DOUBLE MAP SUPPLEMENT: MEGALOPOLIS

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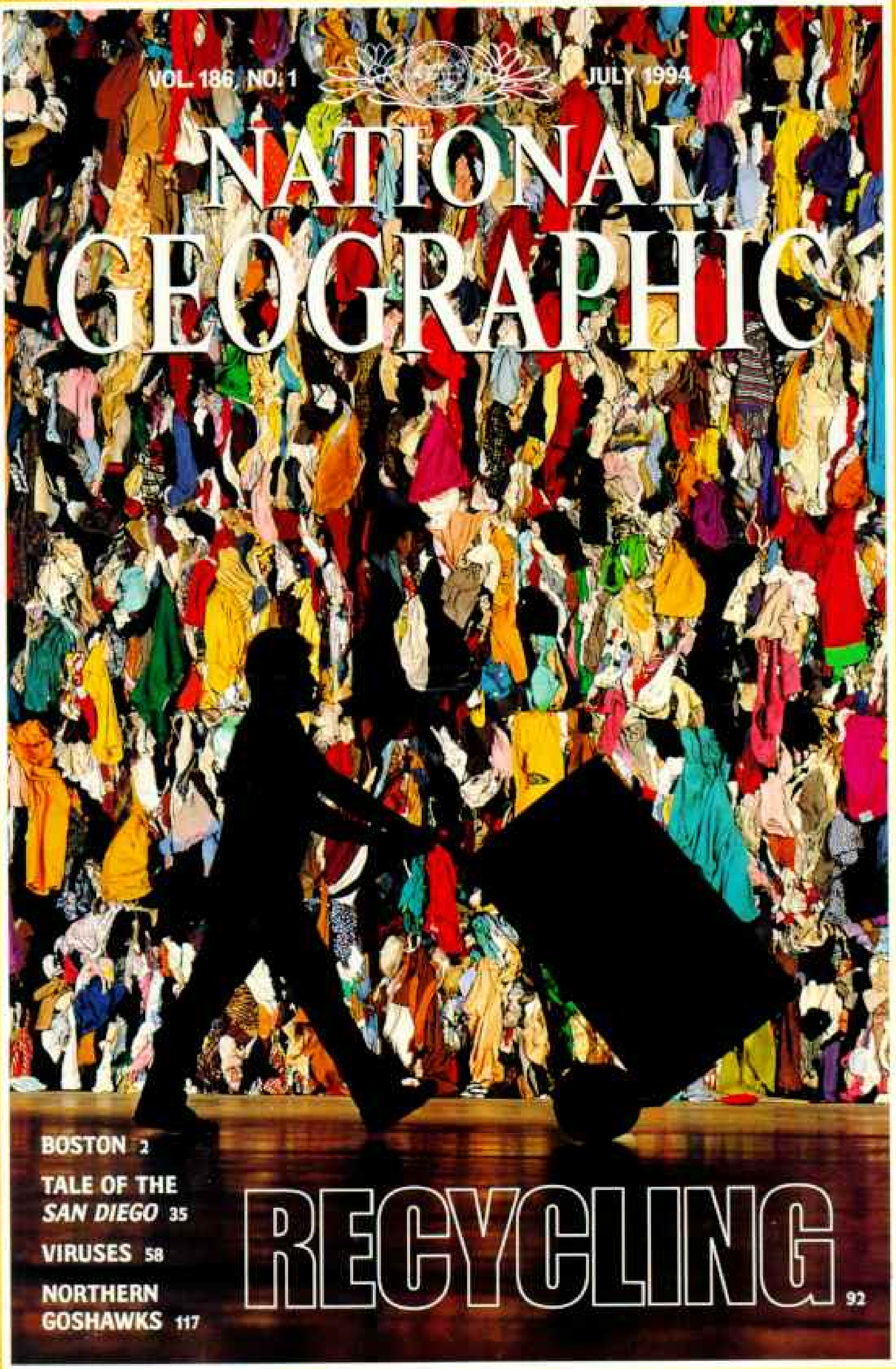

RECYCLING 92

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NATIONAL GEOGRAPHIC

JULY 1994

COVER: Multicolored heap of cast-off clothing at a Los Angeles recycling mill will be transformed into new products—industrial rags and carpet pads. Photograph by José Azel.

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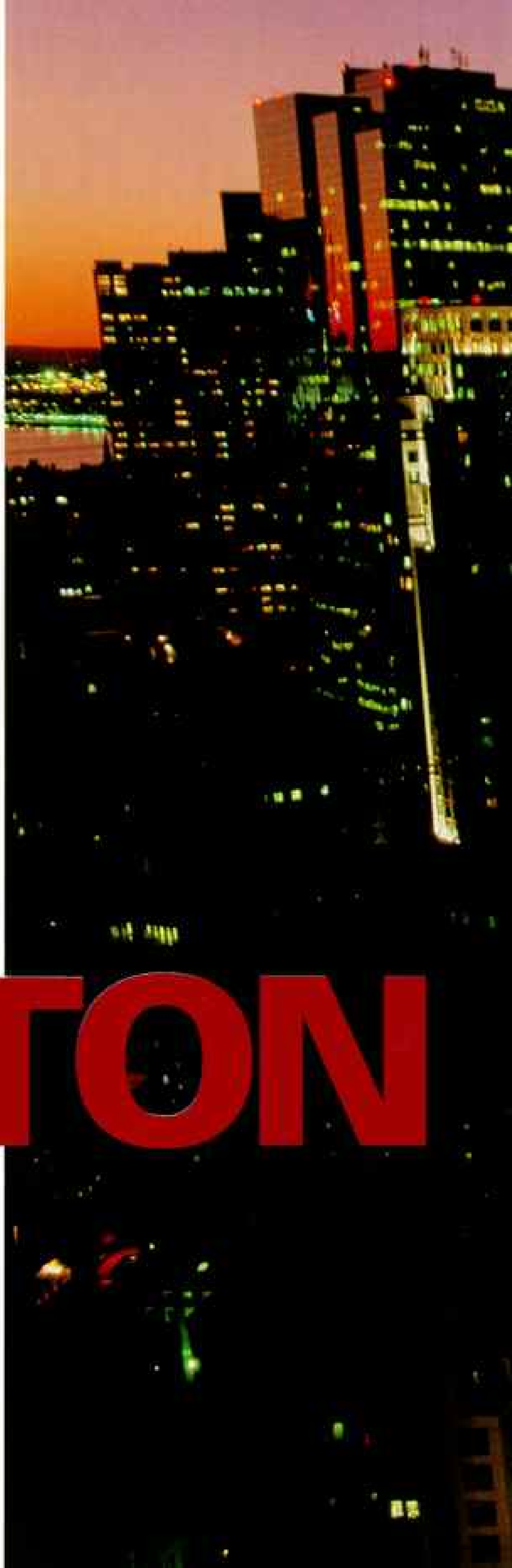
Piercing the heart of the city near the Custom House Tower, the elevated Central Artery suffers from Boston's growing pains while contributing to them. Clotting badly during rush hour, the highway will soon be replaced by a tunnel. The project mirrors a makeover that is reshaping Boston, from its ethnic enclaves to City Hall.

Breaking New Ground

BOSTON

By WILLIAM S. ELLIS

Photographs by JOEL SARTORE



A FEW WEEKS before the city's mayoral election last fall—won for the first time in nearly seven decades by a candidate of non-Irish strain—I listened to a patron declaiming in Doyle's Cafe, a hallowed Hibernian bar in Boston's Jamaica Plain neighborhood.

Of unmistakable Irish extraction, with steely gray hair as wavy as rippled potato chips, he worked for the city, and thus displayed a prudent political correctness. "I'll say nothing bad about Tommy Menino if he's elected," he said. "I like Italians." But clearly he was bewildered by the drift of things in Boston nowadays.

Thomas M. Menino's picture had been hung in the coveted spot behind the mahogany bar at Doyle's even before the election. And Jamaica Plain was now the section with perhaps the broadest mix of national heritage anywhere in the city. Public schools needed improving. And the crime. . . . He snorted. "Read them their rights, huh? How about we read 'em their *last* rites?"

He added a bill to the wet change on the bar for a tip and rose from his stool. "What's happened?" he asked of no one in particular. "What's happened to the place?"

Well might he wonder. That morning I had ridden in two cabs, both driven by Haitians. The night before I had eaten in a restaurant owned by a Lebanese who came to Boston six months earlier and had already made enough money to send for three cousins. On a morning walk in the city, I had passed, it seemed, at least one exotic grocery store on every block selling staple foods of other lands.

Haitians, Dominicans, Southeast Asians, and others have come to Greater Boston in recent years by the tens of thousands, settling mainly in Dorchester and Mattapan (map, page 10). At the same time other sections, such as Roxbury, are occupied predominantly by blacks. Only Charlestown and South Boston remain in the grip of the Irish.

Nor have the changes come without incident. Racial invective, cross burnings, and assaults—all have occurred, reaffirming Boston's repute as a city of fragile tolerance.

But the wonderful incongruities of the city's character remain unchanged, and they continue to confound and delight the visitor. Boston still can be seen as the breeding ground of blue-blooded culture, a fusty place, yet one where saloon-based sociability prevails, Beantown. It is a city of worldliness but also of shackling provincialism. It is here that Brahmins breathe the rarefied air of Beacon Hill at the same time that City Councillor Albert Leo "Dapper" O'Neil is setting new records for attendance at wakes.

"In my last campaign for reelection," Dapper was saying, having just returned from a fitting for a new tuxedo, "I didn't pass out any literature. I didn't even have poll workers. But I work the job seven days and seven nights a week. I'm visible. Last night I went to five wakes, seven the night before. I did 30 for the week, and while I lost 30 voters, may God rest their souls, I gained 30 families."

O'Neil is 74, and when he ends his City Hall service, now in its 23rd year, Boston will have exhausted its draw on the Irish-American political legacy of James Michael Curley, the legendary mayor (and Massachusetts governor) who once warned that if Herbert Hoover were reelected President, Americans would come to envy India's loincloth-wearing spiritual leader, Mahatma Gandhi, for his lavish wardrobe. It was only natural that Curley would attract lifelong devotion from the likes of John "Up-Up" Kelly. Dapper O'Neil, of course, was a friend of both.

"When Curley came to speak at a rally," O'Neil told me, "it was Kelly's job to run through the aisles yelling, 'Up, up. Up, up for the governor.'

"Up-Up was also responsible for planting a guy in the front row. He'd look like a broken-down bum. As Curley was speaking, the bum would stand up, look at Curley, and start weeping. Up-Up, who was near the rear, would yell, 'Sit down, sit down.' Of course, the bum was a professional weeper, and he'd go on to tell the crowd about what wonderful things Curley had done to help his sick mother,

"The worst thing about Harvard was that college had to end," says graduating senior Pete Stovell (center), celebrating as he and classmates head to the 342nd commencement at the Boston area's best known school, in Cambridge.

Private box pews at the Old North Church give visitors a separate peace, though they were built in 1723 to keep worshipers warm. Churchgoers would tote metal boxes full of hot coals into the high-walled pews, which helped retain heat. It was here, late one night in 1775, that two lanterns in the belfry signaled Paul Revere that the British were coming—by sea.

and Curley would reply so everyone in the place could hear him, 'Now young man that was between your mother and me.' "

THERE ARE ELDERLY BOSTONIANS who carry memories of those times close to their hearts, men and women who still look on the charisma of a Mayor Curley or Councillor O'Neil as a gift from God. They cherish the brogue of the Old Sod in the voice of the city, but they realize what is happening—that Boston is no longer a checkerboard of clear-cut ethnicity and that minorities are likely to account for half the population by the turn of the century.

It is a time in Boston, as Kevin White, an urbane and brainy former mayor, observed, when the Irish are ceding the public schools and wardenship of some of the city streets to the minorities. He sees this as something of a revival of the Boston social drama of the 19th century, when the Yankees, uncomfortable with the rising tide of Irish immigration, sought higher ground.

For the first three-quarters of this century, life amid the laboring class in the city was cast in the righteous mold of daily Mass, devotion to work, and marriage until death do us part. Bostonians with memories of the harsh motherland across the sea grew old without moving from their Boston neighborhoods or, for that matter, without even changing houses. And their sons, as teenagers, gathered on favorite street corners, gave one another outrageous nicknames, and forged alliances to last for as long as they lived.

So it was that Thomas P. "Tip" O'Neill, holder of elective office for 50 years, Speaker of the U. S. House of Representatives from 1977 to 1987, and a Boston politician with looks from central casting (as well as a man of decency and caring), was remembered at his death this past January for having faithfully attended reunions of his North Cambridge neighborhood chums from teenage years for four decades.

Now Thomas Menino is in office, a man of unshakable integrity but plodding and with none of the instincts for oratory and political showmanship. Indeed, when Bostonians of Italian ancestry speak of one of their own, they mention, as often as not, Gennaro "Jerry" Angiulo, onetime Mafia boss in Boston, who is serving a 45-year term in federal prison. When

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WILLIAM S. ELLIS recently retired as an assistant editor after 28 years with NATIONAL GEOGRAPHIC. This is his 43rd article. Photographer JOEL SARTORE's work for the magazine has taken him to the U. S. Gulf Coast, Florida, northern California, and Connecticut.

he was arrested in 1983, while dining in a restaurant in the city's heavily Italian North End, he vowed as he was being led away in handcuffs: "I'll be back before my pork chops get cold."

IF THE POLITICAL CLOUT of the Irish in Boston is spluttering, it would be wrong to pronounce it dead. "The Irish gravitate to politics the way Germans do to the Midwest," Kevin White said, talking with me at Boston University, where he is chairman of the Institute for the Study of Political Communication. "The Irish here are still in politics when it is no longer necessary for them to establish anything. For them, politics is a natural environment, and I don't expect that to change. They are not going to go away."

That would certainly be true of Boston politics on the national level, where funds can be found for badly needed local projects.

Consider the "Big Dig," as it is called here. At this time work is progressing on relocating the city's infamous Central Artery, an elevated roadway on which drivers are regularly pushed to the edge of madness by the heavy traffic. A new road will bore underground, and the overhead will be pulled down. As part of the same project, another tunnel is being constructed under the Inner Harbor to connect Logan Airport with South Boston.

It is a gigantic undertaking, with each link

BOSTON

City upon a hill

Sailing to the New World in 1630, John Winthrop promised his Puritan followers, "We shall be as a city upon a hill." Figuratively, perhaps, and literally true: Three hills once dominated the narrow peninsula that was Boston. But in the early 1800s, to enlarge the city, the hills were cut down and used to fill in the peninsula's coves, leaving places like Dock Square and Water Street landlocked. Today Boston brims with cultural attractions, biotech businesses, and yuppies, while in neighborhoods such as Roxbury and Dorchester the poor wonder: "What about us?"

Raising political palaver to new heights in 1895, the Massachusetts House of Representatives proclaimed its wooden codfish a symbol of "Democracy . . . free institutions . . . progress." It was originally hung to celebrate, simply, the local cod fishery.

of tube for the 3,850-foot-long tunnel measuring longer than a football field. Lying 50 feet below the surface, the tunnel is expected to open to commercial vehicles by 1995, and when that and all the other work is completed, the cost will have reached 7.7 billion dollars, setting a new record for a public highway project in this country.

