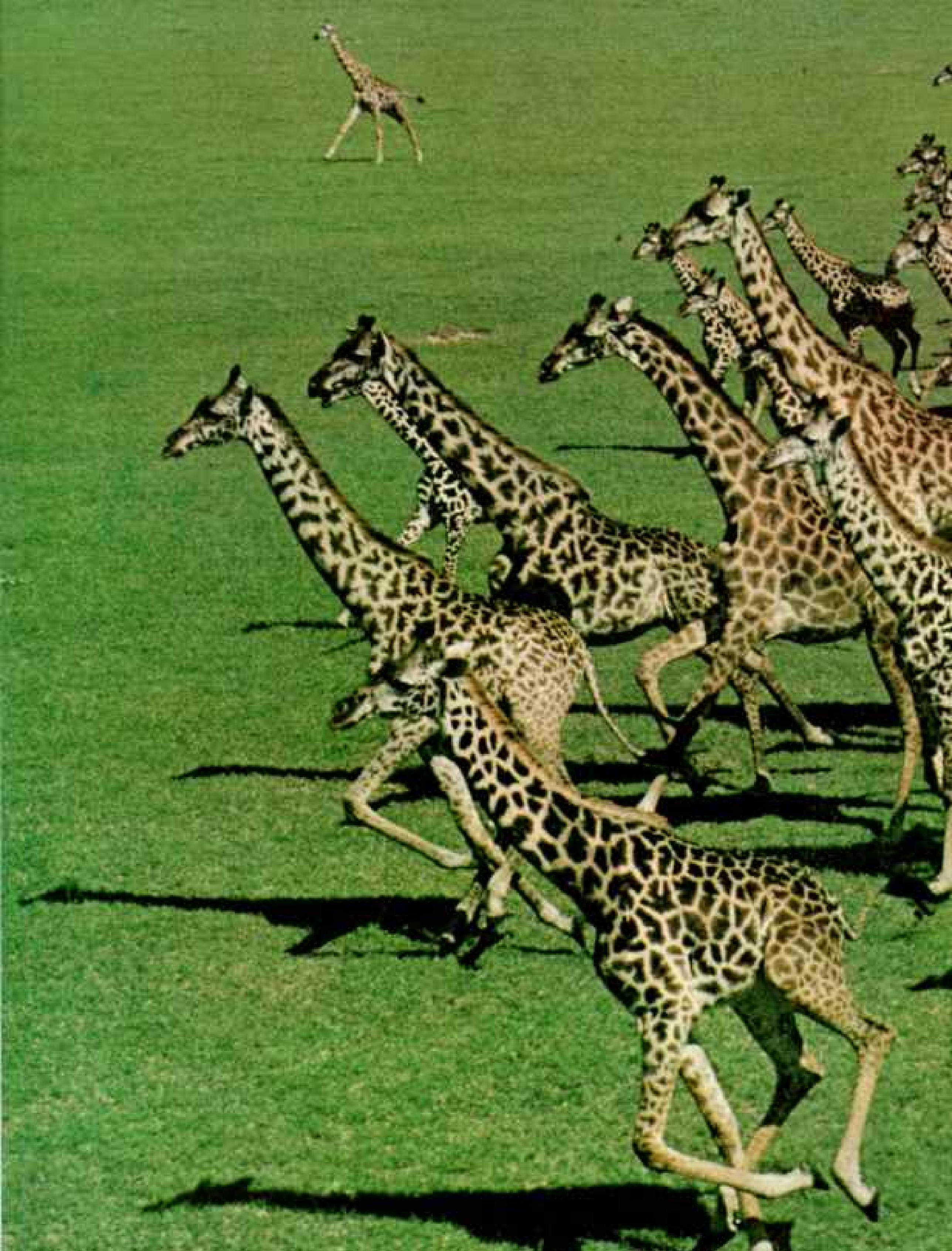
But what makes the giraffe a standout among earth's mammals is, of course, its long neck, holding its owner's head 14 feet or more above ground. And, as I said, each neck is unique. The giraffe's pattern—its protective coloration of spots and lines—does not change markedly with age on any part of its body, except sometimes to become darker.

For my photographic record, this offered an obvious opportunity. A whole giraffe is an awful lot of animal, so it was easiest to picture just the neck. Arbitrarily I chose the left-side view. Eventually I compiled a catalog of 241 giraffe profiles, each "neckprint" mounted on a field-data card.

Year by year my affection grew for these mild-mannered, knobby-horned prodigies of the African plains, with their soulful brown eyes. My family and I took a house in Nairobi, and from it I would set out down the

Standout in the crowd, a rare white bull in Kenya's Masai Mara Game Reserve lacks the patches that may serve as camouflage. Proponents of the camouflage theory argue that patterns among different subspecies vary according to habitat—and tend to blend with it. Others counter that the animals are just too big to miss, patches or no.

*The author is now Director of Ecological Reserves for the Province of British Columbia.



In a burst of power, a herd of giraffes gallop across the Serengeti

THOMAS NEBBIA

Plain. The graceful giants can run as fast as 35 miles an hour.

THOMAS NEBBIA (ABOVE); BRIAN VIGOR

Satisfying hunger and thirst, a giraffe dines on its favorite, a whistling-thorn acacia tree. With long, hairy lips to protect against the stab of thorns, the giraffe uses its 18-inch tongue to pluck the watery leaves. Even the acacia's stinging ants (**below**), attracted to the sweet pulp of young shoots and here infesting a gall, fail to discourage the giraffe's pursuit of its dinner.

Mombasa Road toward the park in the cool and fragrant dawn. Sometimes my wife, Anna, could accompany me, leaving the children snug in bed, watched over by their nursemaid.

At the park's first viewpoint, we would stop to survey the whistling-thornbush plains. Perhaps we would see a hartebeest push its way through the red oat grass, its horns festooned with spiderwebs strung with pearls of dew; at times a yellow-throated longclaw would trill to a rival across a dry donga.

"Trees" Begin Moving at Dawn

One morning, seeing no signs of giraffe friends, we headed south toward the hippo pools. The sun touched the knuckles of the Ngong Hills and within minutes flooded the plains with slanting golden light. What had been vague shadows became wildebeests, zebras, reedbucks, warthogs, elands, hartebeests—but still no giraffes.

We dipped down toward the Athi River just as the sun reached the yellow-trunked fever trees. Vultures still roosted on the flat treetops, awaiting the thermals that would carry them aloft in quest of carrion.

What had seemed to be a tree moved from its place. Then another. It was our first herd of giraffes, slowly idling along, nipping branch tips. We coasted down the hill and were soon among the herd.

"Isn't that Mabel?" my wife asked.

It was. Mabel stopped ruminating to study us, then grasped a branch with her prehensile tongue. By the time we had identified ten old friends and photographed four newcomers, we suddenly discovered that we were cool no longer. The heat had become oppressive, and soon the giraffes and other game faded into the cooler thickets.

As we pulled out, heading home for breakfast, a Masai herdsman stepped from the bush, seeking stray cows. The giraffes bolted, threading their way through the tangle of trees to the open plains. That was a safer place to keep watch on an old enemy.

The giraffe has amazed civilized man for thousands of years. As early as 2500 B.C., the animals were imported for display in zoos of Egypt, where the species was by then extinct.

Julius Caesar introduced the first giraffe to Rome in 46 B.C. Advance publicity dubbed the animal a "camel leopard" because it was as big as a camel with spots like a leopard.

The poet Horace called it a hybrid of the two This bit of unnatural history produced the giraffe's modern scientific name, *Giraffa camelopardalis*.

Romans hoped this strange beast would prove as fierce as it was huge, providing new thrills in the arena. They were disappointed. The elder Pliny described it as "more remarkable for appearance than for ferocity."

Though capable of uttering a variety of sounds, it seldom does, giving rise to a myth that it is mute. The giraffe also gives a deceptive impression of ungainliness—but watch one in stride with its long, loping gallop and you see a paradigm of power, a kind of imperial grace. A big bull may weigh 3,000 pounds or more; the cow, as much as 2,500. But they can run as fast as 35 miles an hour, a speed matched by few other large animals.

Elongated legs and neck lift the giraffe above the common herd. Yet the neck has the same number of vertebrae as the necks of humans and most other mammals—seven. The giraffe's vertebrae, of course, have become greatly lengthened.

My measurements established that the average cow giraffe stands about 14 feet tall, and the bull 15 to 17 feet. The record giraffe of trophy hunters, undoubtedly a male, measured 19 feet, 3 inches—certainly an exceptional height. Its lofty bearing gives the giraffe the best view of any land mammal, helpful in spotting its principal threats, lions and men.

Expanse of Hide Keeps Giant Cool

A giraffe's great surface area helps provide effective "air conditioning" in a hot environment. Other African mammals as heavy as or even heavier than the giraffe—the rhinoceros, hippopotamus, and elephant for example—slosh about in water or mud to cool their bodies. Each one needs to drink water at least every few days.

No giraffe, on the other hand, has ever been seen bathing or wallowing, and the camel leopard seemingly can keep going indefinitely without drinking, if it has access to its normal succulent food, such as acacia-twig tips, which are up to 74 percent water.

Evolution has modified the giraffe's anatomy to allow this stretched-version mammal to function (page 404). The lungs are oversize to compensate for the volume of dead air in the long trachea. Without this extra air-pumping capacity a giraffe would breathe the same used air over and over.

To drive blood eight feet up to the head, the heart is exceptionally large and thick-muscled, and the blood pressure—twice or three times that of man—is probably the highest in any animal.

Unique Valves Check Surges of Blood

Early observers wondered, seeing a giraffe lower its long neck to drink, why the blood rushing down to the head didn't cause a fatal hemorrhage. To withstand the surge of blood to and from the brain as its neck sweeps up and down, the giraffe has developed control valves in the jugular veins and a special network of blood vessels in its head. Known as the *rete mirabile caroticum*—wonder net of the carotids—this circulatory buffer keeps blood pressure constant in the brain.

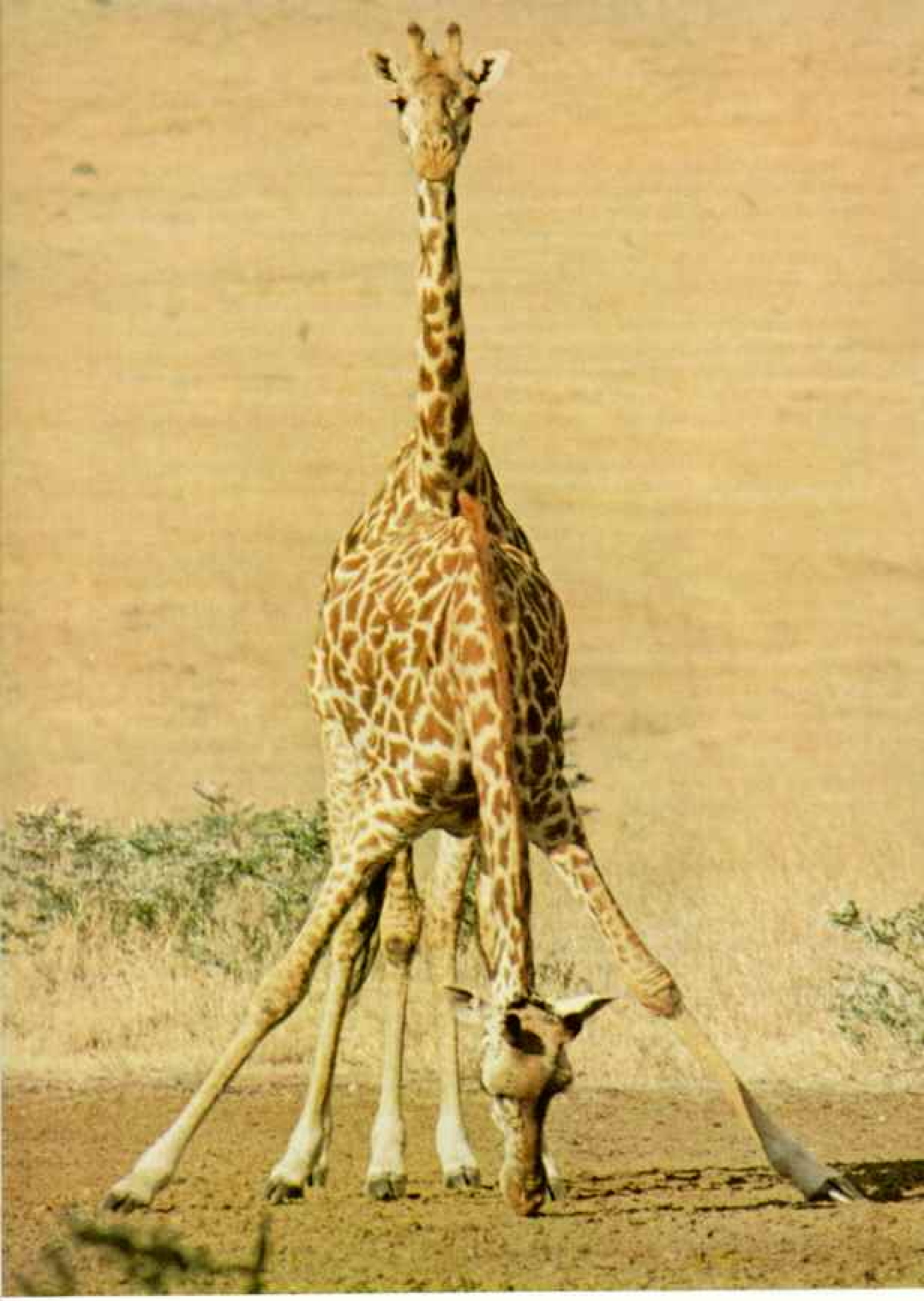
Such remarkable adaptations notwithstanding, giraffes have one vulnerability. I've followed them running all out—and have noted how quickly they tire. Their great size and heavy bone structure may put a limit on endurance.

Feeding and chewing the cud occupy the giraffe for most of the day and night. Its favorite fare is the tender, growing tips of the whistling-thorn acacia tree. A ton-and-a-half bull probably consumes 75 pounds of this highly nutritious food every 24 hours.

Giraffes are well adapted for reaching up, awkwardly built for reaching down. To feed on a bush, drink from a pool, or lick the salt in the dirt, they have to spread their front legs wide apart. Water holes are notorious hideouts for predators, and in their spraddled drinking position, giraffes are vulnerable. When a 300-pound lion fixes itself to the end of a giraffe's six-foot neck, the victim is more than likely doomed to die by strangulation.

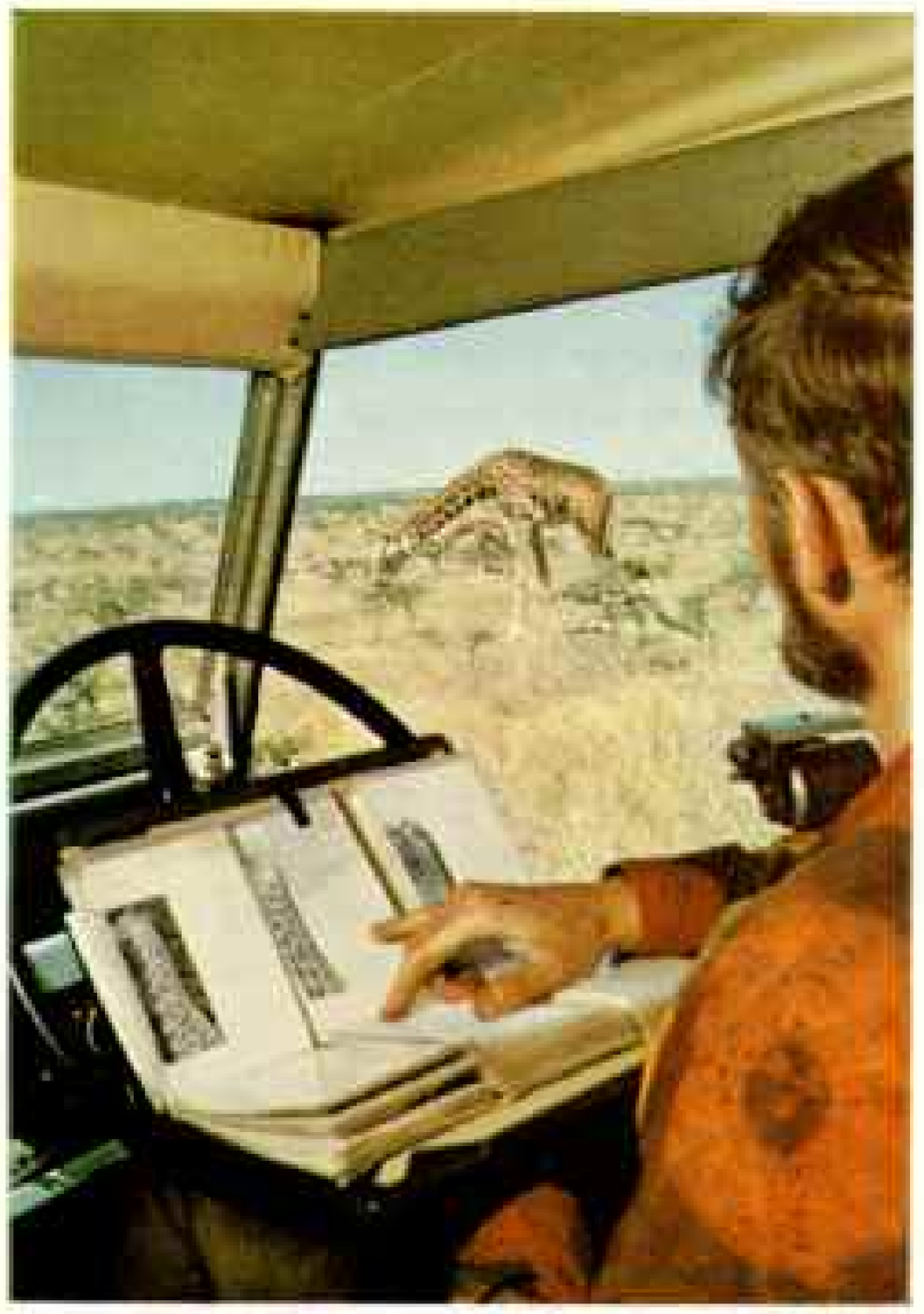
Time and again, though, I observed with what difficulty a lion approaches the all-seeing giraffe. A herd of giraffes catching sight of a lion commonly crane their necks to keep it under surveillance, even walking toward the predator to get a better view. A lion hesitates to attack prey that is aware it is being stalked.

Under direct threat of attack a giraffe generally beats a hasty retreat, although a female shepherding a small baby will stand



Splayed legs at a salt lick make a giraffe vulnerable to attack. A companion keeps head up as if on lookout (**left**). Suddenly lowering the head some seven feet below the heart could trigger a brain hemorrhage had nature not provided special equipment. When the head is at ground level, a network of blood vessels controls the flow of blood into the head. When the head is raised, the same net counters the danger of blackouts from reduced blood pressure.

In pursuit of a profile on giraffe life in Nairobi National Park, author Bristol Foster periodically measures how high the animals browse (**above**). Dr. Foster succeeded in identifying the park's entire giraffe population by each animal's highly individual pattern of patches (**right**)—as distinctive as the fingerprints of a human.



ALL BY BOB CAMPBELL

her ground. Giraffes never employ their knobby horns against predators, but they can deliver a crushing blow with the hind foot, chop-kick with the forefoot like a horse, or strike with the whole stiff foreleg.

Only once did a giraffe actually threaten me. I had just discovered her newborn baby, still soaking wet, and was examining the extraordinary placenta. My back was toward the cow, perhaps 60 feet away.

Suddenly I heard crashing in the trees and looked around to see the mother charging toward me, slashing the air with her front hooves. I leaped for the Land-Rover, falling over a thornbush. By the time I scrambled to my feet, my would-be attacker was standing still, peering down at me from about five yards away. She looked enormous, and very hostile. As I watched, her baby wandered over and began searching for the udder—at the cow's wrong end. The mother's rage subsided, and the two ambled off.

Baby Giraffes Suffer Fearful Toll

Although predators take few adults, my records show that about three-quarters of the babies die in their first year, mostly in the first few months. Lions, leopards, cheetahs, crocodiles, and hyenas probably all take their toll, along with disease. Such natural cropping helps keep giraffe numbers from outstripping available food supply.

But human poachers take an unnatural toll. Giraffe meat is quite tasty, and the animal's thick, tough hide serves admirably in whips and tribesmen's shields. Some East African peoples cherish giraffe tails as love fetishes and wear them as amulets. Tourists buy bracelets made from the tails.

I noted that giraffes give birth anytime throughout the year, after a pregnancy of about 15 months. Twins are rare among wild giraffes; in captivity only two twin births have been recorded.

Since the giraffe gives birth standing up, the young has to sustain a five-foot drop to the ground (page 414). Weighing close to 150 pounds at birth, the six-foot-tall youngster grows about four feet more the first year.

I saw baby giraffes begin to nibble the tender tips of whistling thorn within a month of birth, rarely nursing thereafter. The bond with the mother is surprisingly loose, and a calf may wander off for days with neither showing alarm. Very young giraffes often gather in groups of as many as five, generally with one of the mothers as "sitter."

Adult giraffes tend to segregate by sex—cows with cows and bulls with bulls—and the commonest group unit I encountered was a pair of females. Overall I saw females far more frequently than males. The bulls, however, are less visible, as they more often forage in the denser woodlands.

At about age 3, males begin swinging their necks at other males in a ritual called "necking" (pages 416-17). The combatants are rarely hurt, for the horns are blunt and the hide is tough and thick, but occasionally a skirmish grows into a furious battle.

The fiercest bout I have seen occurred on the outer slope of Ngorongoro Crater. When we came upon them, two huge bulls had obviously been sparring for some time—the ground was scuffed over a wide area.

Our intrusion froze them for a minute. Then one bull slowly moved its head away

Maternal inspection finds a four-month-old offspring friendly but independent. Most

and down. Suddenly it whipped up its head toward that of the other. The second giraffe saw the blow coming and arched its head and neck out of the way. As the blow passed, the second giraffe gave a quick bunt at the other's neck, which was now under his. The necks became almost entwined, and the first giraffe had to heave mightily to free himself.

Stirring up clouds of dust, the jousting went on for another ten minutes until one wilted and drew back. The winner pressed his advantage, and the fight became a rout.

Bulls Roam Far in Search of Mates

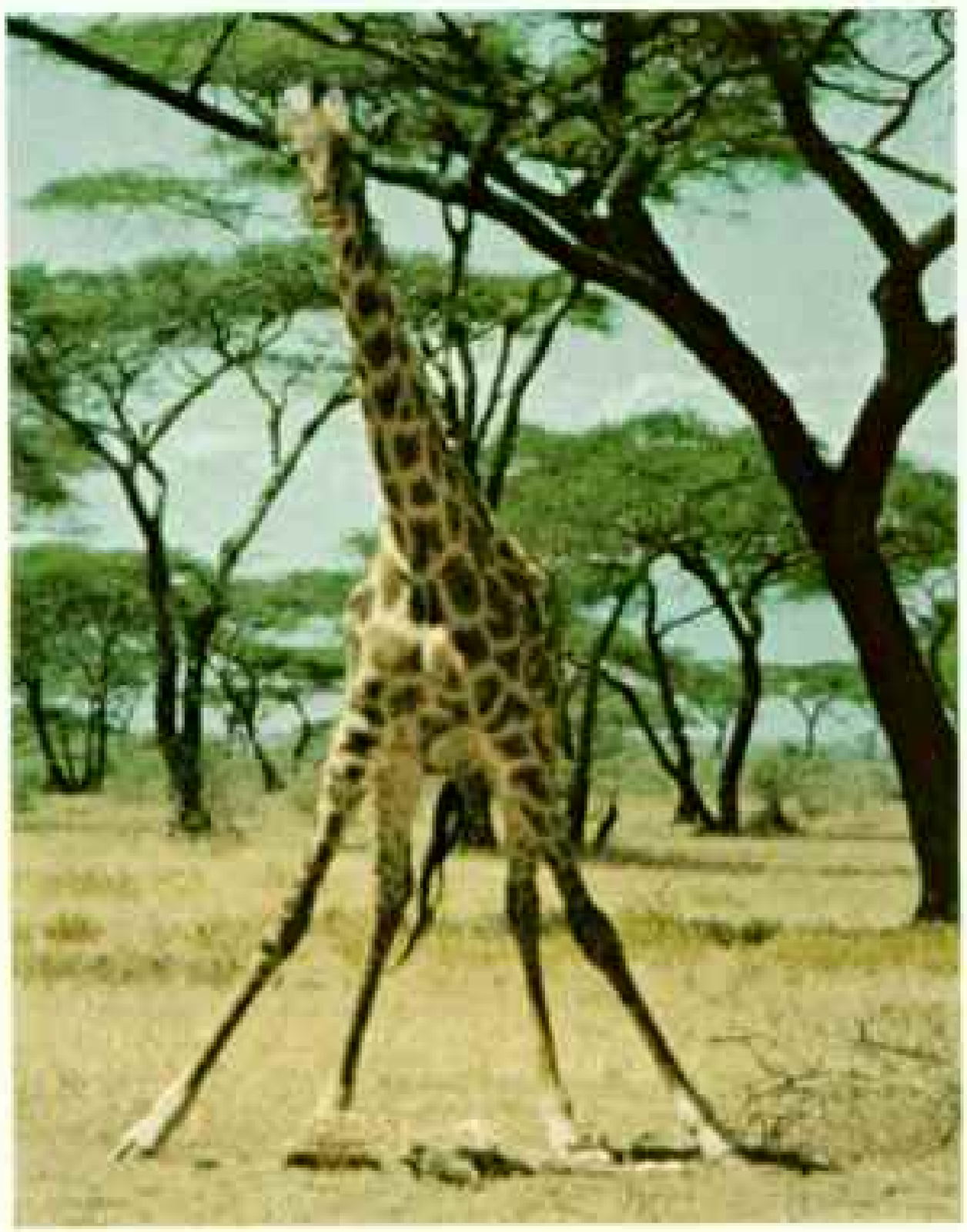
When we saw a lone giraffe wandering steadily over the plains, we could be sure it was a bull searching out the cow herds. Sighting a group of females, the bull would march over and determine whether any of them were ready for mating. If a cow was receptive, the bull might stay with the herd for several days. During this time any other adult male approaching the herd would be threatened by the bull in charge. Usually the newcomer would back away.