No less than 85 percent of that dizzying sum will be provided by the federal government, in whose council sit Ted and Joe Kennedy, Joe Moakley, and others of Irish stock charged with guarding the interests of Boston and all of Massachusetts.

Work is also under way to clean up the waters of Boston Harbor, as ordered by a court in 1985. There has been some government funding of this project too, but the heavy burden of the 4.2-billion-dollar cost is being carried by homeowners and businesses in the 44 communities involved; the water and sewer rates for these customers have increased on average more than 450 percent over the past nine years, making them the highest of any major U. S. city.

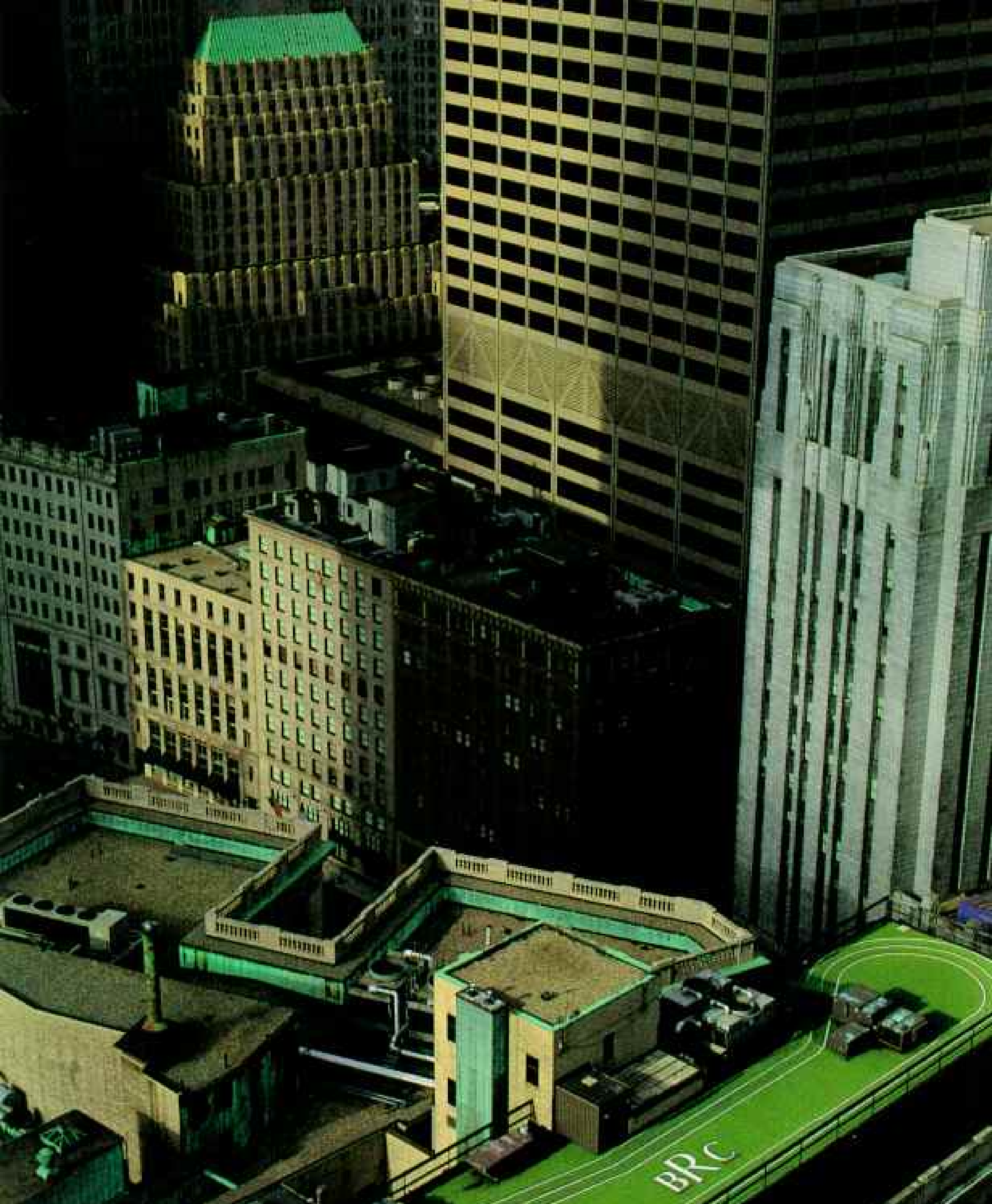
The results, however, have been spectacular. Two and a half years ago, 400,000 gallons of liquid sludge poured into the harbor daily; the waters were, by all reckoning, among the most polluted in any state.

Today sludge is transmuted into pellets of fertilizer. There will be a new plant for secondary treatment of wastes. The beaches of Boston Harbor are once again fit for swimming, and marine life is returning, with more and more sightings of porpoises and seals. Whatever the cost it is probably a bargain, for the harbor annually generates eight billion dollars in revenue through shipping and other activities that bond the city to the sea.

FOR ALL THAT, the full essence of Boston is much more than public works, politics, and ethnicity. The city is like a strongbox, holding the treasures of academia, of medical research and care on the highest levels the world over, of professional sports teams that command the rabid support of

They haven't won a World Series since 1918, but the Red Sox remain world champions of the last-minute meltdown. Remember when the Yankees eliminated the Sox in '78 on Bucky Dent's bloop of a home run over left field's Green Monster? Or the error by Bill Buckner that blew game six of the '86 Series? Sox fans can't forget, yet they still pack Fenway Park because *this* could be the year.


CITGO
RIGHT GUARD


BRC

Looking like a million bucks—in hundred-dollar bills—these men prefer anonymity, for security reasons (right). They work at Boston's Federal Reserve Bank, which handles 250 million dollars a day to keep New England's banks supplied with currency. Looking for green space in the financial district, a runner hits the roof at the Boston Racquet Club.

Bostonians, of history and the wisdom of the giants who nurtured this country at the birth of independence. And certainly Boston is culture—arty, musical, bookish, and yet it is all not without some irony and humor.

"You know, we have the ashes of Sacco and Vanzetti here, in a vault no more than ten feet from where you're sitting," Arthur Dunphy said, smiling when I started at the revelation. Some of the ashes were sent to their families in Italy, and some were kept by their defense committee and later donated to the library.

Dunphy is a spokesman for the Boston Public Library, and the famed anarchists Nicola Sacco and Bartolomeo Vanzetti were Italian-born residents of the Boston area—one a shoemaker, the other a peddler of fish—who were found guilty of robbery and murder in a Boston suburb. The verdict pitted ideologues on the left and right against each other and reverberated widely through the world. By the time both men were executed, in August 1927, Boston's civility had been ripped apart.

It is appropriate that the Boston Public Library should hold the ashes of the two immigrants, for it is in many ways an institution of last recourse. It is a library that will find the book or answer the research questions when most others cannot. Endowed with vast resources, it was the first large free municipal library in the country, the first of its size to allow people to take a book home.

Currently the old library building is being restored at a cost of about 50 million dollars, and when completed, Bostonians will come to know again the architectural jewel raised on Copley Square in 1895.

Boston being Boston, that century-ago opening was not without civic upheaval. A statue of a nude woman holding a bunch of grapes and wearing an unsettling expression of pleasurable indulgence was donated for the library courtyard. The thunder of moral outrage became so loud that the statue (appropriately named "Bacchante") was withdrawn and given to a museum in New York City.

In later years a copy of the piece was cast and brought to Boston, where it now waits for restoration of the building, when it is to be quietly placed on a pedestal in the library courtyard pool, suffering no more the shame—often lucrative—of being "banned in Boston."

As recently as the 1950s a weekly newspaper in the city, the *Mid-Town Journal*, was considered racy, and all copies were removed from the Public Library (later, in more enlightened times, a collection of the periodical was happily accepted).

In 1962 Boston ran bulldozers through Scollay Square to make room for Government Center and its City Hall building, which looks like an oil-drilling platform in the ocean. Scollay Square was all tattoo parlors and places of adult entertainment, including the famous Old Howard burlesque house. It broke Dapper O'Neil's heart to see it destroyed, to see the

lights dimmed forever on the stage where Ann Corio and others opened the eyes of countless young male Bostonians wider than ever before (or since, probably).

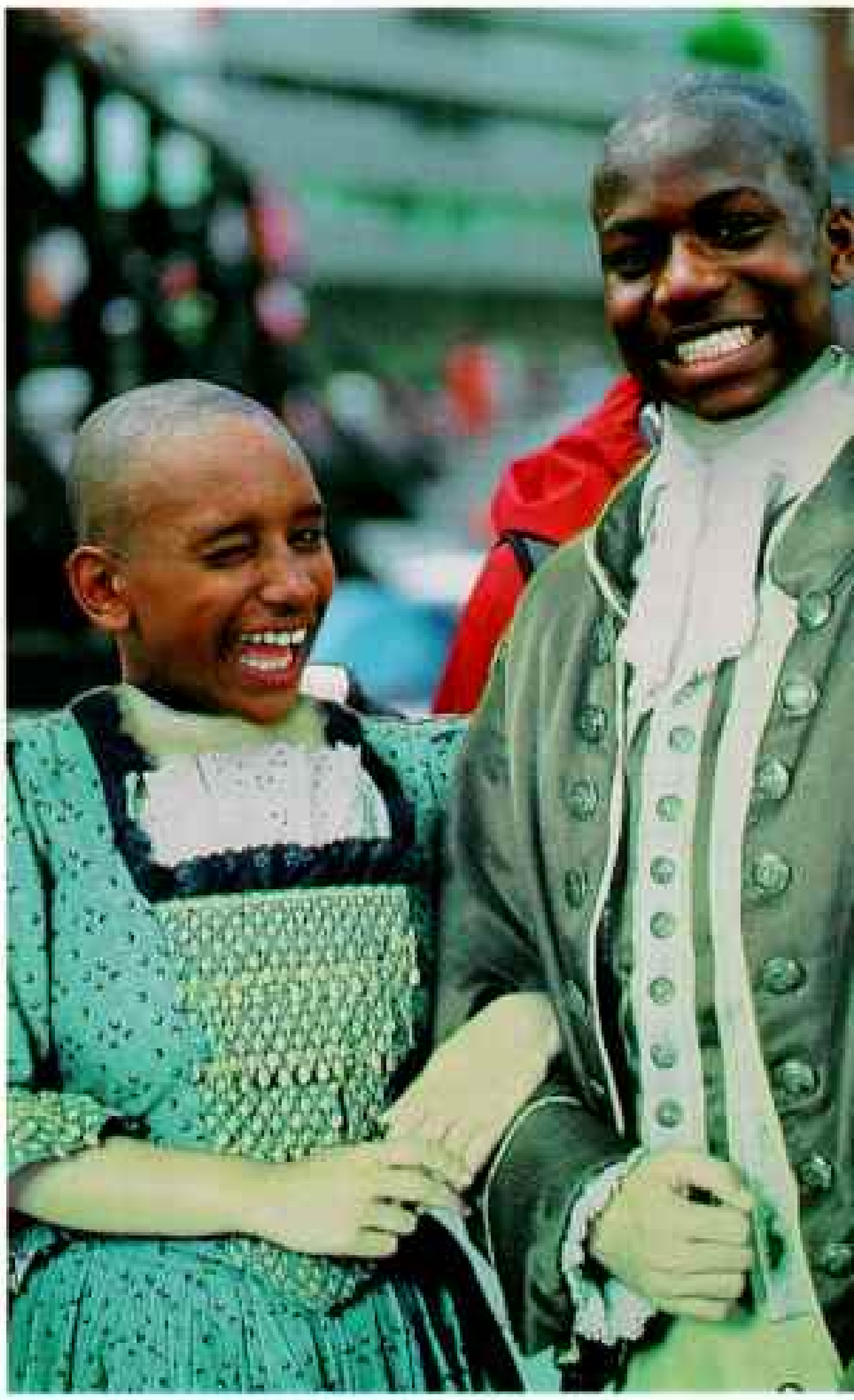
"I once invited Ann Corio and some of the other strippers to come back for a reunion, and they did, and we got an old police car and made a mock arrest," Dapper said. "Kiddingly I asked Ann, 'Why don't you and I go out some night?' and she says to me, 'For God's sake, Dapper, you should be home praying for a peaceful death.' "

IT SEEMS a world away from Councillor O'Neil's office, with the cigarette box that once belonged to Mayor Curley on the desk, to Cambridge. But it's no more than a ten-minute drive, past Beacon Hill with its old brick houses and cobblestone streets—all of it designated as a national historic district. There are old people living there who seldom come down from the hill because they can hardly make it back up. There are a lot of dogs kept by the Yankees on the hill as pets, and they too have a difficult time with the slope, panting and throwing down rainstorms of drool on the sidewalk.

Still, Beacon Hill is a pleasurable place to stroll. The sense of history hangs in the air like fog, setting a mood for thoughts of a time when John Hancock lived on the hill. It is more proper to reside on the south slope of Beacon Hill than on the north, where there is commerce on the bordering streets. It is on the south where the gold-domed Massachusetts State House rises, the cornerstone of which was laid by Samuel Adams on Independence Day, 1795. Close by is the Boston Athenaeum, a superb independent library and art collection much loved by eminent Bostonians, who, for nearly 200 years, have used it to hone the edge of intellect, inquiry, and Yankee pride.

Cutting up behind colonial cutouts that recall the American Revolution, Jermaine Lawrence and Steve Mitchell pose at the Boston Tea Party ship, where tourists can toss tethered crates of "tea" into Boston Harbor.

Doing a video limbo at the presidential library and museum of Boston native John F. Kennedy, Barry Lazell focuses on a replica of Kennedy's presidential desk. The original, a gift from Queen Victoria to President Rutherford B. Hayes in 1880, now sits in the Oval Office of President Bill Clinton. "The Kennedys," says Lazell, a Brit, "are the closest thing America's ever had to a royal family."



If you continue past Back Bay you'll cross the Charles River, where Sepehr Kiani may or may not be out on the water, testing the human-powered hydrofoil he and three others built. The project is under the auspices of the Massachusetts Institute of Technology, where Kiani is a graduate student in mechanical engineering. The work has proceeded in the basement of a building on the MIT campus, and this is what they have: a 17-foot kayak-type vessel large enough to hold one person, who, sitting in a reclining seat, pedals a chain arrangement like that of a bicycle.

"The pedaling turns the propeller," Kiani said, "and when the boat reaches a speed of about five and a half knots, you start to get lift from the foils. The boat will come two or three inches out of the water."

It is a wonderful thing to behold—that funny-looking boat sitting in the basement, basking not only in the strong light of the shop lamps but also in the blessing of one of the world's outstanding universities.

So then along Massachusetts Avenue in Cambridge until Harvard Square is there. Observing from a coffee shop in the square, I perceive an aura of good fortune, of men and women privileged to chase the blue-chip degrees of this oldest institution of higher learning in the country.

For the Harvard class of 1996, there were 1,600 openings for which 13,029 applied. The tuition and room and board total close to $25,000 a year.

"It's worth that outrageous amount," a student from Puerto Rico said to me in the coffee shop. "How many universities can you attend where they have had more than 30 Nobel Laureates on the faculty through the years?"

Another student, Bonney Pelley, was sitting on the floor of the foyer in Harvard's Memorial Hall, waiting to attend Michael Sandel's

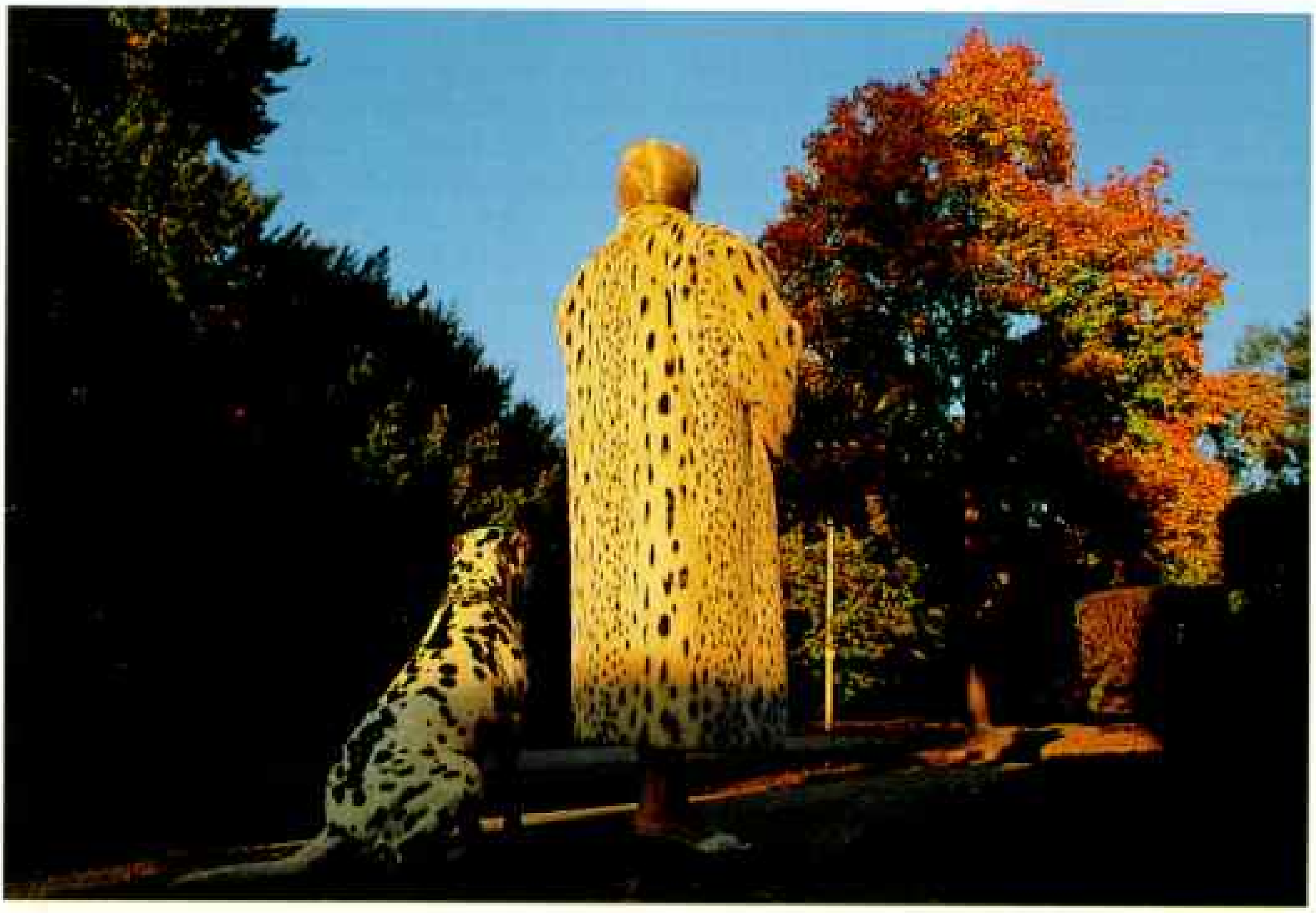
lecture for his course titled, simply, "Justice." It was the most popular course at the university last year; 933 students were enrolled.

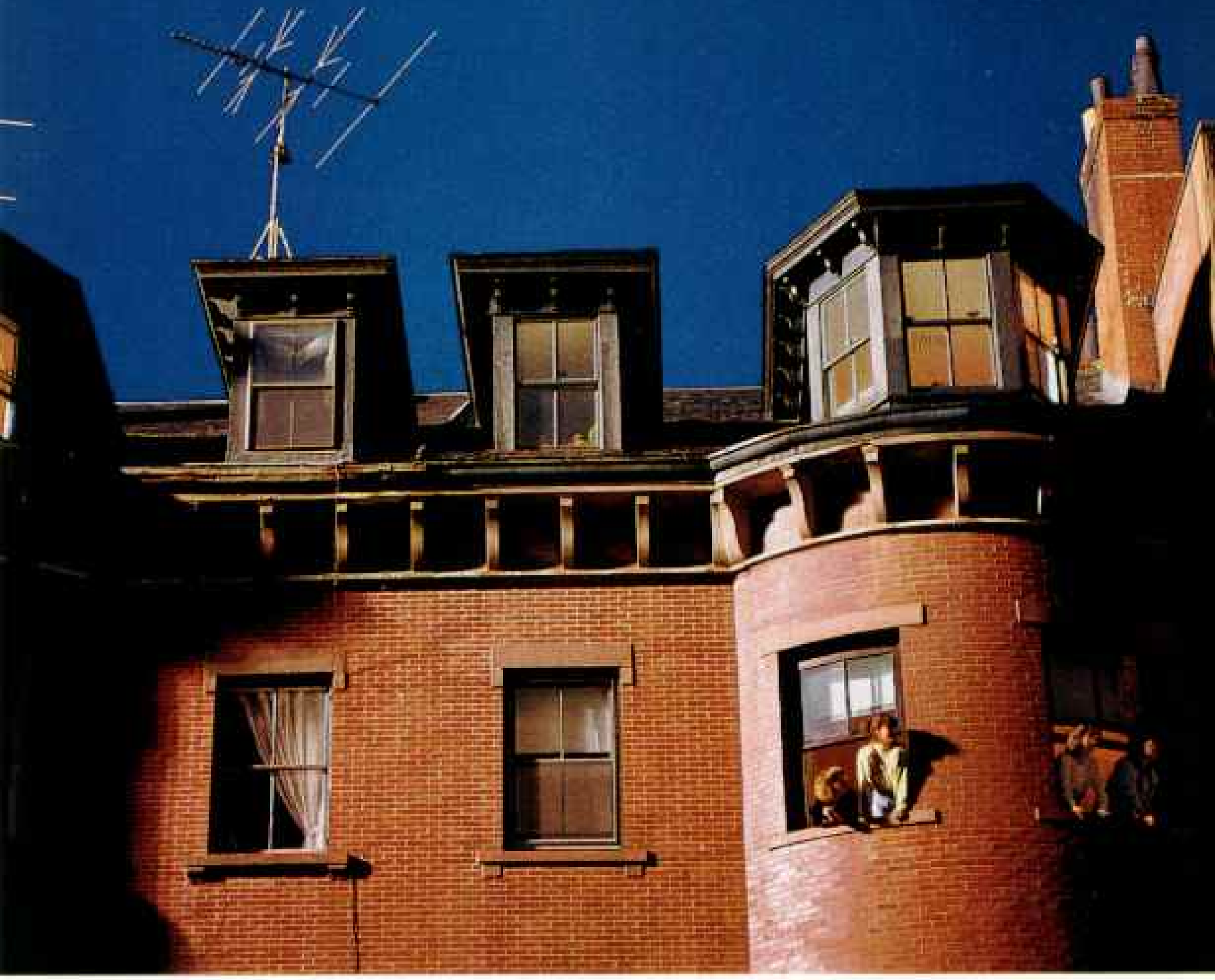
"It's a wonderful course," Pelley said. "It offers a classical education with a contemporary focus. Sandel is such a good lecturer that he makes you forget how many students are there." She said she was a sophomore history and science major who comes from the Boston area. "I've been to other places, of course," she added, "but I really couldn't conceive of living anyplace but Boston."

Sandel, a slight, balding man, waited for his musical introduction by a student saxophone player and singing group (was Plato afforded this type of grand theater at the Academy?). He then lectured for an hour on whether a market society is just. "Is the contribution of the CEO, like his salary, a hundred times that of the average worker?" he asked. Barely into his lecture, the sense of crowd has vanished, and Sandel has transformed the restless into rapt listeners and scribblers of notes.

THE PRESENCE in Greater Boston of so many renowned universities—among them Boston University, Boston College, Tufts, Wellesley, Brandeis, Northeastern, Suffolk University, Emerson College, and the University of Massachusetts—attracts students from all parts of the world. Many come endowed with credit cards and checking

"The sunny street that holds the sifted few" was Oliver Wendell Holmes's description of Beacon Street, so named because it runs along the hill on which Boston's beacon once stood. The city's "uppah" classes were drawn here by the sylvan setting and the elegant town houses, many of which have lately been divided into condominiums (right). Stretching from the State House to the suburbs, Beacon Street runs through Brookline, where Dr. Hedda Rev-Kury wears a fake fur on daily walks with her Dalmatian, Dorado. "I put on the coat," says the doctor, "and the dog thinks I'm her mother."





accounts, and the spending has an impact on the economy of Boston. Some 250,000 students are enrolled in the more than 60 colleges and universities in the area. After paying for room, board, and tuition, the students, it is believed, are left with around 1.25 billion dollars for discretionary spending.

And Boston can use the money.

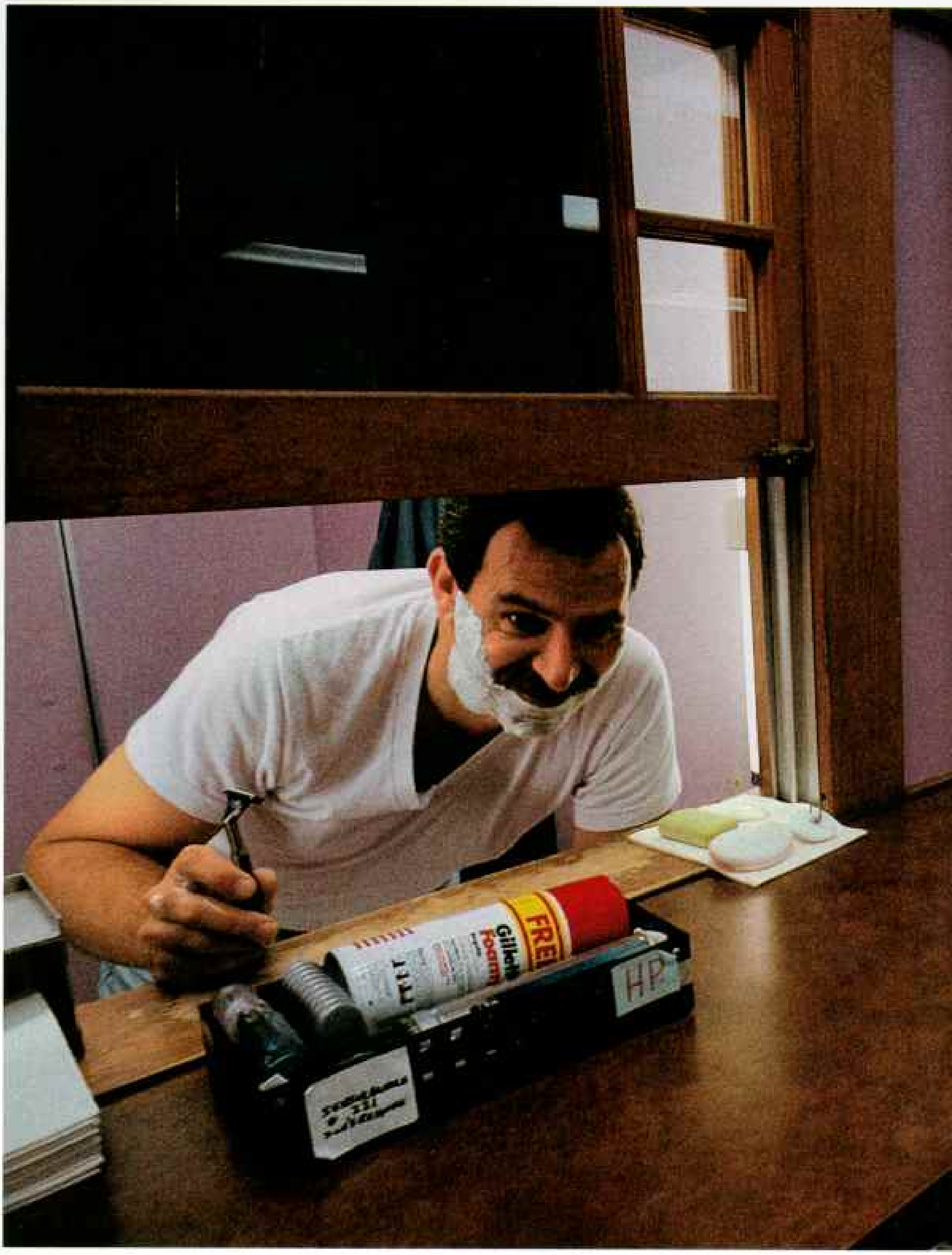
In the early 1980s the area was drawing high-tech industries, including those making computers. They were strung out along the ring road, Route 128 (Interstate 95), technological pioneers fated to rescript the way we live. But things began to unravel when corporate behemoths failed to recognize the promise of the small, personal computer.

There was Wang Laboratories, Inc., for example, with revenues of nearly three billion dollars and 31,000 workers in 1988. Within six years Wang would go through bankruptcy and seek 60 million dollars in private financing. Employees now number 6,200.

Many towers were erected in Boston in those glory days of large computers and high-tech firms. But as competition sprang up elsewhere, employment fell and companies failed; Boston's economy weakened, and the occupancy rate of the high-rise buildings dropped.

"We probably won't build another office building in Boston for four or five years," Paul Barrett, then director of the Boston Redevelopment Authority, said. "What is big here is medical and biotech research. That has taken off. People aren't familiar with that type of work and activity. They walk down the street, and because there are no new towers going up, they think nothing is going on."