Bull giraffes don't defend particular territories but occupy certain areas as home ranges. Over the years, I learned that cows roamed over about 25 square miles, the bulls probably much more. I decided to install a radio transmitter on one animal and track its movement over a period of several weeks. More easily said than done!

With the support of the capture unit of the Kenyan Game Department and an electronics specialist from the University of Nairobi, I set forth with drugs and dart gun. Selecting a young female, we worked to within 50 yards and fired the gun at her rump.

Ten minutes later the giraffe was reeling drunkenly, towing 12 of us at the end of a rope! We managed to snub the lasso around a stump to stop her—momentarily. As we watched, tension grew on the rope, and on our nerves. With a twang, the stump pulled loose, showering us with termites. Finally

youngsters live together under the watchful eye of an adult female, who will rotate her baby-sitting chores with other female volunteers of the herd.



Death comes on cats' paws to a baby giraffe (**above**), only an hour after its birth and jolting five-foot drop to the ground (**left**). Too late, the mother futilely tries to protect her dead baby (**right**).

Lions and man are the chief predators of the gentle but well-armed giraffe, whose hooves can become lethal weapons. Kicking in all four directions, they are capable of decapitating a lion. Hunting for food, the big cats probably bring down only solitary bulls, individuals in vulnerable splay-legged stances, or the very young. Man, on the other hand, has taken a cruel toll of giraffe populations since earliest times, seeking their tasty meat, their tails for fly whisks, their thick, tough hide for sandals and drumheads. Today most giraffes range national parks, where they are somewhat protected from poachers. But certain subspecies, such as the Rothschild's giraffe, inhabiting private lands and competing for space with farmers, are still in great danger (pages 419-21).

ALL BY GERALD HILLING

a second loop around a hind leg brought the drowsy but determined cow to the ground.

We made a note to increase the dose of tranquilizer next time.

Many hands held up her neck so that food from her stomach would not find its way into her lungs. Quickly we fixed the transmitter collar around her neck, spray-painted her sides a bright pink, and injected the antidote to the drug. She roused, got to her feet, and walked off unsteadily.

Next day we drove to the park's highest hill and swept the horizon with our directional antenna. We caught a faint "beep-beep" from the southwest. My binoculars located the pink-flanked giraffe feeding with a pair of others in a valley two miles away. Completely recovered from the drug, she seemed oblivious of her new adornments.

Keeping track of this young cow over a period of several weeks, we found to our surprise that she spent about half her time outside the park boundaries.

Numbers in Precarious Balance

Throughout East Africa, giraffe populations vary widely, depending on habitat and human pressure. In Nairobi Park the number of animals averaged out to 86—about two per square mile—over the span of my three-year study. I think that's a fair figure for the density throughout the African gamelands, although on the Serengeti Plain only about 6,000 giraffes live in 5,000 square miles.

Our study strengthened the evidence supporting extension of Nairobi Park to include part of the vast Athi-Kapiti Plains lying to the south, to which many of the game animals stray at will. Certainly the present park is near the limit both of its animal and human-visitor capacity.

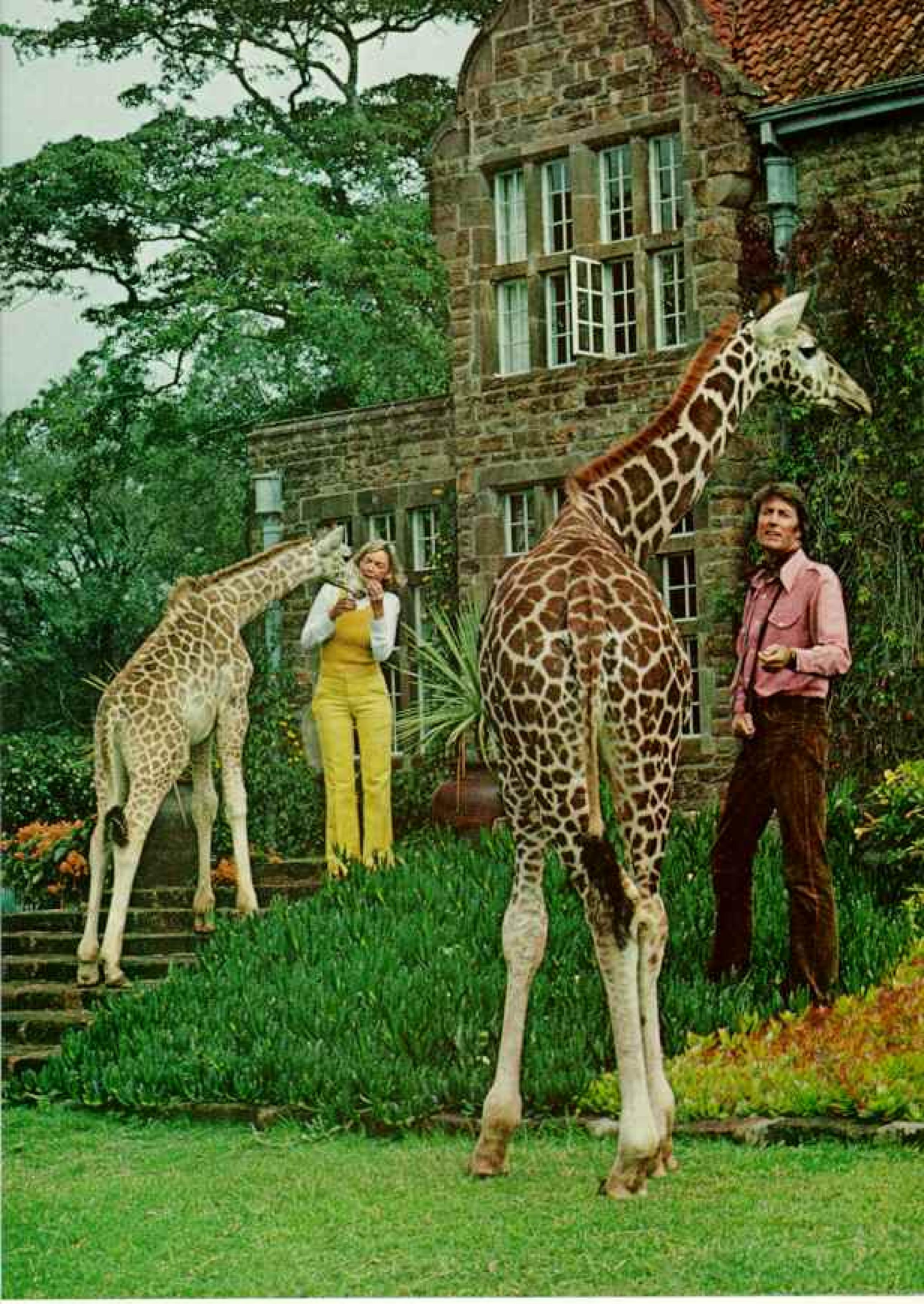
Each year of study reinforced my admiration for the giraffe. Like other big mammals of the African plains, *Giraffa camelopardalis* is the end result of many millions of years of evolution. Marvelously adapted to its environment, the giraffe is highly efficient as a converter of plants into protein. Its balanced birth and death rates help to ensure survival; while giraffes possess powerful weapons of offense and defense, they rarely do damage to one another.

One could wish that *Homo sapiens* might emulate these traits. □

"Necking" males spar for feminine

THOMAS NEBBIA

favor. Using blunt horns, two rivals seek dominance by butting each other.



MARION GORDON

Rescuing the Rothschild

BETTY STANDS on the terrace, eyes sweeping the broad green lawn, the lake, and, beyond, the virgin forest near Nairobi. On the horizon the snows of Mount Kilimanjaro hang in the sky like a shining cloud. Then she calls: "Marlon! Daisy! Where are you?"

Her husband, Jock Leslie Melville, joins her. They make a handsome, undeniably human couple. Few would suspect they have other identities: loving "mothers" of 7½- and 10-foot-high youngsters. Marlon, 4 months old, and Daisy, 11 months, belong to an endangered East African subspecies known as the Rothschild's giraffe, named after eminent English zoologist and financier Lionel Walter Rothschild. The calves have been adopted by the Leslie Melvilles in the hope they will eventually breed.

Suddenly, at the forest's edge, the giraffes appear on the run, taking long strides in slow-motion grace.

Marlon climbs the terrace steps to Betty and stretches his neck for a kiss on the nose. His long tongue reaches for her thumb, which he begins to suck happily.

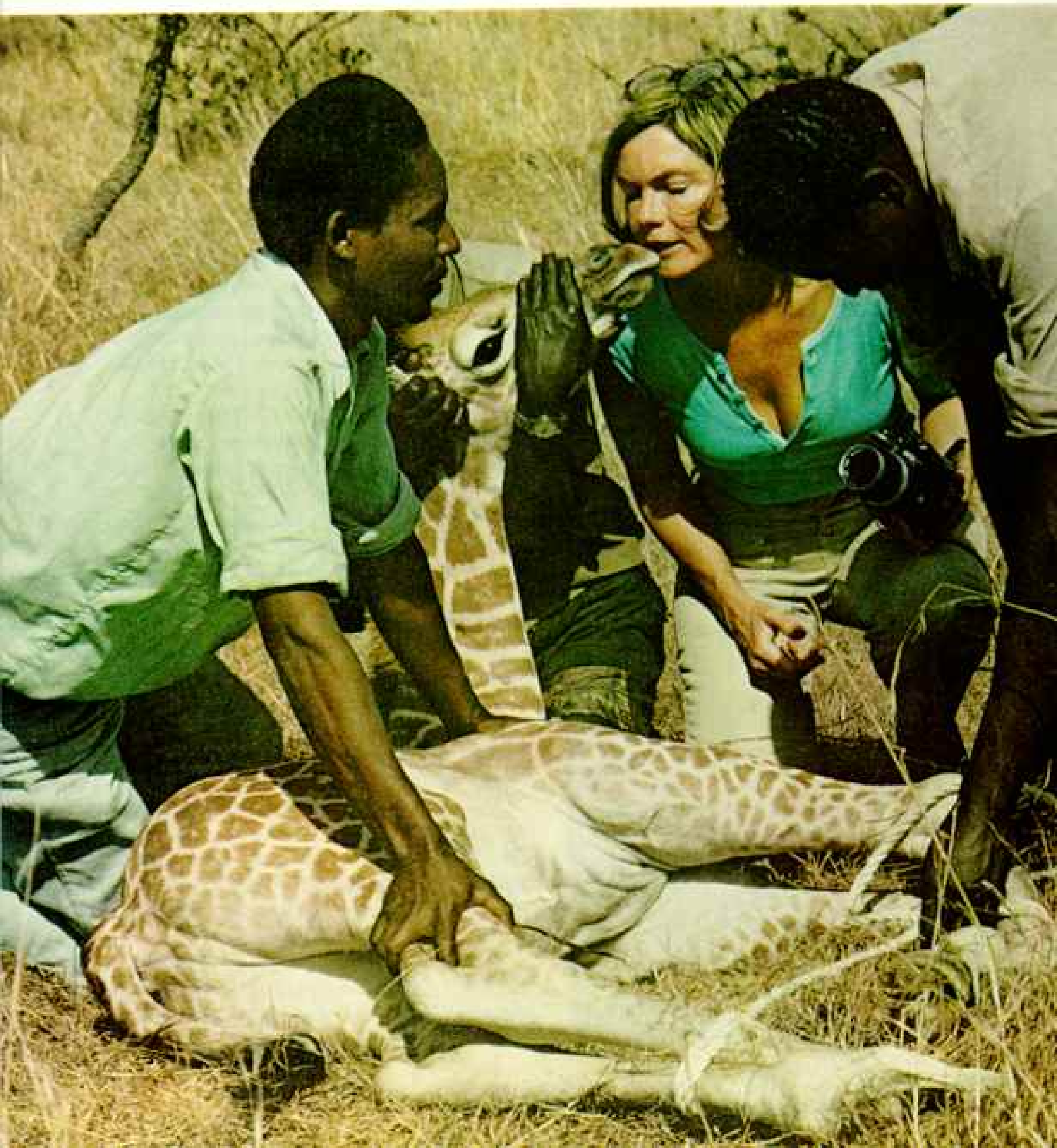
Daisy stops before Jock, clearly delighted to see him.