Although the authority is an independent agency, it runs Boston's city planning and development and is invested, therefore, with considerable pushing power. In an attempt to clean up an infamous area known as the Combat Zone, for example, the authority has purchased property there by outbidding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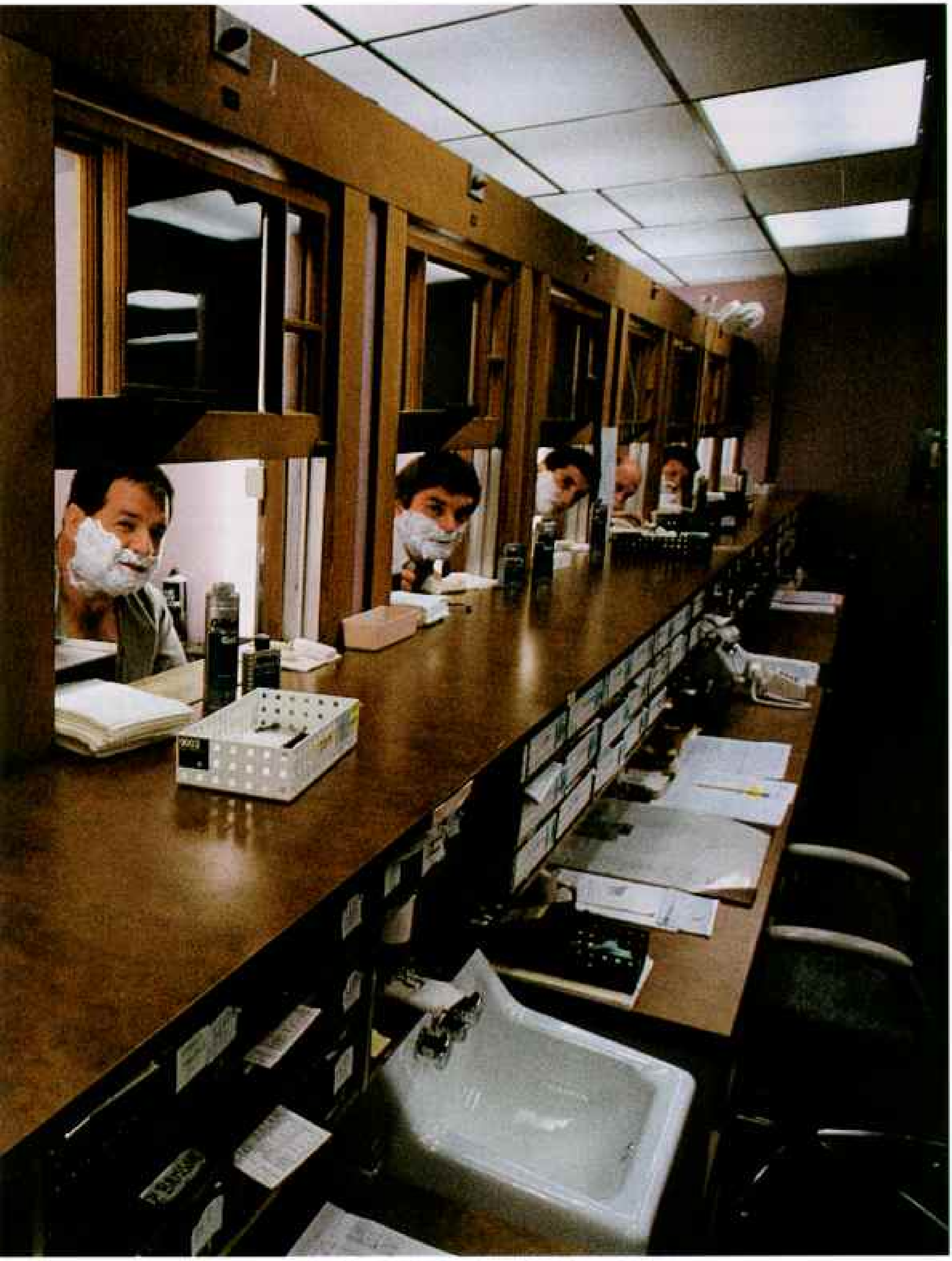


Sticking their necks out in search of the perfect shave, employees at Gillette's "World Shaving Headquarters" in South Boston volunteer to test prototypes of the company's new products. Why do these men and 200 others choose to risk nicks, cuts, and skin irritation? "Because," says Bill Jones, chief of the Shave Test Lab, "they get to come to work messy and clean themselves up on company time."

prospective owners of shops selling pornographic materials. "The number of adult entertainment businesses in the Combat Zone has fallen from 30 to four," Barrett said.

Through it all—ethnic readjustments, the demise of high tech and budding biotech, boom and bust—some things uniquely Bostonian remain blessedly unchanged. The rolls at the Parker House hotel continue to fairly dance with lightness and flavor, and the baked scrod, to my way of thinking, still puts a flounder to shame. But it's the beans, Boston baked beans, that bear the standard of fame for Boston taste. And no better beans are made than those served at the old, old restaurant at Faneuil Hall Marketplace called Durgin-Park.

The place has been in business for more than 160 years, and a man can sit there at one of the long wooden tables and eat with his hat on. Calvin Coolidge, Franklin Roosevelt, and, before them, the Lord knows how many silversmiths and bootmakers—they all ate at Durgin-Park, with Silent Cal finding words enough to order, without fail, the codfish dinner. There are waitresses who have been there, so it seems, since cows grazed on Boston Common, and their use of the endearing putdown is rivaled only by those who serve at Wolfie's Delicatessen in Miami Beach.

Faneuil Hall Marketplace is a major attraction, a place for pleasant strolling and shopping and sampling baked Indian pudding. There are three long buildings in the complex, including Quincy Market, which was built in 1826, and the shops and restaurants now number close to 150. It was the forerunner of the type of urban marketplace—street performers, yogurt stands, quaint shops, and the like—now found in large cities throughout the country. There are special observances at the marketplace, such as the one held last September 17 and 18. It was called Halfway to St. Patrick's Day Celebration.

WAILING AMBULANCE SIRENS often penetrate the marketplace, for not far away stands venerable Massachusetts General, one of the world's premier hospitals. A teaching hospital for Harvard Medical School, it shares credit for many of medicine's major advances, stretching back to 1846 with the development of anesthesia. Both kings and paupers in need of healing come here from around the globe and find deep and classless caring.

Massachusetts General operates extensive research facilities at, of all places, the Charlestown Navy Yard. That base was closed in 1974, with a loss of 5,000 jobs, then revived as a commercial center. The young, determined scientists here, armed with cutting-edge software, are foot soldiers among regiments of researchers toiling in laboratories all over the Boston area.

One fascinating quest aims at fully understanding the pathways of signals between the outside of a human cell and its inner nucleus. Some signals that move along these paths are faulty and can trigger woefully common afflictions like allergies and arthritis. When the immune system overreacts to such false alarms, the result can be the misery of itching, swelling, and sneezing, or even irreparable damage to the joints. If a drug can be developed to block the passage of those wrong signals, perhaps the world could come to know the true beauty of ragweed.

One biotech company, Ariad, is in the vanguard of this research. "We are quite far along from the basic research, but quite early in the development of a drug," said Charles C. Cabot III, senior vice president for business operations. "The hit rate for success is improving, but pharmaceutical research is still high risk. Some people liken it to oil exploration; it takes so long, and it costs so much money. And lots of times, there's no oil."

As Mr. Cabot spoke I tried to recall that classic verse about Boston, ". . . home of the bean and the cod, / Where the Cabots speak only to Lowells / And the Lowells speak only to God." Was he?

"Yes, I am one of the Boston Cabots. But it's the other way around. The Lowells speak only to us; *we* speak only to God."

To whomever they speak, Bostonians are doing so with less and less of the accent in which the *r* is dropped and the *a* is broadened. There are some who continue to say "lahst" for last, and "pahk" for park, but such accents are rapidly becoming stigmatized. Yet Bostonspeak will not die easily; there will be "bahking" dogs here for years to come.

"The Boston dialect, which for years had been expanding because of the growth of the metropolitan area, has now been encroached upon by general American English," said Robin C. Barr, a historical linguist and a faculty member of the English department at Boston's Northeastern University. "So what

Beaming beneath her tiara, Caitlin Lewis celebrates her seventh birthday with friends at Charlestown's Bunker Hill development, the largest public housing project in Boston. The face of the city, once mostly black and white, now reflects a growing Asian and Latino population.

is happening now is that there is a shift in prestige from British English to the majority dialect in this country."

The English in use around 1635, when Boston was in its infancy as capital of the Massachusetts Bay Colony, must have echoed the good English of Londoners, perhaps with strains of the speech of the earlier Pilgrims from East Anglia. Even then there were portents of separation. By the middle of the 18th century the colony's population approached 15,000, including some who would lead the struggle for independence:

The first armed conflict between British and colonists occurred in Boston on March 5, 1770, and resulted in the death of five, including a runaway slave who worked as a seaman. His name was Crispus Attucks, and he was, as far as it is known, the first African American to be martyred for the sake of American independence. There is a question, however, as to which side should carry the blame for the skirmish, known as the Boston Massacre.

"The massacre was the result of British troops reacting to a gang of street toughs who posed a threat," said Philip S. Bergen, librarian of the Bostonian Society. We were talking in his office at the Old State House, the oldest public building in Boston, dating from 1713. "The British troops, I feel, did not get an objective judgment in our history books on that one."

Three years after the massacre a broadside was posted all over Boston:

"Friends! Bretheren! Countrymen! That worst of Plagues, the detested tea shipped for this port by the East India Company, is now arrived in the Harbour; the hour of destruction, or manly opposition to the machanations of Tyranny, stares you in the Face; every Friend to his country, to Himself, and to Posterity, is now called upon to meet at Faneuil Hall, at nine o'clock this day, at which time the bells will ring to make united and successful resistance to this last, worst and most destructive measure of Administration."

The patriots responded, and disguised as

Indians, they pitched the tea into the harbor. Nowadays the Boston Tea Party is reenacted aboard a replica of one of the three ships involved. A young man plays Samuel Adams, talking patriot talk stirring enough to draw responses from the tourists, and when it comes time to dump the tea, they find some visitors from England among the crowd and pass the dumping honors to them; and, the crown be damned, they do it and smile and bow when they hear the applause.

Don't look for the watery site of the original Boston Tea Party; it now lies under fill. And the Bunker Hill Monument, of course, stands half a mile away on Breed's Hill, where the fighting really took place. But you encounter 15 other sites of importance to the Revolution on Boston's Freedom Trail, and to follow that three-mile route is to set off little cherry bombs of patriotism that tingle the spine. They are all part of Boston's rich role in American history.

Some things in the earliest days might have been different if, as James Koch says, the beer barrels on the *Mayflower* had not run dry.

"The Pilgrims did not intend to stop in New England," Koch said. "They were on their way to Virginia, but they ran out of beer." He went on to cite this passage from the journal of a Mayflower settler: "We came to this resolution, to go presently ashore . . . our victuals being much spent, especially, our Beere."

James Koch owns a brewery in Boston, where he makes a beer called Samuel Adams. The beer is stirring up its own small revolution, winning accolades in this country and abroad. He began to brew Samuel Adams in 1984, with a first year's production of 500 barrels; by last year that figure had risen to a yeasty 450,000 barrels.

It is fitting that Koch makes his beer in Boston, even though he could no doubt brew the same thing in Georgia and call it James Oglethorpe. He is in his 40s, young enough to have finished paying off his student loans just seven years ago, having received three degrees, including one in law, from Harvard. He is

"**Are you afraid** of black people?" said the Reverend Bruce Wall (above, in red tie). "Can you walk the mean streets with us?" That was the challenge issued last year to Boston's mayoral candidates by anticrime activists, who prayed for safety before ushering one candidate through a rough section of Roxbury. The election winner: Thomas M. Menino, the city's first Italian mayor.

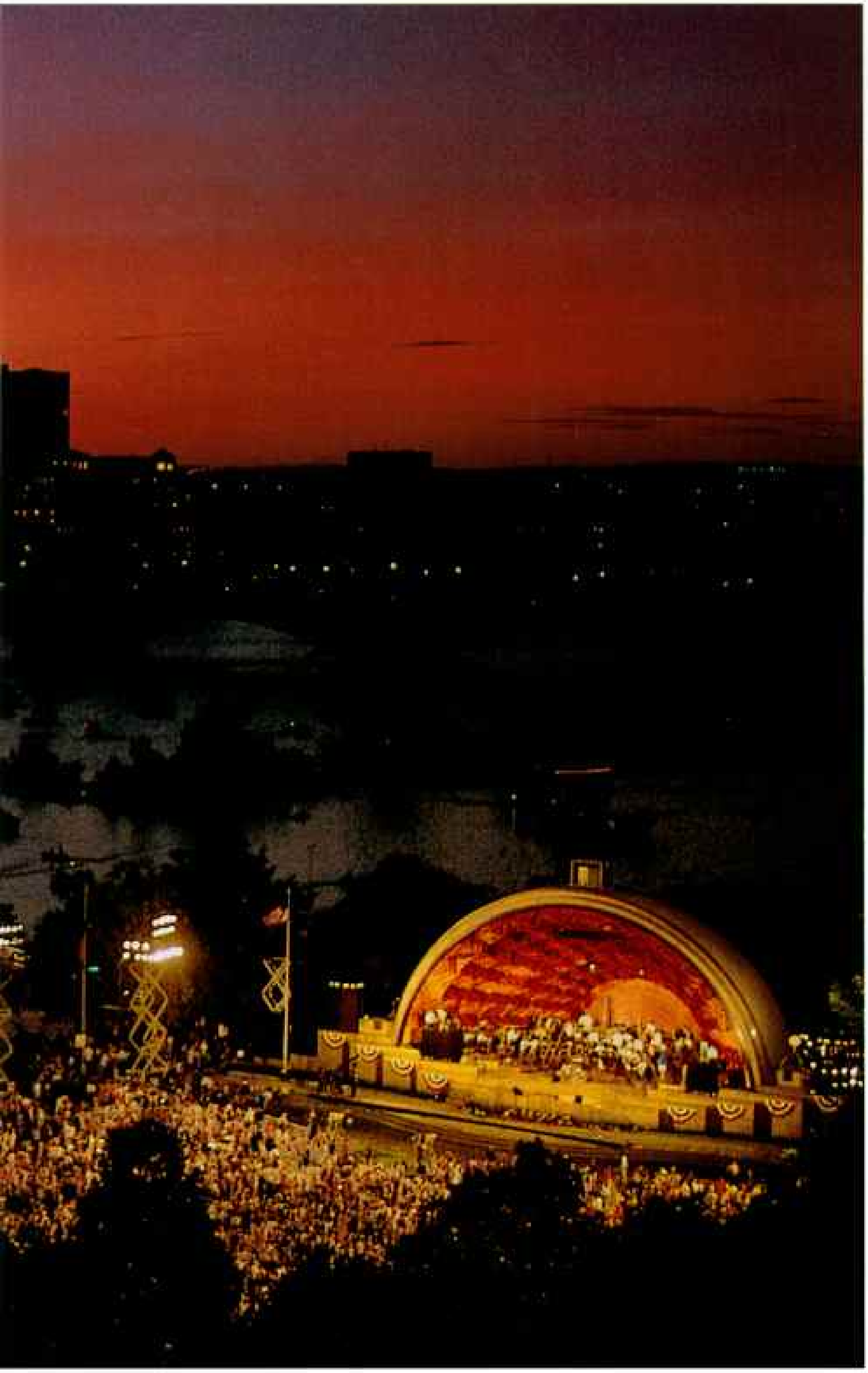
In the North End, Italians parade with the Madonna del Soccorso at the annual festival to benefit their fishermen's club.

driven by what he calls the dynamism of Boston. "This city is like 350 years of history with a future," he said. "You know, the first brewery in the English colonies was here in the Boston area, so there's that wonderful tradition I consider myself part of."