Adopted as infants, the giraffes imprinted on the Leslie Melvilles, considering them their mothers. "But now," says Jock, "Betty also thinks she's Marlon's mother!"

TO SAVE a Rothschild, or any other kind of wild giraffe, the trick is to catch it first. For both Marion, grounded and tied (**below**), and Daisy, boarding a minibus for the trip to her new home (**below, right**), the trials and terrors were the same.

Ranging a private ranch that is scheduled for subdivision and settlement, the last remaining Rothschilds in Kenya, a herd of some 150, gave up the youngsters only after a struggle. Spooked by a horseman swinging a rope, a band of the giraffes put their youngsters ahead of them and fled, galloping across marshy terrain mined with ant-bear holes.

For Daisy the chase covered three miles at breakneck speed. When brought down, she fought furiously, thrashing out at her captors with four-way kicks. Finally they tied her legs but carefully held her head high, since blood vessels might burst if it were lower than her heart for more than a few minutes. During the 225-mile trip



to the Leslie Melvilles' home, Daisy rode in the minibus with her legs folded under her.

Showered with affection, Daisy and Marlon soon adjusted to life with their human mothers and other members of the family—Quicksilver the horse, Shirley Brown the Labrador retriever, Walter the warthog, and Tom, Dick, and Harry, three wild giraffes of the Masai subspecies, which frequently sleep on the lawn.

On the other hand Betty and Jock's long-necked "children" have so pleased them that they have resolved to help Kenya rescue all the young Rothschild's giraffes. Staging an enormous "Giraffe Ball" at their home, the couple raised $6,000 toward relocating them.

Now they are promoting funds to buy the neighboring forest, fence it, and establish an endangered-species sanctuary, where the Rothschilds and other rare animals of East Africa can live in safety.

CAROLYN BENNETT PATTERSON

MARION GORDON (LEFT) AND BETTY LESLIE MELVILLE

MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD UNIVERSITY

Golden Window on the Past

A PICTURE STORY BY
PAUL A. ZAHL, Ph.D.

ONE DAY some 40 million years ago, when dense subtropical forests covered the northern continents and mammals were just beginning to flourish, a young grasshopper landed on a coniferous tree. Shortly the insect found itself mired in soft, gluey resin. Unable to escape, the grasshopper died, and the resin enveloped its body as if a lid had been placed over a grave.

And what a wondrous tomb this resin proved to be. Hardened, it dropped to the ground and eventually became buried. Finally unearthed on the shores of the Baltic Sea some 100 years ago, the rocklike bit of resin still guarded a treasure for all to see—the same half-inch-long prehistoric grasshopper (**left**).

The fabulous embalmer is amber, the common term for fossil resin. Hundreds of long-extinct species of insects and plants have been found perfectly preserved within its depths. Gemlike in its rich shades of yellow, orange, brown, and even blue, and found across the world, amber has been used for decoration since the Stone Age. Yet perhaps its greatest value has surfaced only in the past century. With the study of amber inclusions, scientists can now learn about the flora and fauna of an ancient forest—a realm once largely known only in the imagination.

IT IS NOT SURPRISING that early man regarded amber as something extraordinary. This lustrous fossil resin is warm to the touch, not cool like a mineral. It is often transparent and resembles a gem, yet it burns like wood, frequently giving off a piny scent. When rubbed against woolen or silk cloth, amber becomes charged with electricity. The classical Greeks called it *electron*, a root from which we derive the word "electricity."

Captivated by its beauty and its seemingly magical properties, the ancients developed romantic theories of its origin. Some thought it solidified sunshine, others believed it was the petrified tears of gods. Not until A.D. 77, when the Roman author Pliny made public his *Historia Naturalis*, was amber scientifically described as a product of the plant world.

Stone Age graves in Europe indicate that numerous tribes, obviously in awe of amber's unusual properties, wore pieces of it as amulets to ward off evil spirits. At the Colosseum in Rome, superstitious gladiators fought in clothing studded with amber. The talisman was even used to make spindles for spinning, since spirits were thought to place hexes on thread.

In the Roman Empire, amber was also valued for alleged medicinal qualities. It was hung around the neck to prevent tonsillitis, fever, and other ailments. Ground up with honey and rose oil, it was said to combat ear infections and poor eyesight. Even as late as the 19th century, European doctors prescribed ointment made from amber as a salve for wounds.

Yet the most celebrated quality of amber has been its beauty. Beads, pendants, and figurines carved from amber have turned up in graves dating from 8000 B.C. in northern Europe—placing amber among the early substances used by man for ornamentation. The ancient trade routes of Europe carried large amounts of this unusual commodity, which was esteemed to be as precious as

NATIONAL GEOGRAPHIC PHOTOGRAPHER BRUCE DALE

gold and was bartered extensively for iron, copper, and bronze. Pliny reports that a small carved figure of amber was worth more in the marketplace than a slave. During the Middle Ages guilds of amber artisans sprang up in Europe, supplying finely crafted rosaries, chalices, and crucifixes of Baltic amber.

Quality amber in modern times is reserved primarily for jewelry and such items as pipe stems and cigarette holders. A clear necklace will bring at least $150 in jewelry stores in the United States. Value multiplies with inclusions. Botanical debris highlights an expensive necklace (**facing page**) from the Dominican Republic. A mosquito-like crane fly graces a brooch (**below**) fashioned from Baltic amber by an artisan in Lithuania.

Amber deposits occur wherever resin-producing trees grew. Much of the amber found thus far dates from the Oligocene Epoch of the Tertiary Period, some 40 million years ago.

The most significant and seemingly inexhaustible deposit of quality amber lies along the southeastern shores of the Baltic Sea, near great stretches of conifers and other resin-producing trees. It has been reported that between 1885 and 1914 a million pounds of this "gold from the north" was mined annually in the area around what is now Kaliningrad in the Soviet Union.

In an attempt to account for such a vast lode of amber in the Baltic area, scientists theorized that a disease sweeping through the forests caused the trees to bleed enormous amounts of resin. According to recent studies, however, similar trees in New Zealand exude huge quantities of resin under natural conditions.

After World War II, the Soviets closed the Kaliningrad area. Scant information is thus available on mining activity. Baltic amber, nonetheless, still filters into the Western market, and recent workings of deposits in the Dominican Republic seem to promise a plentiful supply of the organic "gem."

FAMILY TIPULIDAE (above); NATIONAL GEOGRAPHIC PHOTOGRAPHER DEAN CONGER

DISPLAY CASE of ancient insect life, amber preserves species that show little difference from the creatures inhabiting forests today. Related to the common housefly, a fossil fly retains its pigment in a piece of nearly colorless amber (**left**). The air bubbles probably escaped from its respiratory tissues. With a wing askew, a termite (**below**) reveals that it was probably flying when it landed on the trap of sticky resin. The amber's redness is exaggerated by conditions created by the film and lighting.

Many of the entombed insects exhibit poses of struggle, such as a praying mantis (**bottom right**), whose body appears grotesquely jackknifed. Unlike the mantis, a spider (**right**) kept all its legs. These amber pieces came from the Dominican Republic, where about one out of a hundred contains inclusions.

ORDER ISOPTERA, 6 X

ORDER ARANEAE, 8 1/2 X (ABOVE); ORDER MANTODEA, 3 X

Amber: Golden Window on the Past

SCOURING A MOUNTAINSIDE, miners (**below**) search for amber in the damp northern highlands of the Dominican Republic. The bright, translucent fossil resin lies embedded in sandstone (**far right**), in chunks ranging from an inch across to a size larger than a man's fist (**middle**). Because of the brittle nature of amber, miners work cautiously with shovel and pick, avoiding dynamite or bulldozers.

Unlike Baltic amber, which is found in easily mined shoreline deposits and sometimes even washes up on beaches, the Dominican supply is located in rugged, nearly inaccessible country. Only in the past 40 years have miners worked these fields. When Christopher Columbus landed in what is now the Dominican Republic on his first voyage to the New World, it was he who presented as a gift to a young Carib chieftain a string of shiny amber beads. Now the Dominican deposits rate as the most productive in the Western Hemisphere. Today crude amber, which brings from

six to as much as forty dollars a pound, goes primarily to Santo Domingo, where practiced jewelers fashion lumps into ornaments. First the jeweler shaves off the crust with an emery wheel, then shapes the piece to accent inclusions (**middle right**). Last, he polishes it with a cloth wheel.

Among the rarest finds is "blue" amber (**bottom**), shown approximately actual size, which perhaps derives its color from fluorescence created by a peculiar chemical composition.

MARTIN ROGERS (ABOVE, BELOW LEFT, AND FACING PAGE)

IMMUNE TO TIME in its amber casket, a primitive wasplike ant (**upper left**) goes back some 100 million years, making it the oldest ant known to man. Dinosaurs still lumbered across the earth when this half-inch-long example of the species *Sphecomyrma freyi* became imprisoned in resin. The hardened substance was buried until 1966, when two rock collectors uncovered the treasure in a New Jersey clay formation.

Scientists hail the insect, now in Harvard University's Department of Fossil Insects, as an important link in the evolution of ants. Though the specimen exhibits certain wasplike characteristics, the structure of the thorax and

FRANK W. CARPENTER, MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD UNIVERSITY (ABOVE AND BELOW); © R

UNDER ARANEAE; © R

abdomen qualifies it as a primitive worker ant. This leads experts to believe that by the Cretaceous Period ants had established their caste system of social organization.

Ants and flies appear most frequently in amber. Insects larger than two inches are rarely seen. Judged a relatively scarce find, a spider slightly larger than a pinhead (**lower left**) was found in south-central Arkansas, site of a widely studied deposit in the United States.

Heavenly bodies also seem to appear in amber. Inside a Dominican Republic piece, two "Saturns" and their orbiting "moons" inhabit a fiery atmosphere (**below**)—actually air bubbles and internal fractures.

FAMILY LEGUMINOSAE, 3.8

KALEIDOSCOPE OF CHANGING LIGHT reveals fossil leaf fragments inside a piece of honey-colored Dominican amber. Lighted on the side (**above**), the amber fluoresces green. The leaves have been partially

camouflaged by internal fractures and smaller debris. Backlighting throws the fragments into sharp relief as the amber burns yellow as the sun (**above**). The leaves fell from a tropical hardwood tree, perhaps the one that dripped the resin.

A BOTANICAL GARDEN at first glance, the inclusion below proves to be elaborate air bubbles. Apparently a tiny crack developed in an already solidified lump of resin; fresh, sticky resin then began to fill the narrow crevice. Air also crept along the fracture plane, thus forming the array of mosslike pseudo-fossils. Some foreign substance—perhaps iron oxide—colored several of the lacy bubbles.

Studying entrapped plant remains, scientists list ferns, leaves, bark, grass, and flowers like a blossom from the Dominican Republic (**upper right**), perhaps related to the pokeweed.

Such is the clarity of good amber and the state of its inclusions that under magnification the veins of a leaf may still be read like a map (**bottom right**).

Progress is slow in science's effort to learn more about ancient subtropical forests. A great collection of Baltic amber held in Germany was scattered during World War II, and most of the quality Dominican pieces escape scientific eyes on their way to profitable jewelry markets.

But it was ever thus. As the Roman poet Martial wrote in his *Epigrams:*

A drop of amber, from the
weeping plant,
Fell unexpected, and
embalm'd an ant;
The little insect
we so much condemn
Is, from a worthless ant,
become a gem.