I AM WAITING for the beer vendor in Fenway Park, but so far only the peanut man has been around, still tossing the bag to the customer in the middle of the row and waiting while the money is passed back hand to hand, like buckets of water at a fire. It is a warm night, and paper wrappers scud across the infield in the breeze. The Boston Red Sox are playing the Baltimore Orioles.

Nine innings later (Orioles, 11-3) I exited, fulfilled. Of all the joys that Boston offers—the world-class museums, the Boston Pops Orchestra, the swan boats on the lagoon at the Public Garden—attendance at a major-league baseball game in Fenway Park is among the best. Built in 1912, it holds only 35,000 persons and stands in the Fenway section of Back Bay, a small icon of a park treasured by many Bostonians.

But there is talk of tearing Fenway down, with its friendly outfield fences, and replacing it with something larger, without a manual scoreboard and with oceans of parking spaces. No doubt Fenway will have to go one day, but



Free music for the masses was Arthur Fiedler's dream—and legacy. Conducting the Boston Pops Orchestra from 1930 until his death in 1979, he turned his idea of free Independence Day concerts on the banks of the Charles River into a local tradition. Last year more than 300,000 people gathered to hear the Pops play music from *Jurassic Park*, *Oklahoma!*, and, after dark, a Tchaikovsky-and-fireworks duet.

Bostonians will grievously miss the good urban feel of the park, sitting like a candy store on the corner of the block, stocked with the sweets of youth.

Boston Garden, at 66 the oldest enclosed professional sports arena in the country, *is* being replaced with a new facility nearby. Although the beautiful parquet floor, dead spots and all, will be retained, the plush new 160-million-dollar Garden will bear little resemblance to the old—the one with no air-conditioning, the one where celebrities ranging from Roy Rogers and Trigger to Billy Graham have all appeared.

Considering the sports mania that has long hung over Boston, it was not particularly surprising to witness, as I did, this event one evening on the Boston subway, on the way to Copley Square. A man about 35 and of ordinary looks sat across from me, humming something that sounded vaguely Hawaiian. His dress was run-of-the-mill, except for one sleeve whose ornamental buttons were missing, leaving little strings hanging there.

With the Copley Square stop coming up, he rose from his seat and stood in the middle of the aisle. When the car came to a stop, he thrust both arms straight up, like a football referee, and yelled "Touchdown!" And stepped serenely out the door.

"Gourmet coffee, right to your window— it's gotta be heaven . . . or America," spouts the CoffeeBuster to commuters stuck outside Sumner Tunnel. Moving just as slow in Hopkinton last year, 8,930 runners begin the 97th Boston Marathon.

SUCH PLAYLETS are not uncommon on the Boston subway, the oldest in the nation (1897) and better known as the T, for Metropolitan Boston Transit Authority—formerly the MTA. George Sanborn, reference librarian at the State Transportation Library, knows more about the T than anyone else in the world. He can recite for you Oliver Wendell Holmes's poem "The Broomstick Train," and, if you're old enough, it may well evoke the joy of pulling a trolley pole off the overhead electrical wire.

"The history of public transportation in Boston goes back to before the American Revolution," Sanborn said. "In 1631 a Thomas Williams began to operate a ferry from Chelsea to Charlestown. That was probably the first chartered transportation service on the continent."

It was in 1949 when Walter A. O'Brien, Jr., the Progressive Party candidate for mayor, used as his campaign song a piece of doggerel set to music about a man named Charlie riding the MTA. It was meant to show opposition to a fare increase, one where the rider had to pay an extra nickel in order to get not on but *off* the subway. Charlie, as immortalized in the song, did not have the five cents and thus faced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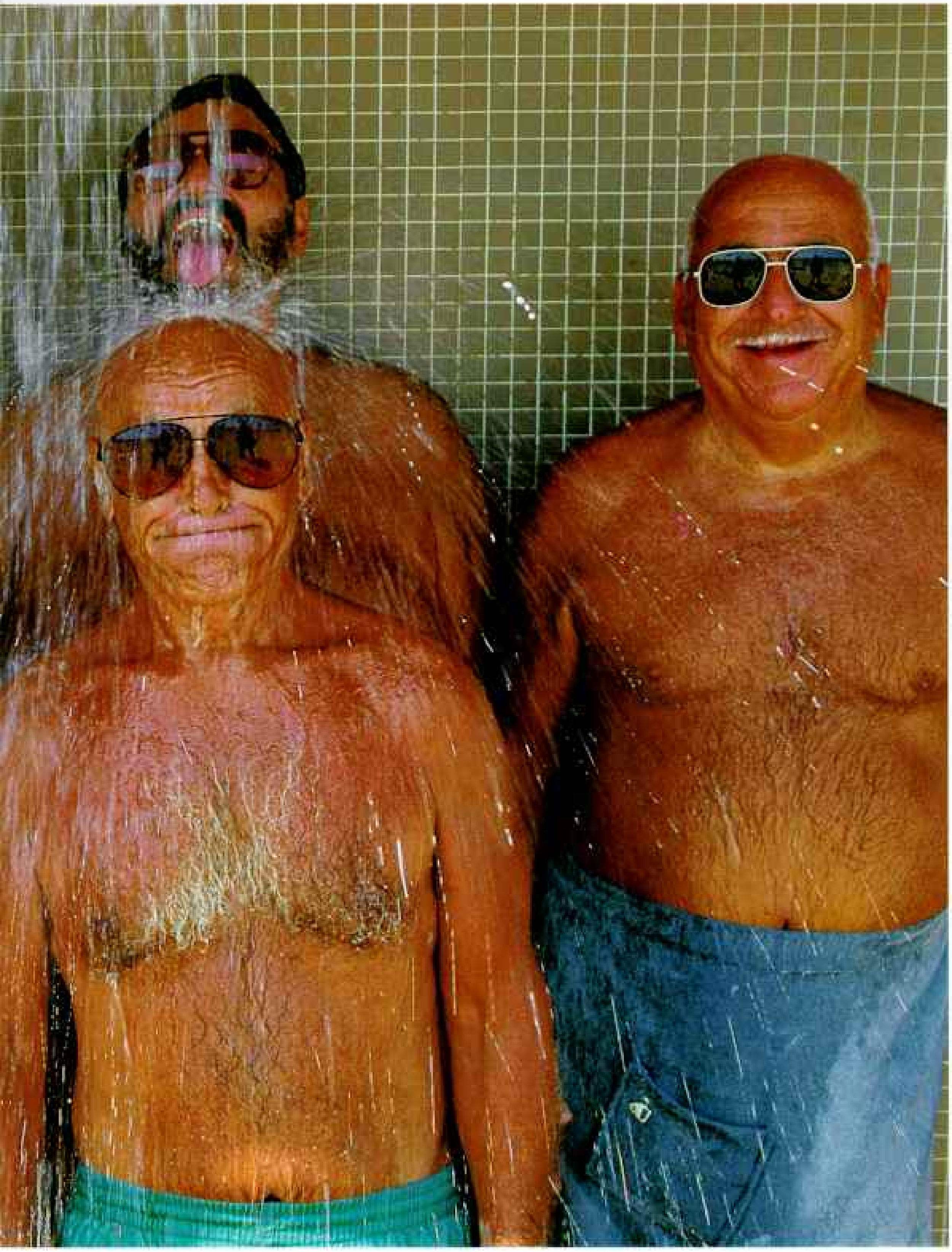


Brave, batty, or both? Every day of the year L Street Brownies take a dip in Dorchester Bay. Named for their deep summer tans, the Brownies are best known for swimming in the dead of winter and enduring bitter temperatures, ice cuts, and a fainting spell or two. "I can't explain it," explains shower-splashed Al Binari, "It just feels good. But my family thinks I'm cuckoo."

the prospect of spending his life underground.

A decade later the Kingston Trio recorded the song, and the whole country came to know something of the MTA. The words, put to the music of "The Wreck of the Old 97," became a national hit. And so people even in Minneapolis and Bakersfield went around singing:

Charlie's wife goes down to the Scollay
Square station
Every day at a quarter past two
And through the open window she
hands Charlie a sandwich
As the train comes rumblin' through.

ALTHOUGH BOSTON is crowded—600,000 in the central city, three million in the metropolitan area—it remains eminently livable in many places. Jamaica Plain is such a place (more so than ever, many claim, for its dramatic amalgamation of various ethnic groups).

There is an old and comforting landscape in Jamaica Plain called Forest Hills, a cemetery with beauty and serenity enough to quickly dry the tears of those who come to mourn. Reggie Lewis, a popular basketball player for the Boston Celtics who died last year while shooting baskets, is buried at Forest Hills, and both young and old continue to visit the grave bearing gifts of remembrance. Eugene O'Neill and his wife Carlotta lie here, and so does e. e. cummings. John Reece has his place too, under mountain laurel and oak, having left as his gift to the world the buttonhole machine.

The infusion of peoples from lands other than Ireland and Italy has been going on long enough for many Asians to have been buried at Forest Hills. Because of the slope of the land, and also because of preference among the Asians, their headstones for the most part face east, as if the souls are borne on winds that blow only that way.

Of all Boston's departed sons and daughters, John F. Kennedy evokes feelings of deepest intensity. His library and museum in Dorchester draw some 300,000 visitors and schoolchildren on field trips each year. It is a sparkling building designed by I. M. Pei and sits in a waterfront park. Although opened in 1979, the museum was completely redesigned, at a cost of 6.9 million dollars, and reopened to the public last year.

"We realized that growing numbers of visitors were under 40 years old, and they had no personal recollection of the Kennedy Administration," said Frank Rigg, deputy curator. "The original museum depended on visitor memories of JFK for much of its effect. So the museum is now designed to have people learn of his decisions and commitment to public life through his own words."

The new format allows the visitor to be on the scene, to stand in a re-creation of the Oval Office, for example, and hear the former President speak some of the words of his civil-rights address in 1963: "We face, therefore, a moral crisis as a country and as a people."

RONAN REYNOLDS hopes to see the Kennedy Library and Museum one day, but first he must find a job, get settled, start a new life. He is 26 years old and newly arrived from Ireland. I came to know him at

In a meeting of the mouths, Mocha and Bart have a ball on Boston Common, the nation's oldest park. Once a cow pasture and a site for public hangings, the Common today is cleaner and much more civil—just as long as dog owners show up with plastic bags and a sense of civic duty.

Although Boston grapples with typically urban problems, its resources to deal with them are world-class. With a rich history, a new mayor, a mother lode of smarts, and plenty of moxie, Bostonians seek to revitalize their neighborhoods so all parts of the city can prosper together.

the Irish Immigration Center in downtown Boston. "It's been an ambition of mine to come to America since I started college," he told me. "But the system is not kind for the people coming here for the first time."

Once there was a strong support network for men and women newly arrived in Boston from Ireland. But that has disappeared. No longer do whole neighborhoods arrive to be met at the dock by the neighborhood that was adjacent to them in the old country. Most arrive alone, few with a family member already here. But the Irish no longer come with scant education and a willingness to work at whatever they can find.

"I am a graduate forester," Reynolds said, "and I have applied to the U. S. Forest Service for a job. They have some volunteer work opportunities in the West, in Wyoming, where they will feed and board me, but no pay. I am applying for that. It is in my field, and I feel it will lead to something permanent."

Monica Diggins of Dorchester listened as we spoke, and nodded. She told of a time ten years ago when she and her husband and two children came to Boston from County Kerry with just $93. "We knew no one here," she said. "We got here on a Friday and had jobs by the following Tuesday. We worked very hard, and I'd say to anyone in Ireland wanting to come here now, 'Come ahead, but be prepared for hard times.' "

Young Ronan Reynolds nodded and smiled and said he had to leave. He hurried down the steps to the street, looked up at the sky and then at me, and said, "You know, right now I can feel the Irishness of Boston."

Yes, it's still in the air. □

Amid the bones of a Spanish galleon, sunk in battle in the year 1600, divers gather Ming dynasty plates, part of a rich cargo uncovered 170 feet deep off the Philippines. The robot **Geek** *lights the scene.*

FREDERIC OSADA

An Account of Adventure, Deceit, and Intrigue

SAN DIEGO

By FRANCK GODDIO

Photographs by EMORY KRISTOF
NATIONAL GEOGRAPHIC PHOTOGRAPHER

ON DECEMBER 14, 1600—the year Shakespeare wrote *Hamlet*, the year the first crude telescope was invented in the Netherlands—a Spanish merchant galleon called *San Diego*, hastily outfitted for war, sailed from Manila Bay before dawn in an attempt to repel two Dutch intruders.

The Dutch vessels, *Mauritius* and *Eendracht*, had no plans to attack the Philippines, a Spanish possession since 1565—forty years after Magellan landed and died there. Their mission was to find trade routes and plunder incoming ships.

CORAL-ENCRUSTED DAGGER HILTS, MADE OF STEEL, WOOD, AND SILVER

Commanding the 270-ton *Mauritius* was Olivier van Noort, a rough Rotterdam innkeeper in his early 40s seasoned in European shipping and probably in pirating. The 300-ton *San Diego* was led by Seville-born Antonio de Morga, 41, the lieutenant governor of the Philippines and chief justice of the colony's supreme court.

It should have been an easy victory for *San Diego* and her companion ship, *San Bartolomé*. They carried more than 500 freshly armed men against barely 90 Dutch sailors, the remnants of a fleet of four ships and 248 men that had set sail from the Netherlands two years earlier and had been whittled down by a disastrous crossing of the Atlantic, pummeled by the Strait of Magellan, and malnourished by Pacific-crossing rations of Chilean bird eggs and salted penguins. But by early afternoon *San Diego* and most of her crew were sinking to the bottom of the

South China Sea, *San Bartolomé* had captured *Eendracht* only after a chase, and the stunned crew of *Mauritius* was praising God for victory and escaping toward home on the wind caught by her one remaining sail.

I became intrigued by the battle after reading the accounts of the ships' commanders. Antonio de Morga survived to chronicle a valiant, if ill-fated, Spanish fight in *Events of the Philippine Islands*. For the Dutch perspective I had Olivier van Noort's memoir, *My Arduous Journey Around the World*. De Morga wrote of a struggle "obstinately and bitterly waged on both sides so that it lasted more than six hours," until the pounding of the battle caused his ship to "burst asunder at the bows." Van Noort boasted that even though his men were far outnumbered by the Spanish "we gave them such a welcome . . . with our pikes and muskets that their ardor was terribly cooled."

When I set out to find *San Diego* with my team from the European Institute of Underwater Archaeology, I was not looking for gold and jewels but for cultural treasure. I knew the ship would be a time capsule of what the crew had brought on board for a voyage into battle. I also knew that the search was an opportunity to add to our knowledge of the naval architecture of that era.