TEXT BY THOMAS J. O'NEILL

19 X

FAMILY PHYTOLACCACEAE, 10 X

22 X

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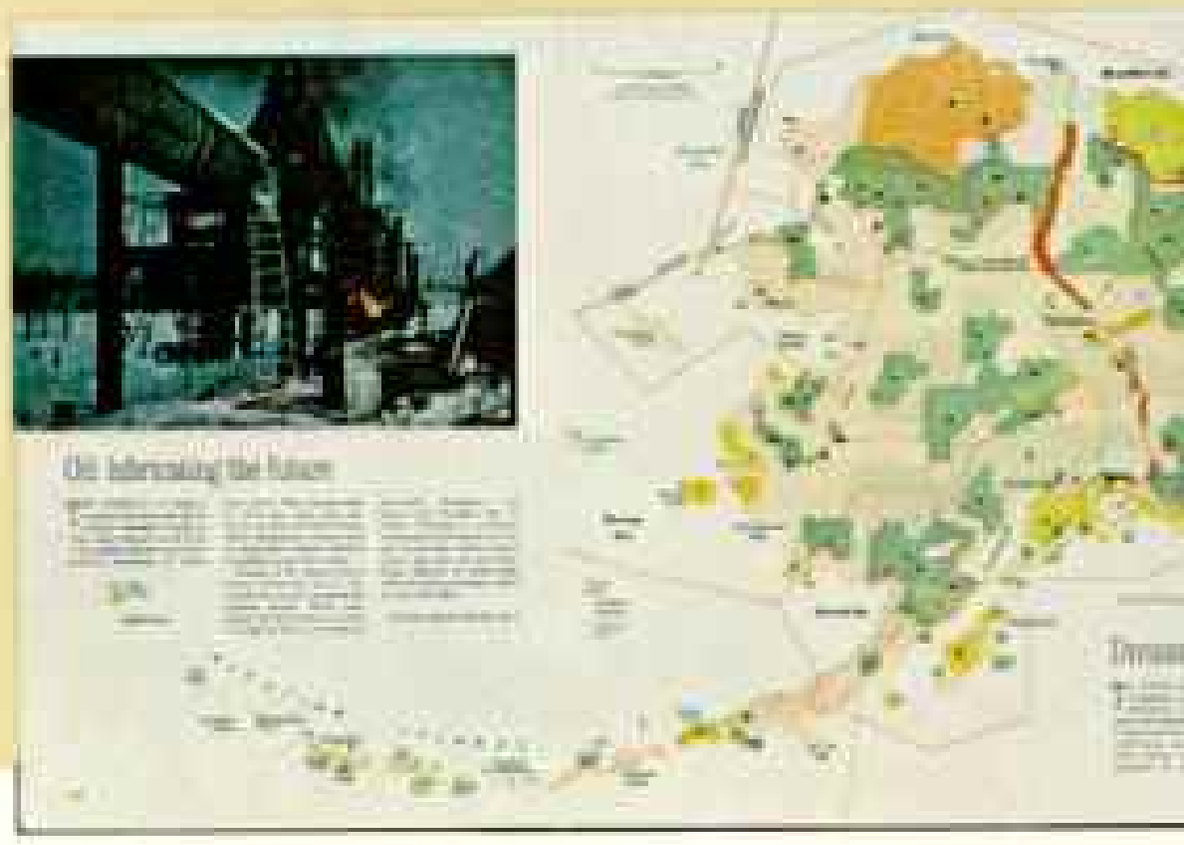

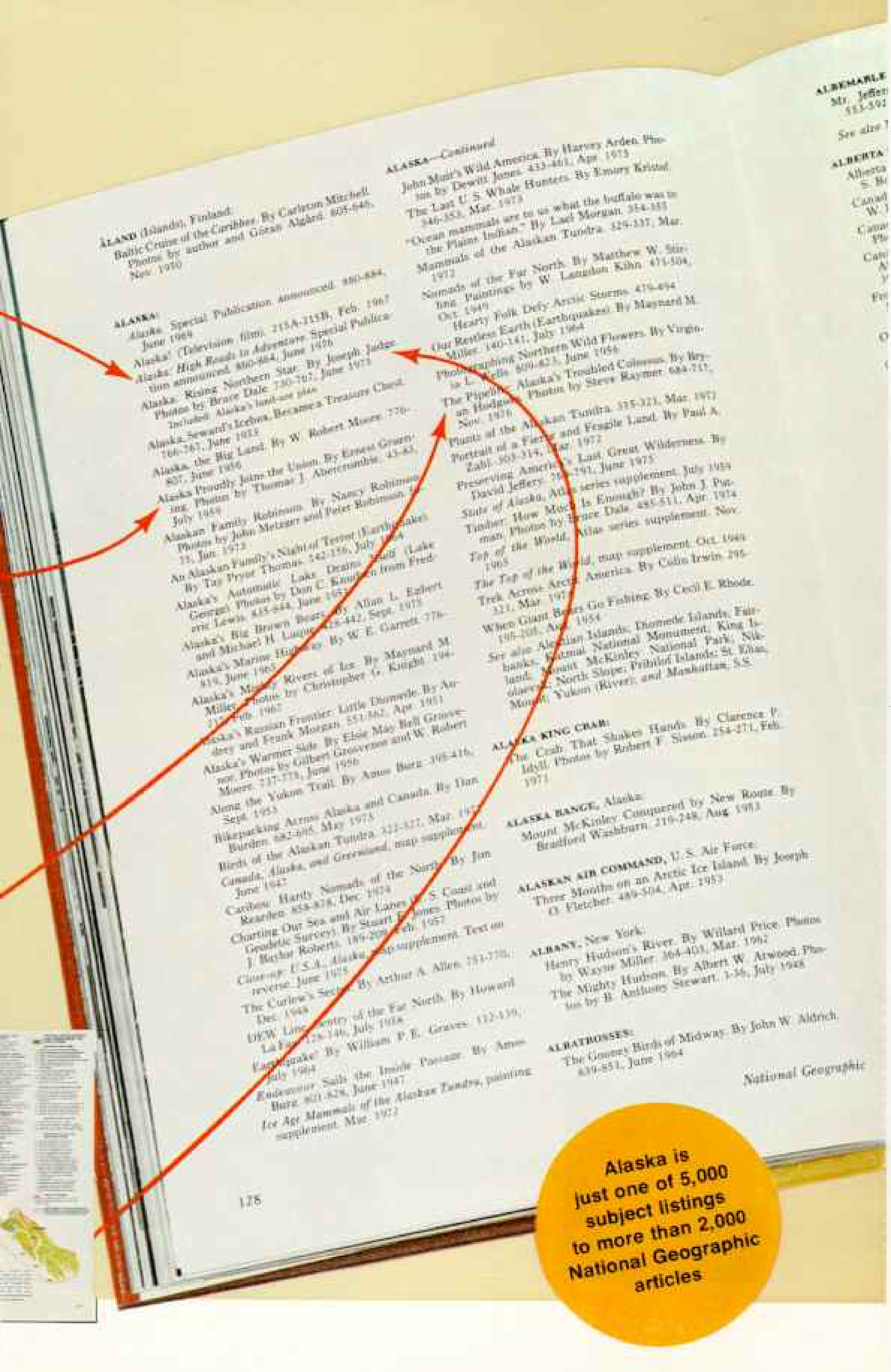

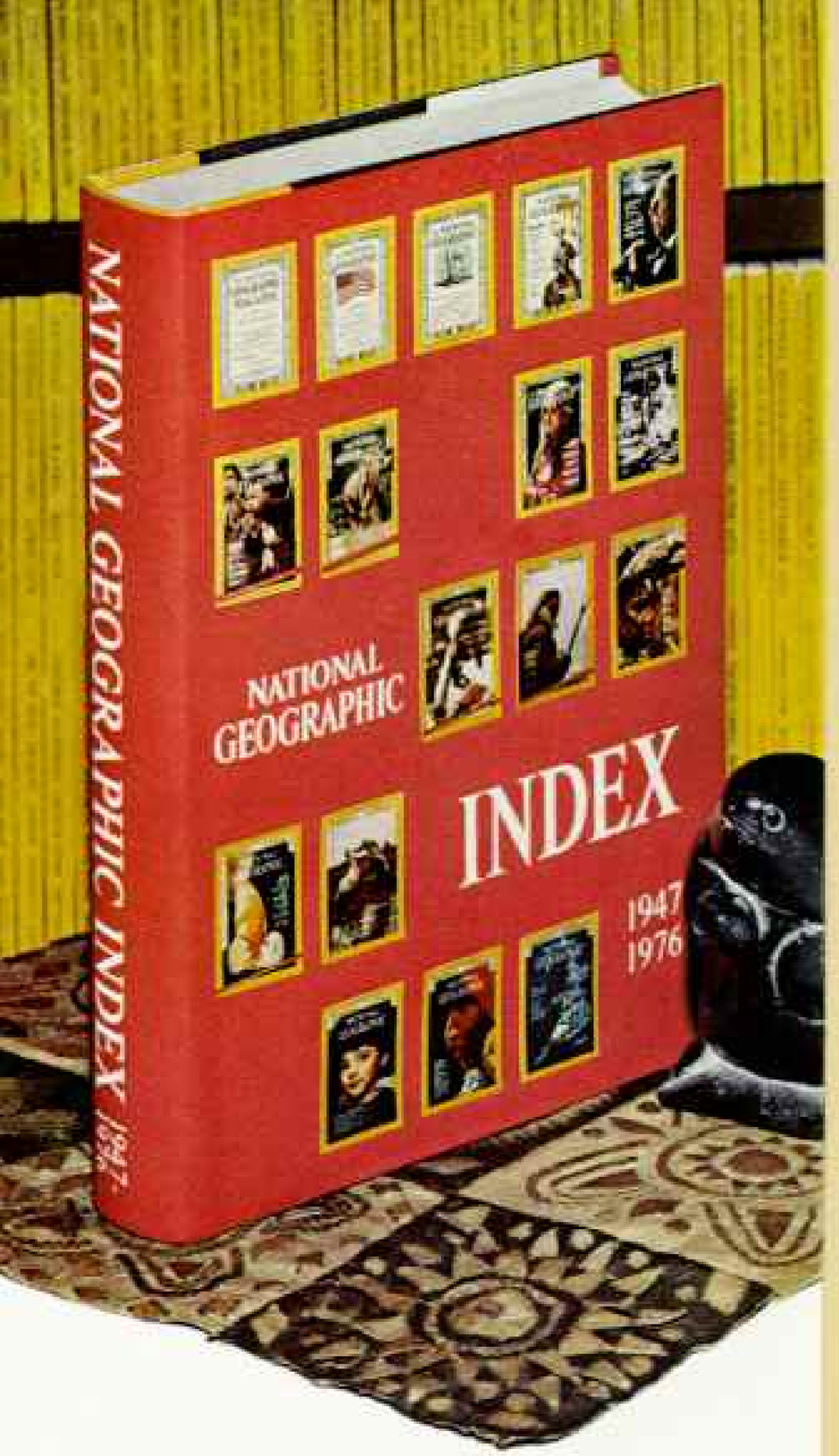

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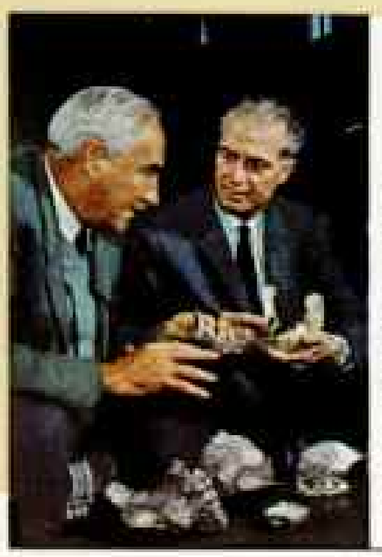

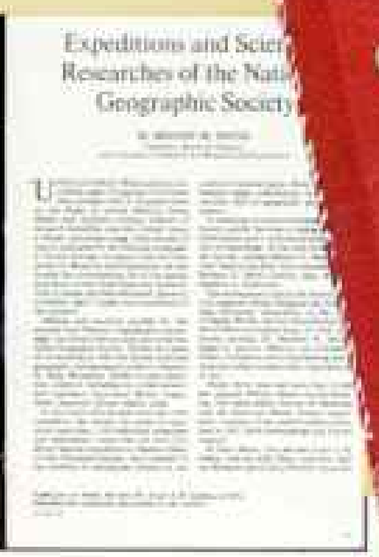

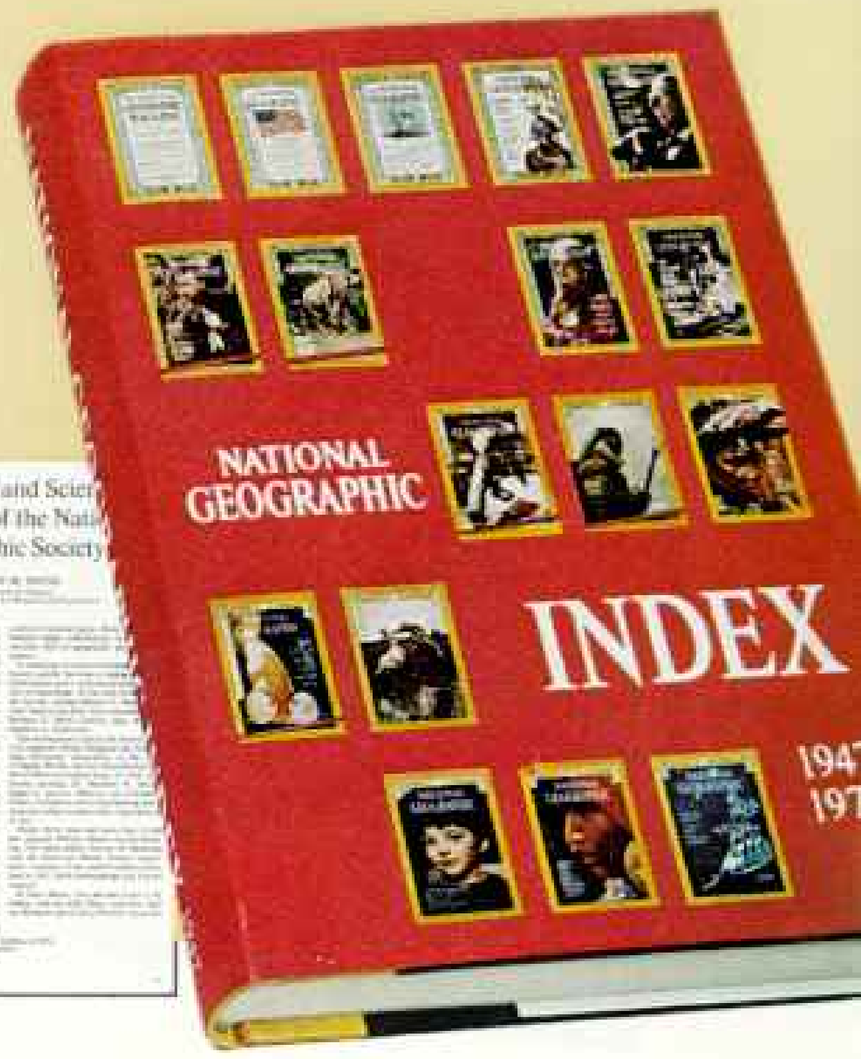

NATIONAL GEOGRAPHIC SOCIETY

WASHINGTON, D. C.