SOLDIER'S BRONZE HELMET LAY NEAR A SHIELD AND HUMAN SKULL. BOTH BY J. C. REVY AND P. H. BOURSEILLER, *LE FIGARO*

An Inglorious Sinking

"Surrender, dogs!" cried armored Spanish soldiers, surging from San Diego*'s crowded deck to battle the Dutch aboard* Mauritius *on December 14, 1600. Victory seemed certain, but six hours later* San Diego *plunged to the bottom of the South China Sea, taking 350 crew with her.*

Mauritius *had approached Manila Bay to attack ships coming to the Philippines. Antonio de Morga, lieutenant governor of the Spanish colony, countered with the 300-ton galleon* San Diego, *whose crew of some 450 included Japanese mercenaries and Spanish aristocrats.*

According to de Morga's account, his men fought gallantly for hours after San Diego *rammed* Mauritius. *Archival research tells a different tale. So overloaded was* San Diego *that her cannon were useless, their gunports below the waterline. After the initial attack, the battle fizzled as de Morga, possibly seasick, cowered behind the capstan. When he suddenly ordered his leaking ship to be cut loose, the "sea devoured her in one fatall morsell," wrote a 17th-century chronicler. A Spanish cannon (below) stayed buried for almost 400 years.*

PAINTING BY GARY KELLEY; GILBERT FOURNIER

Neither the rich nor the pious were spared in the San Diego *debacle. An ivory-and-gold rosary (opposite) may have been last clutched by a well-appointed priest on board. At least a hundred noblemen died. Among the gold artifacts found were a heraldic seal and a ring.*

Nothing in the historical record told me precisely where *San Diego* had gone down. De Morga wrote that he swam six miles, carrying two flags captured from *Mauritius*, to "a very small unpopulated islet, named Fortuna . . . where some of the ship's crew who were strong enough to survive in the water, had also found safety." But clearly he was exaggerating the distance in the strong currents that parallel Fortune Island, 20 miles south of Manila Bay.

There were other mysteries. How had so few Dutch held off so many Spanish? And why did so many Spanish go down with *San Diego* when they had the sound, undermanned *Mauritius* alongside for the taking?

BOTH BY J. C. REVY, *LE FIGARO*

THE LATE 16TH CENTURY saw the Protestant Dutch challenging Catholic Spain for control of the most precious commodities of the day: porcelain and silks from China and cloves, cinnamon, pepper, mace, and nutmeg from the Moluccas—the Spice Islands of what is now Indonesia.

Five Dutch fleets left for the East Indies in 1598. Three sailed east around the Cape of Good Hope. Two sailed west, hoping to learn in the Pacific the routes of Spain's Manila galleons—the ships that carried Asian goods to Europe via New Spain (today's Mexico) and returned to the Philippines with New World silver.*

*See "Track of the Manila Galleons," NATIONAL GEOGRAPHIC, September 1990.

Olivier van Noort, aboard the flagship *Mauritius*, led the second westbound fleet, landing in the Philippines a year behind schedule on October 16, 1600. *Mauritius* and the fleet's other surviving ship, the smaller, 50-ton *Eendracht*, anchored 200 miles southeast of Manila. They obtained fresh food and water from Spanish officers by pretending to be French; van Noort dressed one of his sailors as a Catholic priest. The ruse lasted barely ten days, but the Dutch escaped.

More luck came as they sailed toward Manila Bay; seizing a Chinese vessel, van Noort and his crew were told that 400 junks came from China and Japan every year between December and April. Two Japanese ships were due soon. And—if it had made good time from Acapulco—a Manila galleon might arrive in December with chests of silver pesos.

Van Noort knew his small crew was no match for the well-equipped Spanish. But the chance to steal the cargoes was worth the risk of waiting, and risks were what he had come halfway around the world to take.

In Manila the mood was desperate. The news of van Noort's arrival gripped the city of some 2,000 Spaniards, 15,000 Chinese, and perhaps 20,000 Filipinos. The colony survived on the transpacific Manila galleon trade, and any disruption in that network meant ruin. Worse, the city was virtually defenseless; the Spanish fleet was off fighting Muslim insurgents in the south of the Philippine archipelago.

It was exactly the sort of crisis de Morga had been waiting for. For two years he had been lobbying the king for promotion to the Americas. Now, if he could personally capture these Protestant pirates, it would be his ticket out.

De Morga was possibly the most powerful Spaniard in the Philippines. He had the ineffectual governor firmly under his thumb, and, more important, he was a member of the *audiencia*, a supreme court composed of four magistrates called *oidores*. As first oidor, de Morga had the authority to indict anyone.

Lacking a navy when the Dutch appeared, the audiencia decided to requisition and arm

J. C. KEVE, LE FIGARO (RIGHT)

Leaving no piece of ballast unturned or mound of sediment unsifted, divers picked up items as tiny as shoe buckles, belt clasps, and an insignia pin (left). Some 430 coins were found—"pocket money to tip and gamble with," says an excavator. Coin of the realm, a silver eight-real piece (below) was minted in Mexico.

merchant ships anchored in the adjacent port of Cavite. De Morga saw to it that he was nominated to outfit the ships. With his mania for organization, he managed, within 30 days, to oversee the final construction of a lateen-rigged vessel christened *San Bartolomé* and to equip the galleon *San Diego* with 14 cannon borrowed from Manila's fortress, 127 barrels of gunpowder, and thousands of cannonballs and musket balls. Should a lengthy chase be necessary, he stocked barrels and clay jars with food and drink.

But when de Morga set out to recruit the ships' crews, "one and all," he wrote, "showed little enthusiasm for an undertaking that involved more risk and danger than personal profit." Yet, he continued, it was understandable that anyone inclined to volunteer would hesitate "until he knew who was to command the fleet." The dilemma was solved, according to de Morga, when the governor "saw that the whole of the citizenry were willing to sail with the fleet if Dr. Antonio de Morga went in charge of it."

The whole of the citizenry was, in fact, appalled. Though de Morga was gifted as a lawyer and administrator, he had no military training on land or sea.

To appease his military officers, the governor appointed as vice admiral of the fleet and head of *San Bartolomé* Capt. Juan de Alcega, a man de Morga had earlier convicted on charges of fleecing the Royal Treasury.

FRANCK GODDIO founded the European Institute of Underwater Archaeology in 1984. An international economic adviser, he lives in Madrid.

IT WAS de Alcega whom de Morga would blame for the *San Diego* disaster. De Alcega did not stay with *San Diego* as ordered, charged de Morga, but instead sailed after the escaping *Eendracht*. Captain de Alcega defended himself, saying that de Morga's men urged him to pursue the Dutch ship—which he took following a chase of several hours.

Though de Morga threw de Alcega in jail, I knew from published government records in the Spanish Archives that Manila's people blamed de Morga. Some 350 men were dead, among them 109 aristocrats. Protected by the power of his offices, de Morga weathered accusations of negligence, incompetence, and cowardice and posted his stirring account of the battle to King Philip III in Spain—apparently before any of his detractors could send their own accounts. In July 1603 de Morga sailed again, to take up his long-awaited posting in Mexico.

But I learned the true depth of de Morga's failure to command *San Diego* when archivist Patrick Lizé began searching the Spanish Archives for unpublished details of the battle in order to pinpoint the wreck's location. In Seville he found 101 pages of secret testimonies from 22 *San Diego* survivors, taken behind de Morga's back by the other members of the Manila audiencia between January and June 1601, when battle memories

Final Resting Place

An imposing ship in her time, **San Diego** ***disintegrated in a salty tomb, the cargo settling to the seafloor. For two seasons divers carefully cleared the site with suction tubes (below), uncovering the ship's hull and a bounty of relics.***

"It's like an aquarium," says excavation chief Franck Goddio of the view from a two-person submarine, part of the project's sophisticated gear. From his picture

window he admires a stoneware storage jar. Goddio discovered the wreck using nuclear magnetometers to detect the iron of the cannonballs.

J. C. REVY AND P. H. BOURSEILLER, LE FIGARO (ABOVE); GILBERT FOURNIER

Left alone, San Diego's *storage jars would have formed an intricate coral reef (right). Divers pulled up 570 jars—the largest sunken sample ever discovered—including a huge water jug (above). Inside the jars divers found animal bones, residue of spices, and eggshells.*

were fresh in the minds of the survivors.

Sworn to the law of Spain, the impassioned witnesses ranged in rank from captain to surgeon to sailor to deckhand. There is no record that anyone in Spain ever read or acted on their words, which they prefaced by making the sign of the cross. Perhaps de Morga's promotion to Mexico had already been dispatched when the testimonies arrived, and they were simply filed away as an inconvenient detail in the career of a powerful man.

The survivors occasionally differ in their descriptions of the battle, but not in any substantial way. All agree with witness Lt. Pedro Pinto de Almeyda: The loss "was all due to the bad leadership and lack of experience of Dr. de Morga, for trying to be in charge of something he knew nothing about."

With the secret testimonies to flesh out van Noort's account—and correct much of de Morga's—I could now picture the course of the battle, a tragic comedy of errors.

CHAOS REIGNED from the start, according to the testimonies. Perhaps a hundred soldiers and sailors filled the 70-foot *San Bartolomé*. At least 450 men—including Filipino and black shiphands and servants, Japanese mercenaries, and 150 Spanish noblemen—overfilled the 115-foot *San Diego*. Some of the men had been hastily reassigned from a Portuguese ship, which de Morga scratched from the fleet at the last minute.

San Diego crossed the bay from Cavite to Mariveles "so overloaded and unsteady that the people on board feared . . . something disastrous might happen," testified sailor Benito de el Huerto. "The water was up to the gunports and the ship was so full below deck with beds and boxes [that] the cannon could not be . . . used."

San Diego's owner, Luis de Belver, begged de Morga to take on more ballast and jettison some cargo. De Morga replied that this would only give the pirates time to flee. Instead, testified Capt. Lope de Rada, de Morga ordered the gear on deck stowed below, "which resulted in the hold being cluttered up so much that there was no room to treat the wounded, nor room to put out a spark that might fall on gunpowder—it was a wonder the whole ship didn't blow up."

Sometime after midnight on December 14, *San Diego* weighed anchor "stealthily," without firing a signal shot to alert *San Bartolomé*. The night was stormy, the seas chopped by a northeast wind so strong the crew could run up only the foresail, raising the mainsail and main topsail after sighting the Dutch at dawn. "The ship was listing so badly all the men had to put their weight on the windward side," said soldier Juan de Santiago, "and . . . throw the stove and a barrel of meat near the side overboard."

When van Noort saw *San Diego's* sails breach the horizon, he ordered his companion

ship *Eendracht* to "race toward home," with duplicate records of all they had learned, while he prepared for battle.

Mauritius got off the first cannon shot, tattering *San Diego*'s mainsail and destroying one of her two bilge pumps. De Morga's chief gunner told him they could not fire back "because the ship was too cluttered below, and . . . water was coming in the gunports."

De Morga gave orders to grapple onto *Mauritius* but didn't order the sails lowered for the maneuver. *San Diego* hit the Dutch ship "at full sail," testified Captain Lope de Rada, "which this witness believes caused [*San Diego*] to spring a leak, as he has been in similar situations and knows you shouldn't grapple in that fashion."

Shouting "*Amaina, perros*—Surrender, dogs," some 30 armed Spaniards stormed the Dutch ship. They seized her flags, raised their own, and stripped the main and mizzen masts of sails and rigging.

Van Noort and his 58 men retreated below-decks and asked for terms of surrender. Then *San Bartolomé* reached the battle site and opened fire on *Mauritius*. "Don't shoot, Your Honors, we're friends," yelled the Spaniards on board. An officer told Juan de Alcega the enemy ship was captured and he should try to catch *Eendracht*.

Benito de el Huerto carried the Dutch stern flag back to de Morga and told him "the enemy was offering no resistance . . . and that he should order the men to jump on board as the ship had yielded and [her] men were hiding." Sitting near *San Diego*'s stern, behind the capstan, surrounded by mattresses, his back to the enemy, a "faint and discouraged" de Morga answered: "Do what you can."

Perhaps suffering from seasickness, and what we might today call an anxiety attack, de Morga was nearly catatonic—unable to give orders, without which nothing could happen. Gunner Juan Giraldo reminded him of the honor at stake, but de Morga said, "What do you want me to do?" The men tried to revive him with a drink of water, with no success. Far from waging the pitched, six-hour battle that de Morga later detailed in his written account, the crew of *San Diego* spent most of the encounter awaiting his commands.

A fire then began smoldering on *Mauritius*, set by Olivier van Noort in order to get his men back on deck. "When the enemy realized [de Morga's] lukewarmness . . . [the enemy] found courage," said gunner Giraldo, "and started to fire his cannon and muskets."

The Spanish could scarcely reply—*San Diego* was sinking. Diego de Santiago, a Jesuit father who would drown with the ship, exhorted the men to save their lives and jump onto *Mauritius*. "Where is your courage?" he shouted. "Don't be food for the fishes!"

Now de Morga, alarmed by the smoke rising from *Mauritius*, rallied to give an order—not for his men to storm the Dutch ship but to cut the ropes linking her to *San Diego*.

But, as Lt. Pedro Pinto de Almeyda testified: "Dr. de Morga made a very big mistake in giving orders to push away from the enemy, when the ship was going down, without ordering the soldiers to jump on board."

From the deck of *Mauritius*, van Noort watched as *San Diego* "went straight to the bottom like a rock." His crew extinguished the fire, killed five Spaniards who remained on board, and fired cannon and jabbed pikes at the sea-washed men, many struggling to shed heavy armor and "crying for mercy." Only five of van Noort's men had been killed, 26 wounded.

De Morga—contrary to his account—was one of the first to abandon ship, pushed toward Fortune Island by his personal secretary "on a raft which he made from a mattress." The witnesses do agree with de Morga about one thing: He escaped carrying two Dutch flags.

WITHOUT THE DETAILS provided by the testimonies, I would not have found *San Diego*. The men said they landed on Fortune Island, so I knew the wreck should be near the beach on the cliff-hugged island's southeast end: Some of the men were swimming with gunshot wounds and could not have made any great distance.

I drew up a manageable survey zone two and a quarter miles long and one and a half miles wide, just offshore of Fortune.

The ocean floor there drops as deep as 230 feet and is covered with scattered coral reefs, many the size I expected *San Diego* to be. A sonar scan would not be able to distinguish the wreck from these natural mounds. So I equipped my survey catamaran, *Kaimiloa*, with nuclear magnetic resonance magnetometers to detect the ship's residual iron.

JEAN-MARC BOUR (ABOVE); J. C. REVY AND P. H. BOURSEILLER; ALL *LE FIGARO*

A Porcelain Collection That Went to War

Along with chests of clothes, barrels of gunpowder, and jars of wine and pickled meat,* San Diego *sailed into battle with cupboards of fine china. Divers found more than 800 intact pieces of the distinctive cobalt blue-and-white porcelain from the time of the Ming dynasty's Wan-li reign (1573-1620). The trove contained plates, bowls, and serving vessels, decorated with airy paintings of plants and animals, including a group of frolicking deer (top)—a common motif.

Porcelain arrived in Manila on Chinese junks. Made for export, pieces from the period became known as Kraak ware, named by the Dutch after they seized some from Portuguese ships, or carracks. The delicate water dropper (above), used in the preparation of ink, was likely the property of* San Diego*'s owner, Luis de Belver.

A Chinese figure, perhaps an immortal, enlightens the surface of a 13-inch jar. A carp, emblem of good luck, dignifies a covered box. The meanings were probably lost on the owners; not until the 1700s did Westerners show interest in Chinese symbolism.

Tendrils appear to sprout on a skillfully made kendi, *or pouring vessel (above). The porcelain collection is valued at more than a million dollars.*

J. C. REVY AND F. H. BOURSEILLER, *LE FIGARO* (ALL)

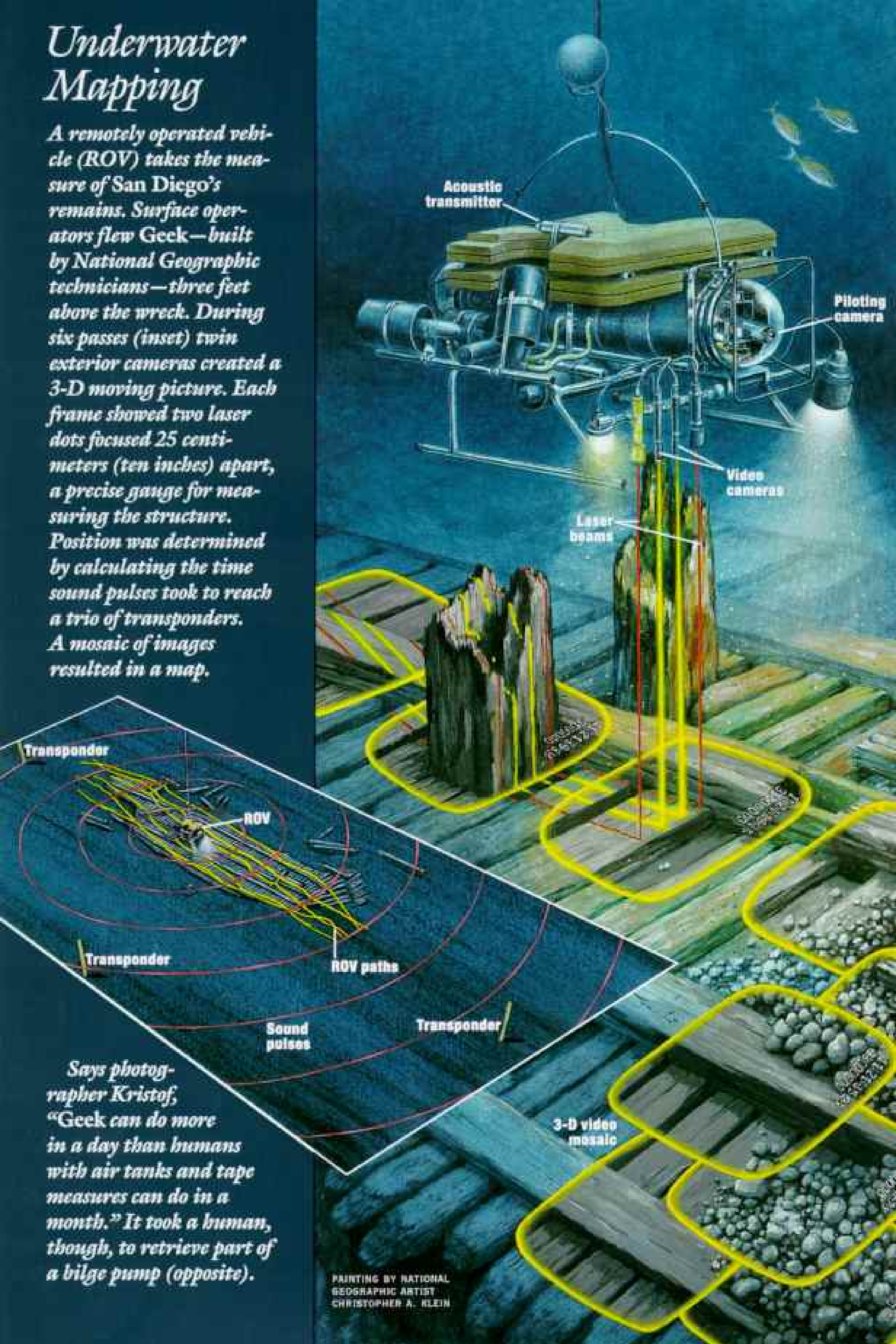
Kraak Artistry Intact After 400 Years

Captured in soft blue-gray hues, a duck graces a six-inch jar, possibly a container for ginger or another spice. Buried in sand for nearly four centuries, the Kraak pieces did not fade in color. The only disfigurement occurred where water infiltrated cracks and oxidized metals in the porcelain, leaving rust.

Underwater Mapping

A remotely operated vehicle (ROV) takes the measure of San Diego's *remains. Surface operators flew* Geek—*built by National Geographic technicians—three feet above the wreck. During six passes (inset) twin exterior cameras created a 3-D moving picture. Each frame showed two laser dots focused 25 centimeters (ten inches) apart, a precise gauge for measuring the structure. Position was determined by calculating the time sound pulses took to reach a trio of transponders. A mosaic of images resulted in a map.*

*Says photographer Kristof, "*Geek *can do more in a day than humans with air tanks and tape measures can do in a month." It took a human, though, to retrieve part of a bilge pump (opposite).*



PAINTING BY NATIONAL GEOGRAPHIC ARTIST CHRISTOPHER A. KLEIN

A document from Manila's Royal Arsenal listed the ship's weaponry, including more than a thousand cannonballs of various sizes. Centuries of saltwater corrosion would have left, at most, a thousand pounds of iron, and I calibrated the magnetometers accordingly.

For three weeks in April 1991 we motored *Kaimiloa* down one side of the rectangular survey zone then up the other, working from the outside in, towing three magnetometers behind us. But the anomalies they transmitted to our control screen all proved to be modern wrecks or natural pockets of geomagnetism. Had de Morga told the truth about swimming six miles? I had to wonder.

We were making nearly our last transect, down the center of the survey zone, when the detectors registered a force of 500 pounds of iron, almost too small to bother checking out. But diver Gilbert Fournier returned to the surface with a smile. *San Diego* lay 170 feet beneath us, not a quarter mile from shore.

IN THE FRAIL BLUE LIGHT that remains at that depth, the disintegrating, coral-encrusted *San Diego* looked at first glance like a natural reef inhabited by moray eels and thick schools of fish. But hundreds of huge stoneware jars formed a crown on its port side, and here and there cannon and anchors poked through the stone ballast.

Work began in January 1992, after typhoon season. The European Institute of Underwater Archaeology excavated *San Diego* jointly with the National Museum of the Philippines; we were financed by the ELF Foundation, the cultural arm of France's largest petroleum company. The team of 52 included archaeologists from the National Museum—led by director Gabriel Casal—divers, a doctor, photographers, and technicians, as well as crews for *Kaimiloa*, the supply tender, and a 158-foot-long platform vessel—our headquarters.

The 18 divers went down four at a time, in teams of two, like a perfectly tuned ballet. Half wore scuba tanks, which allowed them 30 minutes of bottom time; half could stay down 40 minutes, using diving helmets linked to the platform ship by air hoses. Piloting a two-seat submarine, I studied the ship for hours at a time, sketching the site and overseeing the excavation.

As the divers carefully removed the overlying silt, they began to find gleaming blue-and-white Chinese porcelain; it was probably kept on board by *San Diego* owner Luis de Belver, who drowned with his ship. The more than a thousand pieces—most of them, surprisingly, intact—were made during the reign of the Ming dynasty's Wan-li emperor, who ruled China at the time of the battle. Most of the plates and bowls were decorated with deer, often a symbol of immortality, and may have been holdovers from *San Diego's* days as a merchant ship as well as dinnerware for the aristocratic crew members recruited by de Morga. The collection also included 35 slender-necked porcelain pouring vessels, an extremely rare find.

The majority of the pieces, with their floral or pastoral decoration, were crafted for export; the bowls have lips, for example, which appealed to Europeans. They are superb examples of Kraak porcelain, so named by the Dutch because the first shipments to reach Europe were carried by Portuguese ships called carracks. (The Chinese kept the finest porcelain for themselves and guarded the secret of making it until the 18th century.)

FREDERIC USABA

Disarming a galleon, a diver prepares to lasso a cannon and guide it up onto the salvage boat. All 14 of San Diego's *cannon were found, each with an unfired ball inside. Unspent ammunition included a litter of lead shot (below). Human remains were few, most having been carried off by currents.*

JEAN-MARC BOUR (TOP); J. C. REVY AND P. H. BOURSCILLER, LE FIGARO

National Geographic, July 1994

San Diego's goods also included a slightly rougher blue-and-white porcelain that the Chinese sold to Southeast Asia. And we found one exquisite piece perhaps made for the Japanese market, a delicate, eggplant-shaped water dropper that would have been used to moisten an inkstone, which we also recovered. These may have belonged to de Belver or to one of the Japanese crewmen on board. I knew that de Morga had hired Japanese mercenaries—sometimes used by the Spanish to suppress rebellion among Manila's Chinese population. The 24 bronze Japanese sword hilts we took from the wreck bear witness to the men's fate.

More humble than the porcelain, but no less exciting to scholars of ceramics, are *San Diego*'s 570 stoneware and earthenware jars for storing food, oil, water, and wine. It's the largest single collection of such jars ever found—an unprecedented chance to date and study Southeast Asian pottery styles of the late 16th century.

The stoneware jars were imported from China and the countries now known as Vietnam, Thailand, and Myanmar, where potters had the technology to fire clay at temperatures reaching 2400°F and create these very hard, nonporous containers. The ship's more fragile earthenware jars came from the Philippines and Mexico. We needed special nets to bring up the largest stoneware jars, nearly four feet in diameter. They may have come from Myanmar; similar jars are being made there today.

Inside *San Diego*'s jars we found the bones of chicken and cattle, wild boar tusks, almonds, hazelnuts, eggshells, and residue of beans and coconut. The broken bottom of one jar was lined with what looked like yellow textile. Examining it after it had dried, I suspected that it was curry powder; lab tests later confirmed my hunch.

As we laid out each day's discoveries during our three months of excavation, the deck seemed transformed into an international bazaar. *San Diego*'s cargo testifies to the array of Asian, European, and American cultures that had come together in the Philippines by the year 1600: the china and Asian pottery; the earthenware olive-oil jars from Spain and Mexico; the silver coins—pocket change—from Mexico and South America; and the candlesticks and silverware that also came on the Manila galleons. There were bronze mortars and pestles for grinding pepper and other spices, garlic, and drugs; bronze Spanish sword hilts and bronze shoe buckles that once shone on the uniforms of the ship's officers and noblemen; a thin gold Asian neck ring; and a handful of gold rings, book clasps, and document seals with family crests, whose ownership I hope to trace. And who might have owned the ivory chess and checker playing pieces found in the stern? Both de Belver and de Morga had sleeping quarters there. The ivory-and-gold rosary we found near the bow may have gone down with the Jesuit Father Diego de Santiago.

From the stern we recovered a nearly intact bronze astrolabe, used to determine latitude. Only six others predating 1600 and in similar condition are known. The ship's bronze-and-glass compass also lay here—among the few of its era ever found.

One morning we hauled up a 220-pound disk, with no clue as to its use or composition; some guessed wood, others stone. Then as the day warmed, a wonderful scent drifted across the deck. "Who's putting on cologne to go diving?" I laughed, then realized the disk was made of an aromatic resin probably used for caulking. I thought of the testimony offered by the boatswain's mate, Juan Rubio, who placed blame on de Morga for not having "shipwrights down below to caulk and plug any damage the enemy might have done."

IN OUR SECOND SEASON of excavation we concentrated on the remains of the ship itself. Most of *San Diego* disintegrated long ago, destroyed by wood-eating shipworms and relentless currents. But once the 150 tons of ballast was removed, stone by stone, it became clear that parts of the hull had survived—the keel, ribs, and some planks and stanchions remarkably well preserved. We found the rudder turned, pointing the ship toward Fortune Island—possibly a last ditch gesture made by a desperate pilot.

These parts of *San Diego* offer a rare look at how a Spanish galleon of that era was constructed—and our first chance to study a Spanish vessel built in Asia. We knew that she was built on the Philippine island of Cebu, largely by Filipino laborers. From wood samples we took on the site, marine archaeologist Michel L'Hour determined that the ship was built from tropical hardwood. Working from drawings and measurements

Prizes from the past undergo desalination and chemical cleaning in a Manila warehouse. After a world tour, most of San Diego's *artifacts will reside in Manila's National Museum. Planking (right), traced and measured, was returned to the deep, buried in sand with the rest of the ill-fated galleon.*

he made on the site and from observation of video images from the robot *Geek* (page 52), L'Hour concluded that the ship is of traditional Spanish design, showing no Asian influence. Also, she was not very well built—seeming barely up to the rigors of trade, much less fit for a battle. The ship has been covered with sand for protection, should future archaeologists want to take another look.

Despite the number of crew who drowned in the battle, we found few human remains. I suspect that the fragments of 12 skulls and other scattered bones we discovered belonged to the men caught belowdecks. Most of the bones were found near cannon, which may have crushed the victims. A study of the remains is now under way to determine the age and health of the men who went down with the ship. Among the first results was a stunning discovery: The pelvic bones found under one cannon belonged to a woman.

Nothing could have surprised me more. A woman on board a warship? Could she have disguised herself as a man to seek adventure in life? Could she have been hired on as a prostitute? Or is there another explanation? Of all *San Diego*'s mysteries, this unknown woman's presence is the most haunting.

WOULD HISTORY have been different if *Mauritius* had not escaped? Probably not. By the time Olivier van Noort returned to Rotterdam in August 1601, other Dutch ships had cracked Spain's trade monopoly on the Spice Islands. Within 40 years the Netherlands controlled most of Indonesia and was becoming one of the richest countries in the world. But, in spite of repeated attempts, the Dutch never broke the Manila galleon trade.

Antonio de Morga eventually became president of the Royal Audiencia in Quito at age 56. Shortly before dying in 1636 at age 77, he was relieved of his duties and fined 2,000 gold ducats "for having lewd relations with much publicity with many women."

Probably the battle changed history most for the families of the hundreds of men who needlessly sank with *San Diego*. I see the artifacts we recovered from the wreck, and the voices of truth we discovered in the Spanish Archives, as fitting memorials to them. □

V I R U

Scared but holding steady, a Brazilian boy offers his arm for vaccination against the mosquito-borne yellow fever virus. Bringing misery to the vulnerable, viruses cause diseases ranging from the common cold and measles to hepatitis and AIDS. Viruses appear to infect all living things—yet are not quite alive themselves. Particles of genetic material—the essence of life—they lie as inert as the dead until an opportunity arises to invade a host.

On the Edge of Life
On the Edge of Death

S E S

BY **PETER JARET**

PHOTOGRAPHS BY **KAREN KASMAUSKI**

The front line against infection

■ Sealed away from the healthy, a member of a U. S. Army medical evacuation team plays the role of an infectious patient during a drill in West Virginia. In a real emergency—the outbreak of a savage virus somewhere in the world—

the team speeds a few victims to Fort Detrick, in Maryland. There, the victims receive specialized care while offering scientists a chance to develop a strategy to combat the virus.