Organized "for the increase and diffusion of geographic knowledge"

GILBERT HOVEY GROSVENOR
Editor, 1899-1954; President, 1920-1954
Chairman of the Board, 1954-1966

THE NATIONAL GEOGRAPHIC SOCIETY is chartered in Washington, D. C., in accordance with the laws of the United States, as a nonprofit scientific and educational organization for increasing and diffusing geographic knowledge and promoting research and exploration. Since 1890 the Society has supported 1,442 explorations and research projects, adding immeasurably to man's knowledge of earth, sea, and sky. It diffuses this knowledge through its monthly journal, NATIONAL GEOGRAPHIC; supplement maps distributed to members; its books, globes, atlases, filmstrips, and educational films; *National Geographic WORLD*, a magazine for children age 8 and older; information services to press, radio, and television; technical reports; exhibits from around the world in Explorers Hall; and a nationwide series of programs on television.

Articles and photographs of travel, natural history, and expeditions to far places are desired. For material used, generous remuneration is made.

NATIONAL GEOGRAPHIC MAGAZINE

POSTMASTER: Send change of address form 3579 to National Geographic, 17th and M Sts. N.W., Washington, D. C. 20036.

"Solar energy is our most abundant source."

"Solar power is undeveloped, expensive."

Solar energy: a practical reality, an expensive dream? Which?

To some, solar energy looks ideal. Clean. Nonpolluting. Inexhaustible. Available almost everywhere. Enough sunlight falls on New York State in one day to power the U.S. for a week. Already over 200 homes, nationwide, heat with it or soon will. Installations are planned for schools, hospitals and office buildings. Solar use is new, appealing.

Others remind us that solar energy is not cheap. Sunshine may be free, but the systems needed to convert it to useful work are cumbersome and expensive. The collector system for an average home could cover the entire roof and cost 20 times more than a conventional furnace. And a furnace is still needed for cloudy weather.

Forget solar power? Definitely not. Today's biggest energy sources, oil and natural gas, simply won't last forever. New supplies are harder to find. Domestic reserves are dwindling. The National Energy Information Center says we have about 12 years supply of oil and natural gas at 1975 production rates. We're importing oil at an unprecedented rate.

We must manage our energy resources to ease pressure on petroleum products. It will take a realistic, definitive national energy policy to do it. That policy should blueprint rights and responsibilities of consumers, producers and government. It should encourage these bodies to develop and use all energy resources wisely for long-term economic and environmental well-being of the nation.

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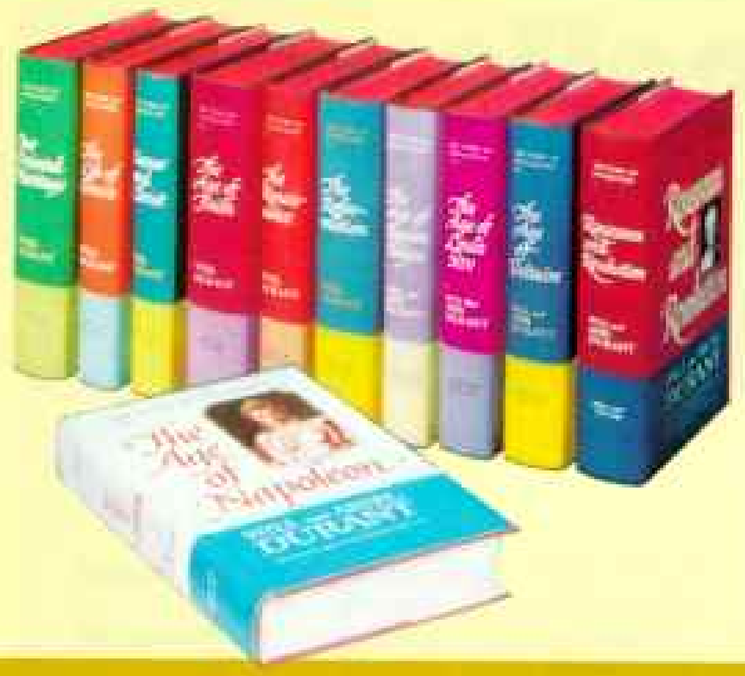

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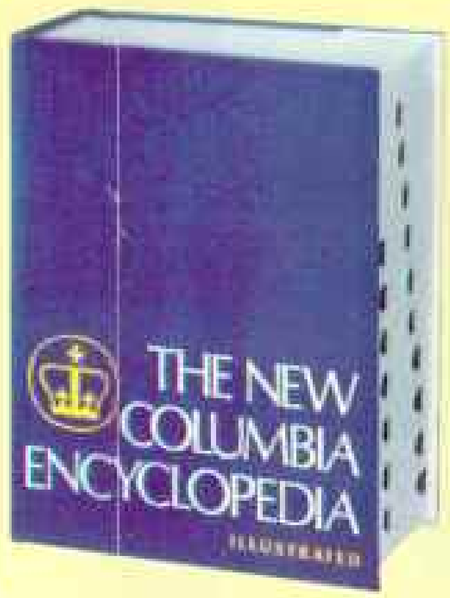

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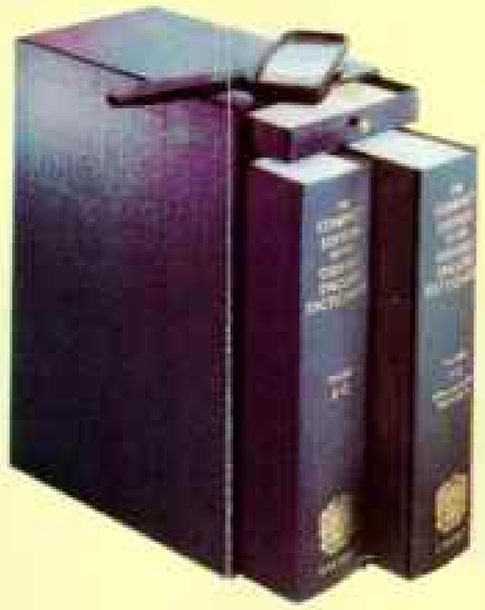

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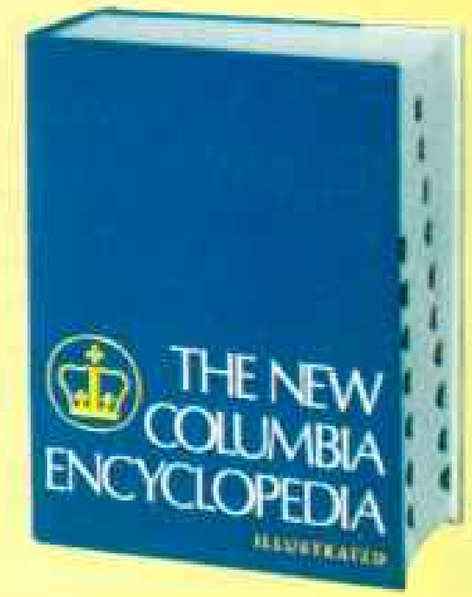

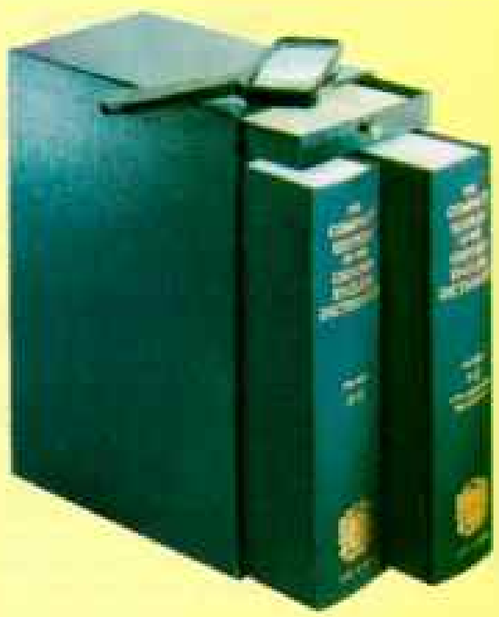

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TIMOTHY W. CLARK (ABOVE); DENISE E. CASEY

Helping an embattled predator

FISTFUL OF FURY greets Dr. Timothy W. Clark of Idaho State University during fieldwork in Grand Teton National Park, where he studies the behavior and population dynamics of the pine marten. A cousin of the highly coveted European sable, with a keen appetite for small rodents, the marten is now a rare and endangered species throughout wide areas of its former range. A long history of trapping and human encroachment on the wilderness has led to its decline.

Supported by a National Geographic Society grant in this and other studies, Dr. Clark has devoted much of his career to a better understanding of our vanishing wildlife. You can support such valuable research by nominating your friends for membership on the form below.

NATIONAL GEOGRAPHIC SOCIETY MEMBERSHIP

$8.50 CALENDAR YEAR 1978 MEMBERSHIP DUES INCLUDE SUBSCRIPTION TO THE NATIONAL GEOGRAPHIC

ANNUAL DUES in the United States and throughout the world are $8.50 U.S. funds or equivalent. To compensate for additional postage and handling for mailing magazine outside the U.S.A. and its outlying areas, please remit for Canada, $11.00 Canadian or $10.45 U.S.; for the British Isles, Australia, and New Zealand, $12.80; for all other countries, $12.35 by U.S. bank draft or international money order. Eighty percent of dues is designated for magazine subscription. Annual membership starts with the January issue.

EIGHTEEN-MONTH MEMBERSHIP. Applicants who prefer delivery of their NATIONAL GEOGRAPHIC to start with the July 1977 instead of the January 1978 issue may upon request become members and receive the magazine for 18 months from July 1, 1977, through December 1978. Upon expiration, such memberships will be renewable annually on a calendar-year basis. For 18-month membership check here ☐ and remit: for U.S. and its outlying areas, $12.75 U.S. funds or equivalent; for Canada, $16.53 Canadian or $15.70 U.S.; for the British Isles, Australia, and New Zealand, $19.20; for all other countries, $18.55 by U.S. bank draft or international money order.

LIFE MEMBERSHIP is available to persons 10 years of age or older. The fee for U.S. (including its outlying areas) is $200 U.S. funds or equivalent; for Canada, $210 Canadian funds ($200 U.S. acceptable); for all other countries, $250 by U.S. bank draft or international money order.

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National Geographic Society
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Number Four in the Involved American Series from Atlantic Richfield Company.

I live in my car. I drive it everywhere. But this week I'm leaving it home.

There's nothing wrong with my car. But rush hour traffic keeps getting worse and the cost of driving keeps going up. So last week I made a decision. Leave my car in the garage for a week and give public transportation a chance. After all, I'm the public.

It's been an experience. Instead of watching the brake lights of the car in front of me, I get to look at some scenery for a change. Or read a newspaper. Or just relax and not think about anything. And besides, I save gas and tolls and parking.

Is public transportation perfect? No. But it could be a lot better if people like you and me would get out there and support it. And while we're at it, we could cut down pollution and save a lot of wasted energy.

Why not leave your car home for a week. Give public transportation a chance. If you're not happy with the way it works where you are, sound off to your representatives in Congress and local government. If it does work for you, use it whenever you can.

Atlantic Richfield Company believes one of our national goals must be to achieve public transportation systems equal to the needs of every city. Every town. Give public transportation a chance. Then when you have the opportunity of expressing your opinion on this issue, we hope you will. Be an involved American. Consider the facts. Take a stand. Get involved.

For a booklet with more information on this issue, please write: Atlantic Richfield Company, Public Transportation, P.O. Box 30169, Los Angeles, CA 90030.

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These delicious, sugar-toasted puffs of wheat are fortified with eight important vitamins and iron.

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SERVINGS PER CONTAINER: 12

	SUGAR SMACKS	
	1 OZ	WITH ½ CUP WHOLE MILK
CALORIES	110	190
PROTEIN	2 g	6 g
CARBOHYDRATES	25 g	31 g
FAT	0 g	5 g

PERCENTAGE OF U.S. RECOMMENDED DAILY ALLOWANCE (U.S. RDA)

	SUGAR SMACKS	
	1 OZ	WITH ½ CUP WHOLE MILK
PROTEIN	4	15
VITAMIN A	25	30
VITAMIN C	25	25
THIAMIN	25	25
RIBOFLAVIN	25	25
NIACIN	25	25
CALCIUM	*	15
IRON	10	10
VITAMIN D	10	25
VITAMIN B_6	25	25
FOLIC ACID	25	25
PHOSPHORUS	4	10
MAGNESIUM	4	8

*CONTAINS LESS THAN 2 PERCENT OF THE U.S. RDA OF THIS NUTRIENT.

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MADE BY KELLOGG COMPANY
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CARBOHYDRATE INFORMATION

	SUGAR SMACKS	
	1 OZ	WITH ½ CUP WHOLE MILK
STARCH AND RELATED CARBOHYDRATES	9 g	9 g
SUCROSE AND OTHER SUGARS	16 g	22 g
TOTAL CARBOHYDRATES	25 g	31 g

VALUES BY FORMULATION AND ANALYSIS

THIS PACKAGE IS SOLD BY WEIGHT, NOT VOLUME. SOME SETTLING OF CONTENTS MAY HAVE OCCURRED DURING SHIPMENT AND HANDLING.

If you have somebody under twelve years old around your house, you've probably seen Kellogg's® Sugar Smacks® cereal. They're crispy pre-sweetened puffs of wheat. And they're about as much fun to eat as a cereal can be.

But that's just for the kids' palates and funny bones. Sugar Smacks has plenty for their growing bodies, too. A one-ounce serving, exclusive of milk, contains 25% of the U.S. Recommended Daily Allowance for seven different vitamins, and 10% of the U.S. RDA for Vitamin D and iron.

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SUGAR SMACKS®

Thomas Edison, reminiscing in 1928, at age 81, is portrayed by actor Pat Hingle in a unique series of television commercials. One is reprinted here. You can see many of the others on upcoming GE television specials.

What was Thomas Edison's biggest blunder?

Here's what we think Edison himself would have said:

"Some people give me credit for being the man who put electricity to work in America. Not completely true.

A lot of people had a hand in it. Thomson. Tesla. Steinmetz.

Charley Steinmetz.

Queer-looking duck. Not even five feet tall. With an enormous head.

Inside that head, there was an enormous brain.

Shortly after he arrived in this country, Steinmetz came to work for General Electric.

Those were exciting times at GE. It was the beginning of the whole age of electricity. Some of the top scientists and engineers in the country were there. Ideas were bouncing around like marbles.

Steinmetz started working with alternating current. The kind of electricity we all use today.

I thought it was a fool idea.

I favored direct current. Of course, it couldn't be transmitted more than two miles. But I didn't see that as any real problem.

That was the biggest blunder of my life.

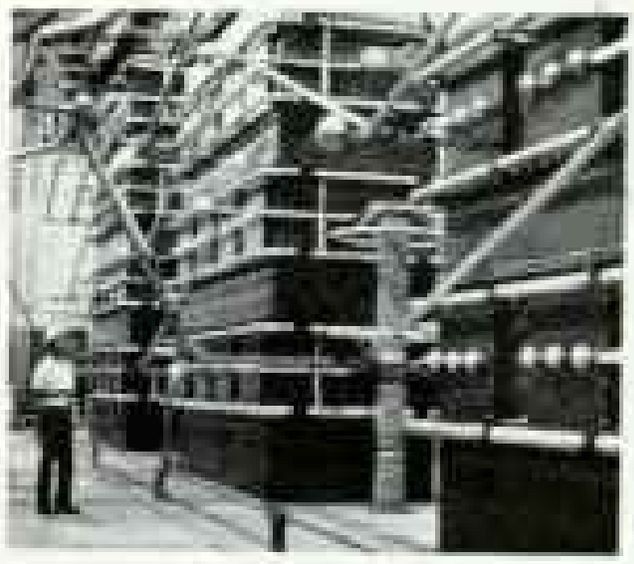
If people had listened to me then, we'd have power plants all over the country. Every two miles.

Well, Charley kept on working at it. Kept on calculating.

The big test came at Niagara Falls in 1894. GE built a transformer and strung a line to Buffalo. 26 miles away.

The switch was thrown at Niagara and the lights came on in Buffalo.

Steinmetz once told me he was almost refused admission at Ellis Island as an unfit immigrant. It's funny. One of the men most responsible for the electrification of America was almost turned away at its gate."



Edison may not have been wrong after all. New solid-state equipment and technology developed by General Electric make it possible to send direct current efficiently over great distances. It will soon be transmitted 450 miles from North Dakota to Duluth, Minn., over a line being built. In some cases, direct current may become the most economical way to transmit electricity.

Progress for People

GENERAL ELECTRIC

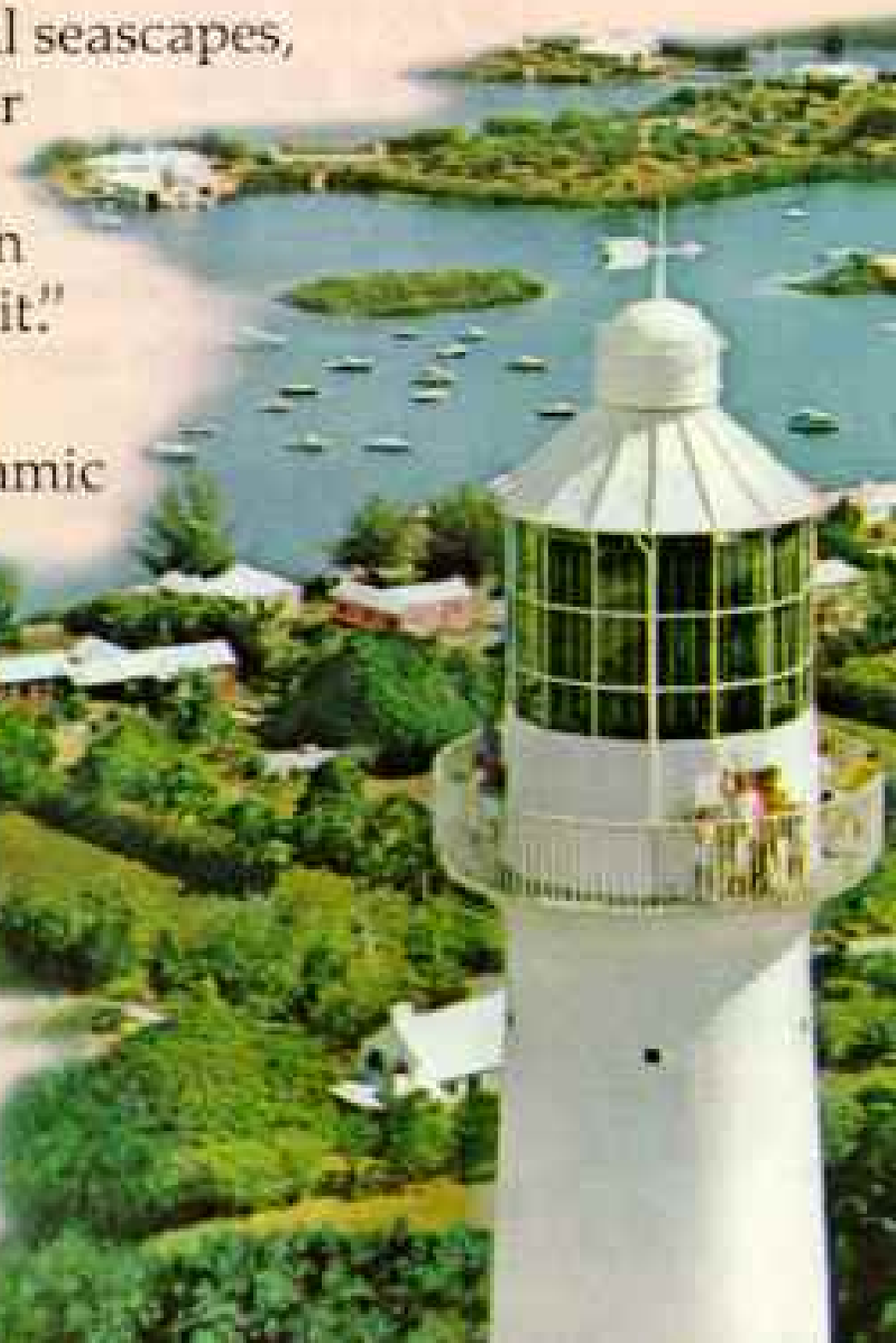
"There are so many ways of entertaining the children. They're so well behaved here, and we're so relaxed."

Mike and Mary Lee Hurley discuss their third visit to Bermuda.

"Tennis, golf, beautiful seascapes, sightseeing. Whatever your passion is, you don't have to go far in any direction to find it."

"We had a panoramic view of the entire island. The beauty is incredible."

"It's the people on this island. They're part of it. Very fine, very pleasant."



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GREAT AMERICAN SAILING SHIPS

A plate collection in china crafted by the Rosenthal Group

Actual size of plate 8¼" in diameter

The America

GREAT AMERICAN SAILING SHIPS

PLATE COLLECTION

Come, let your spirits soar! Watch the wind billow in the sails. Breathe the briny air . . . taste the anticipation of adventure. Voyage back with us to an era of discovery, excitement, and incomparable majesty — the era of the Great American Sailing Ships.

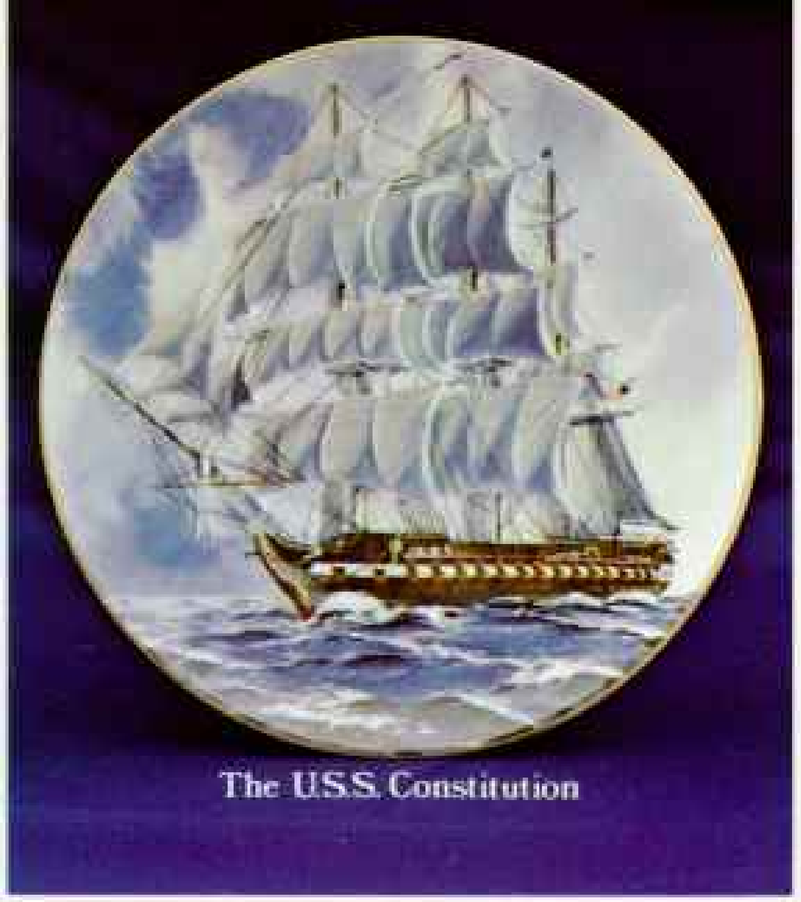
Here is where America's love affair with the sea begins — as our forefathers harness the forces of nature, master the elements, explore the unknown, dare the impossible. Today, who among us can behold the majesty of a ship at full sail and not be inspired?

Now, for the first time, twelve great American sailing ships are portrayed in a magnificent collection of china plates. The Danbury Mint is proud to announce the *Great American Sailing Ships Collection.*

A Major First Edition in Fine China by the Rosenthal Group

As befits the importance of this collection, the Danbury Mint has commissioned Rosenthal to produce each

Actual size of plate 8¾" in diameter


The U.S.S. Constitution

and every plate – to their exacting and uncompromising standard of excellence.

Since 1879, Rosenthal has produced the world's finest china – establishing china as a distinctive and beautiful art medium.

The *Great American Sailing Ships Collection* proceeds in the proud Rosenthal tradition. Time-honored craftsmanship is combined with the work of a major artist – to create a unique collection of enduring beauty. *The plates in this collection are the only plates of their kind in the entire world!*

Original Works of Art

Robert Devereaux, a distinguished American artist, has been commissioned to paint the original watercolors for this series. A lover of sailing history, he spent months creating art which is both authentic and strikingly original. His brilliant brushstrokes capture every subtle detail of each ship. The illustrations reproduced here can only hint at what has been achieved. When transformed onto fine china, these Devereaux originals are breathtaking!

A Limited Edition at a Guaranteed Price

This is the first series of fine china plates crafted by the Rosenthal Group for the Danbury Mint. For this reason alone, the plates will have exceptional collecting importance. Moreover, the *Great American Sailing Ships Collection* is being issued in a strictly limited edition. It is available only directly from the Danbury Mint. None of the plates will be available individually, and none will be sold in museums, galleries, or stores.

Reservations can be accepted only until October 31, 1977 and the edition is limited to one set per subscriber.

The original issue price of $35.00 per plate is guaranteed to each subscriber for the entire collection. Each subscriber will receive a numbered certificate of registration authenticating the status of the individual collection within the limited edition.

Guaranteed Satisfaction

Each plate will be individually handcrafted for each collector and will bear the famous "Crossed Roses and Crown" Coat of Arms of the Rosenthal Group. A band of 24kt. gold will be hand-applied to each plate, adding to the extraordinary richness of the entire collection.

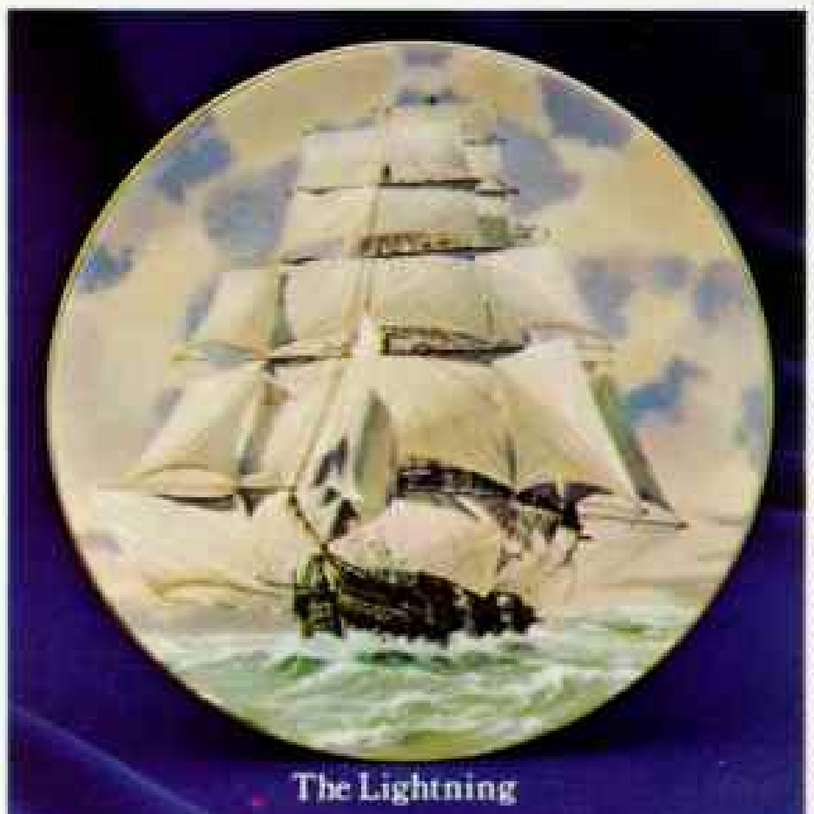
Before each plate is approved for shipment to a subscriber, it must pass the exacting standards of both the Rosenthal Group and the Danbury Mint. But should any plate fail to satisfy you, in any regard, you may return it within 30 days for replacement or refund. Naturally, you may cancel your subscription at any time. But once cancelled, a subscription cannot be reinstated and the opportunity to acquire a complete collection is lost.

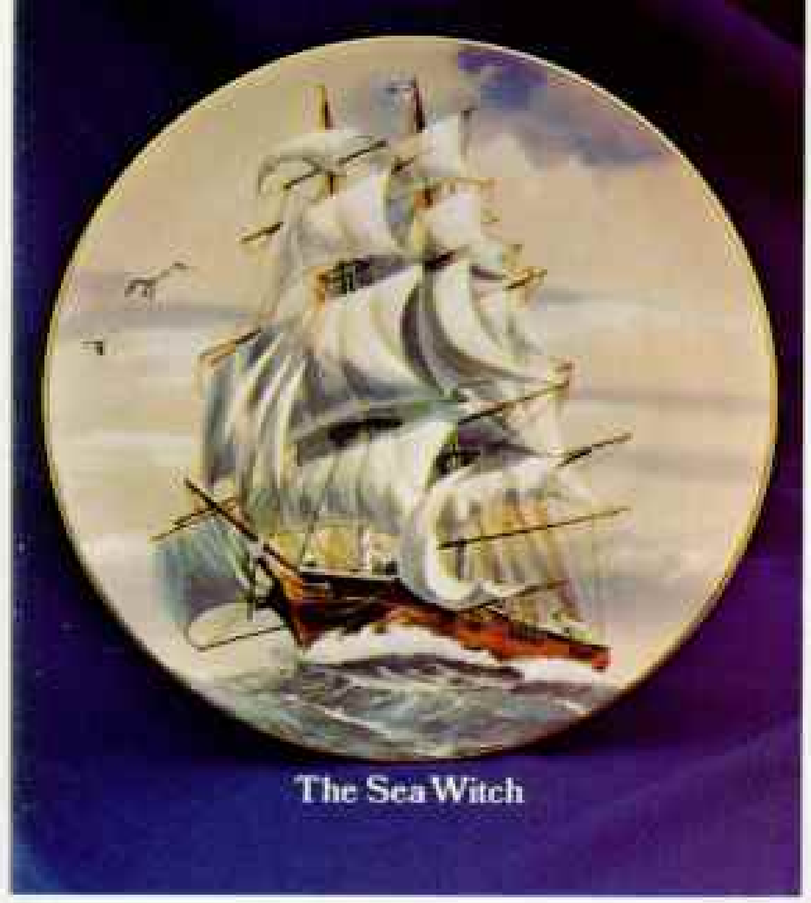
Convenient Acquisition Plan

To reserve your collection, no payment is required at this time. You will be billed for your first plate prior to shipment, then for each subsequent plate on a pre-shipment basis, every two months.

Prompt Action Needed

To acquire your personal collection of these fine china plates, be sure to mail the accompanying reservation application no later than October 31, 1977.


The Lightning


The Sea Witch

Preferred Reservation Application

The Danbury Mint
47 Richards Avenue
Norwalk, Conn. 06856

Must be postmarked by October 31, 1977
Limit: one set per subscriber

Please accept my subscription to *The Great American Sailing Ships Plate Collection.* I understand there will be 12 fine china plates in this limited edition series. The plates will be issued approximately one every two months at a guaranteed price of $35.00 per plate (plus $1.50 for shipping and handling costs).

I will be billed for the first plate prior to shipment and invoiced on a pre-shipment basis for each subsequent plate every two months thereafter. I may cancel this subscription at any time and any plate may be returned for a full refund if upon receipt I am not completely satisfied.

The method of payment I choose for my collection is (please check one):

☐ Charge each plate when it is shipped to my
☐ Master Charge ☐ Bank Americard

_____ _____
My credit card number is Expiration Date

☐ Bill me for each plate prior to shipment. I agree to pay promptly upon being invoiced.

Name _____

Address _____

City _____

State _____ Zip _____

Signature _____

HG

WHY MAZOLA? ASK YOUR DOCTOR.

More and more doctors these days are becoming concerned about the high-cholesterol food habits of Americans. So as part of a total meal program for your family, ask your doctor about Mazola® Corn Oil. It contains no cholesterol.

Recently, such a program was tested to reduce blood cholesterol. It included skim milk, lean meats, plenty of fruits and vegetables, and Mazola pure corn oil.

Result: blood cholesterol was reduced an average of 17 percent. Couldn't your family benefit from such a meal program? Mazola suggests you ask your doctor.

MAZOLA: THE ONLY LEADING BRAND THAT'S PURE CORN OIL

NOTE TO PHYSICIANS:
The complete report mentioned above was published in the "Journal of The American Dietetic Association" Volume 62, February 1973.

Best Foods, a Division of CPC International Inc.
CPC INTERNATIONAL

The thinking person's guide to slide projection.

It's exciting when you really get to enjoy the dramatic beauty of your own color slides. There's nothing like seeing them projected. Which is why you should consider one of the many Kodak Carousel projectors.

They treat your slides gently.

Every Kodak Carousel projector uses gentle, dependable gravity to drop each slide into place. All now come with the Kodak Carousel Transvue slide tray with illuminated slide numbers so you can always locate a slide, even in the dark. Kodak Transvue slide trays make slide storage easy, too.

Curved-field lens makes slides sharper.

Chances are your slides come to you in cardboard or plastic mounts. With these mounts, the film image curves slightly at the center. Which is why we have developed a series of curved-field projection lenses called Kodak projection Ektanar C lenses. They compensate for the film curvature.

Different controls for different requirements.

Kodak Carousel projectors are available in a variety of models. Many models offer remote control slide change—both forward and reverse. Some models give you automatic focusing; and some models even offer automatic slide changing at selected intervals.

Know what your future options can be.

Everything from special-purpose lenses, stack loaders and slide clips, to special "presentation aids" for slide-to-tape synchronization are available for use on most Kodak Carousel projectors. See them at your photo dealer's. The 600H shown is less than $115. Price is subject to change without notice.

Kodak Carousel projectors

Kodak

Model illustrated is new 20" #8621.

Turn foliage into fertilizer with a Bolens® Mulching Mower.™

Most lawn mowers can't cut it with leaves. But the Bolens Mulching Mower can. It mows, then mulches, a dry leaf cover into tiny, nutrient-rich particles. Then feeds them down into the lawn, giving it an important late season feeding. Naturally.

Saves you all the work of raking, bagging and hauling. Saves on the cost of leaf bags and commercial fertilizer as well. And it will save you work and time each Spring, too.

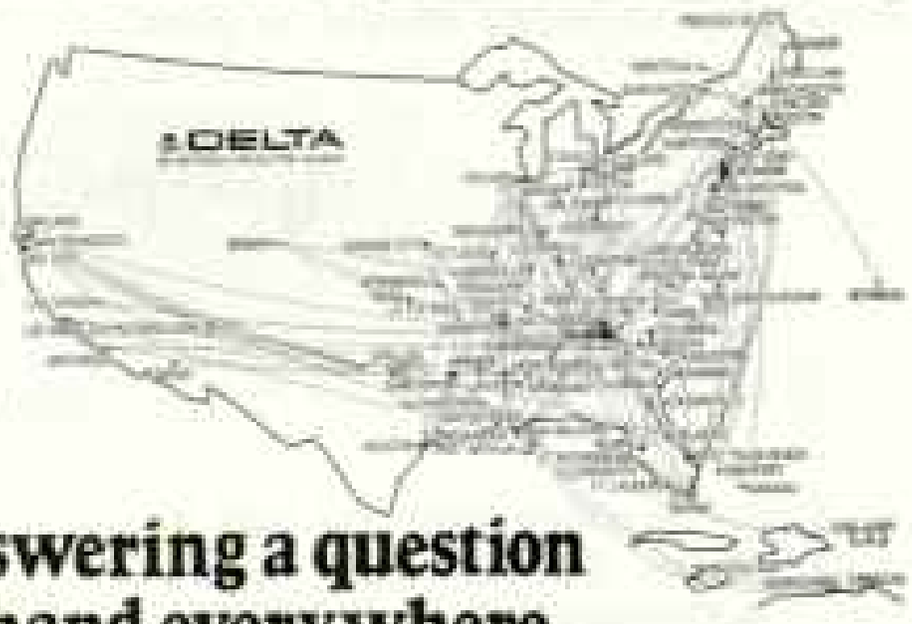
22" self-propelled

The Bolens Mulching Mower comes in 18", 20" and 22" cutting widths. Manual or electric start. Self-propelled or hand-propelled.

See the three season Bolens Mulching Mower at your Bolens dealer. For his name, check the Yellow Pages or call toll-free anytime **800-447-4700** (in Illinois **800-322-4400**). FMC Corporation, Port Washington, Wisconsin 53074.

FMC Consumer Products

Delta is an airline run by professionals. Like John Riley. He's been with Delta for almost 9 years. And he's just about done it all. He's worked on the baggage ramp, at the ticket counter, the boarding gate. Now he's a Passenger Service Agent.



John is all over the Delta terminal. Answering a question here, checking a ticket there, lending a hand everywhere. And keeping an eye out for a passenger who has to make a tight connection. John knows every second counts when he's got just minutes to get that passenger on her flight.

When it comes to people, John Riley–like all 28,000 Delta professionals–couldn't care more. Delta is ready when you are.®

This is Delta's Wide Ride L-1011 TriStar, a $21 million superjet. Cabins are almost 19 feet wide. All seats are two-on-the-side.

To give you an idea of diamond values, the piece shown is available for about $6500. Your jeweler can show you other diamond jewelry starting at about $200. De Beers Consolidated Mines, Ltd.

She made me promise not to get her anything this year.
She doesn't know I crossed my fingers.

A diamond is forever.