An African catastrophe

■ Sorrow weighs as heavy as the decades on 80-year-old Christina Mukakibibi, mourning in Uganda at the grave of her eighth child—a 38-year-old daughter —to die from AIDS. A widow, she now has three grandchildren to care for. AIDS

has orphaned hundreds of thousands of Ugandan children. Its swift spread provokes the question: How many other deadly viruses await introduction from their hidden tropical reservoirs to the rest of the world?

VIRUSES

FIRST CAME FEVER. Then Hamid Mansaray, a young nurse's aide at a remote African hospital, began to hemorrhage. Blood erupted from his nose and mouth. It burst out of capillaries beneath his skin and eyes.

By the time I reached the village of Panguma in Sierra Leone, Mansaray lay isolated in a special ward. Doctors had diagnosed an obscure illness called Lassa fever. Its cause was a virus, an infective agent so small that 100,000 all clumped together would still scarcely be visible. Viruses are little more than bundles of genes—strands of DNA or RNA, the molecules that carry the blueprints for all life. Yet viruses are far from simple. They invade our cells, causing ailments as benign as a common wart, as irritating as a cold, or as deadly as this bloody African fever.

The virus that causes Lassa fever is one of more than a dozen that researchers call hot agents—viruses that spread easily, kill swiftly, and have no cures or vaccines. Scientists who study hot agents at the U. S. Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia, must wear suits hooked to outside air supplies and enter a lab via airtight hatches that seal behind them. All materials leaving the lab must be sterilized or burned to ensure that nothing hazardous escapes.

No such facilities existed in Panguma.

"We have to take every precaution," said Larry Parker, a physician at the hospital, as we put on medical gowns, latex gloves, and paper masks.

The Lassa virus swarms not only in the blood and urine of infected patients. It can also become airborne, a major reason CDC scientists categorize this virus as hot. It is also what made my chest tighten as we entered the Lassa fever ward. I knew that in neighboring Liberia a medical team had unsuspectingly treated a pregnant woman who was infected with the Lassa virus. Within four weeks two patients from the ward and two of the hospital staff were dead.

Parker pushed aside a curtain and led me into the dimly lit ward. Alone in one corner Mansaray rested under a thin sheet on a metal cot. His chest rose and fell spasmodically. When he learned he had a visitor, he struggled to raise himself. "They announced my death in the village," he said in a rasping whisper. "They said: 'Hamid is dead.' Yet here I am."

Indeed. Although some cases of Lassa can be mild, few people survive the Lassa virus if it progresses to the stage of bleeding. Somehow Mansaray's immune system rallied to win out.

"Hamid is young and strong. He should recover completely in a few weeks," explained Parker. "He is also a lucky man."

Mansaray probably contracted the Lassa virus while caring for two small children who subsequently died. But the danger of infection lurks throughout much of West Africa. A species of rat carries the virus and can contaminate food and household items.

An even more frightening hot virus also resides in the dense rain forests of Africa. Producing a disease called Ebola fever, this virus was first documented in July 1976 when it struck a small village in Sudan. Victims became fevered and began to bleed, much as they do with Lassa fever. Ebola killed half the people it infected. In September it struck again, in Zaire, seemingly more virulent than before. Sweeping through more than 50 villages, it killed 90 percent of its victims. To prevent an explosive epidemic in the capital city, Kinshasa, the Zairean government sealed off all roads into the afflicted area.

Then Ebola subsided, disappearing as mysteriously as it had appeared. The virus is certainly still around, being harbored by some species of animal without apparent harm, just as rats carry Lassa without becoming sick. Despite an intensive search, epidemiologists have not identified the species that harbors Ebola. Isolated outbreaks continue to occur.

What keeps these hot viruses from spreading faster and farther? Nothing that scientists can document. Some suggest that, ironically,

An end in sight

■ Last known polio patient infected in the Western Hemisphere, Luis Fermín shows off his progress in walking to his doctor in Lima, Peru. Vaccination campaigns in still affected countries aim at global eradication of polio by the year 2000.

they may be *too* deadly. They might be killing their victims before they can infect enough new human hosts to sustain an epidemic.

Like all viruses, the hot agents need hosts to survive. They cannot reproduce on their own. To make new viruses, they commandeer the reproductive machinery of cells they invade.

Viruses use countless invasion strategies. For the past decade the deviousness of one in particular—human immunodeficiency virus, or HIV—has spread AIDS around the world. Most scientists believe that AIDS, like Lassa, originated in Africa decades ago.

Tropical regions may pose the greatest threat of unleashing viruses, simply because they contain such great concentrations of different species of plants and animals—and thus viruses that prey on them. As human populations penetrate previously uninhabited regions they may encounter viruses that have long remained sequestered.

Not far from Panguma hospital I toured areas where miners have cleared away dense vegetation for excavation. Thousands of men were living in shantytowns along the road.

"Crowded conditions and lack of sanitation can fuel an outbreak of Lassa," said Parker.

When a rare virus does emerge from its seclusion, modern air travel may offer it a free ride anywhere in the world.

In 1989 a 43-year-old mechanical engineer walked into a suburban Chicago clinic complaining of fever and sore throat. His doctors prescribed antibiotics and sent him home. The man soon died of Lassa fever. Physicians at the hospital discovered that the engineer had recently attended his parents' funerals in Nigeria. Both had shown symptoms of Lassa fever before their deaths.

"We had all the makings of a catastrophe," said C. J. Peters, who directs the CDC's Special Pathogens Branch. More than a hundred people came in contact with the patient before he died. Fortunately, none became infected.

PETER JARET, a medical writer based in California, wrote "The Disease Detectives" (January 1991) and "The Immune System: The Wars Within" (June 1986). Photographer KAREN KASMAUSKI's previous work for NATIONAL GEOGRAPHIC includes coverage of radiation (April 1989).

Standard sanitary procedures at the hospital, made more stringent since the advent of AIDS, may have prevented disaster. "Next time," says Peters, "we may not be so lucky."

VIRUSES have plagued humankind since the beginning of recorded time. An Egyptian bas-relief from about 1500 B.C. depicts a priest with a shriveled leg: a telltale aftermath of poliovirus. A 13th-century Arabic manuscript shows a crazed dog, tongue lolling, biting a horrified man: evidence that the rabies virus is also centuries old.

Some viruses have changed the course of human events. Historians believe that the Spaniard Cortés and his meager force overwhelmed the vast nation of the Aztec in 1521 with help from a virus. Some of Cortés's men carried smallpox, which had long existed in Europe but was new to the Western Hemisphere. The virus ignited a pandemic that is thought to have killed more than a third of the indigenous population.

For centuries the cause of such devastating outbreaks of disease remained a mystery. By the early 1700s the newly invented light microscope had revealed the single-celled organisms we now know as bacteria, which proved to cause such diseases as cholera and plague. But the agents that caused illnesses such as smallpox and polio remained baffling, invisible until the advent of the electron microscope in the 1930s. Under this powerful new instrument, capable of magnifying objects 7,000 times or more, viruses finally revealed themselves. Most were spheres hundreds of times smaller than living cells.

Ever more powerful instruments have aided the study of intricately shaped molecules projecting from the surfaces of these viruses. The shapes of these projections have turned out to be critical to a virus's ability to function. Each strain of virus has its own unique configuration of surface molecules. These surface molecules work like keys in a lock, enabling viruses to gain entry into hosts by precisely fitting the molecules on their surfaces to those on the membranes of targeted cells.

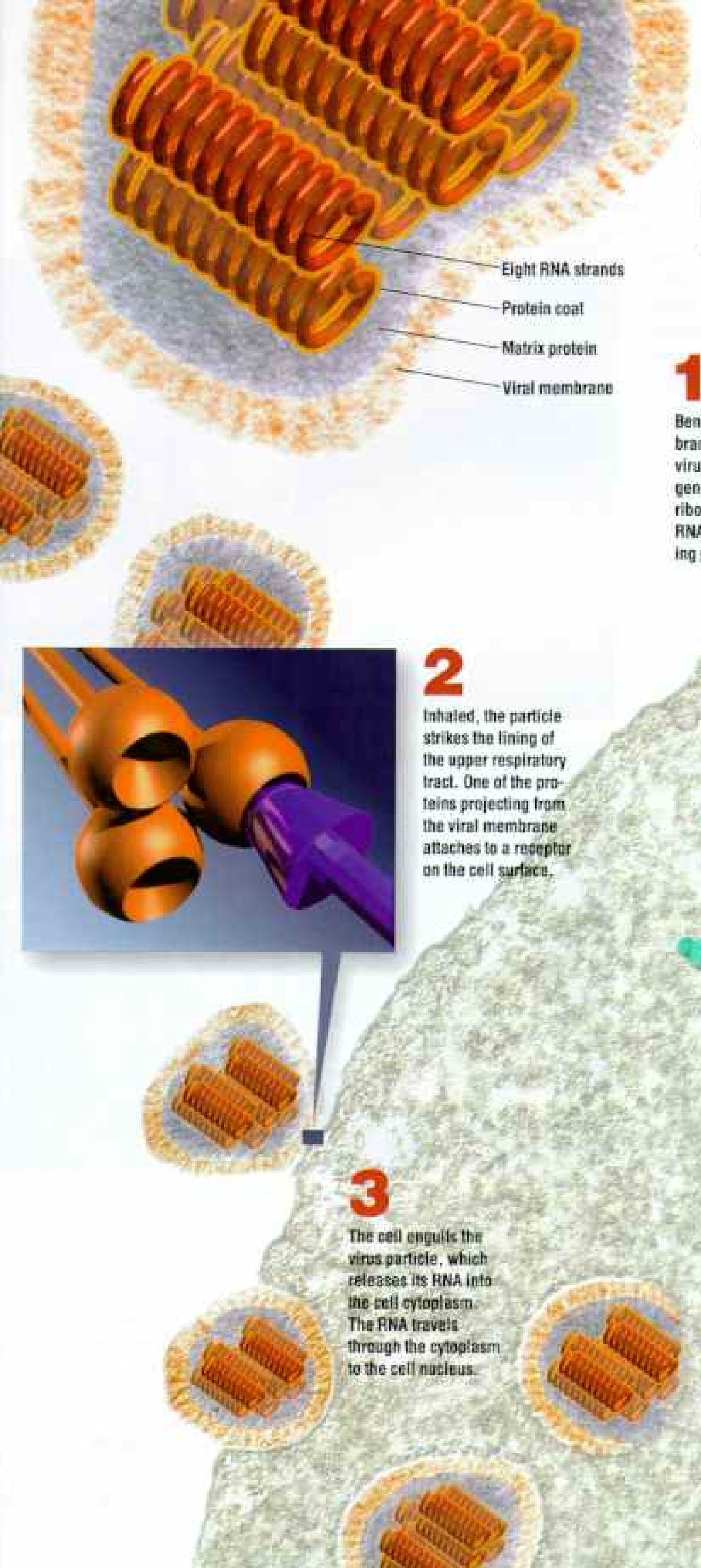
Until the moment a virus enters a cell, it seems more dead than alive. "Alone, a virus can't reproduce. It can't move on its own," Eckard Wimmer, a virologist at the State University of New York at Stony Brook told me. "It is as lifeless as a speck of dust."

At its core, a virus is pure information, encoded in the molecules of DNA or RNA. In

Sniffling for science

■ Straight up the nose of a University of Virginia student goes a dose of a common cold virus in a treatment and prevention study. Two days later, another infected volunteer deals with full-blown symptoms. The weight of mucus on tissues (bottom) indicates the severity of infection.

Invasion of the influenza virus



1

Beneath the membrane of an influenza virus particle lies genetic material—ribonucleic acid, or RNA—and surrounding proteins.

2

Inhaled, the particle strikes the lining of the upper respiratory tract. One of the proteins projecting from the viral membrane attaches to a receptor on the cell surface.

3

The cell engulfs the virus particle, which releases its RNA into the cell cytoplasm. The RNA travels through the cytoplasm to the cell nucleus.

4

In the nucleus the viral RNA (red) uncoils and takes over the cell's genetic factory. Primed with stolen pieces of the cell's messenger RNA (green), the viral RNA commands the production of thousands of strands of its own messenger RNA (blue).

"A virus is a piece of bad news wrapped in protein," said the late Nobel Laureate immunologist Peter Medawar. The bad news—genetic information—directs the virus's reproduction inside a host. For a flu virus the host site is the respiratory tract. A special protein on the surface of the virus particle passes cells with the wrong receptors and fits perfectly onto a cell lining the nose or throat. The virus then invades the cell, forcing it to make more virus particles. Mistakes often occur in this replication, altering the virus. In following flu seasons, our defenses offer less protection against new invaders.

10

As new virus particles travel down the respiratory tract, the body fights back: Antibodies from the immune system bind onto viral membrane proteins and inactivate the invaders.

9

Protein-covered RNA picks up its outer membrane and proteins at the cell surface as it buds from the cell. Before the cell dies, it may produce several thousand new virus particles.

6

Ribosomes decode the instructions of the viral messenger RNA for making viral proteins.

7

Ribosomes assemble proteins needed for new virus particles. Viral membrane proteins migrate to the cell surface. Interior viral proteins travel to the nucleus.

5

The viral messenger RNA strands migrate to the cytoplasm, where they seek out ribosomes, the cell's protein factories.

8

Meanwhile, the machinery in the nucleus has been producing viral RNA. Proteins arriving from the ribosomes envelop the viral RNA. Protein-covered viral RNA coils migrate to the cell surface.

living organisms those molecules, or genes, contain the instructions for building and maintaining cells. The instructions to make a new human, for instance, require some three billion bits of information. By contrast, the smallest virus consists of only about 2,000 bits of information.

Scientists speculate that viruses may have originated as primitive self-replicating molecules that later began to parasitize living cells. Or perhaps they began as genes within a cell that found a way to jump free and survive—"rebel human DNA," biologist Richard Dawkins of England's Oxford University calls them.

TODAY, IN EXPERIMENTS that herald a new age in medicine, viruses are being harnessed to save lives. "Viruses can target specific cells, slip inside, and carry new genetic information," explains Ronald Crystal, a professor of medicine at New York Hospital-Cornell Medical Center in New York City. To treat an inherited disease called cystic fibrosis, which occurs when children are born with a defect in the gene that helps lung cells prevent mucus buildup, Crystal spliced a replacement gene into cold viruses. The viruses, inhaled through a nasal spray, ferried the gene just where it was needed, into lung cells. Although experimental, the technique promises to help the estimated 30,000 U. S. residents who suffer from the fatal illness.

In the future, viruses will be an important tool for many other forms of gene therapy. Scientists at Biosource Genetics, a California-based biotechnology firm, are devising ways to use viruses to inject new genes into tobacco plants. The inserted genes will redirect the plants to produce potentially useful substances such as industrial chemicals or medicines—perhaps even anticancer drugs.

Despite such promise, however, viruses remain a deadly foe, capable of crippling or killing with terrible speed. As soon as a virus enters a living cell, its tightly bundled viral genes begin to unfold and drift through the cellular fluid. They inject themselves into the cell's own operating instructions, ordering its reproductive machinery to make multiple copies of the virus.

Soon thousands of viral clones, ready to be unleashed on the outside world, begin to bloat the cell. Some types of virus escape by slipping back out through the cell's membrane, a process called budding. Others keep multiplying until the swollen cell ruptures, releasing the new viruses to infect nearby cells and repeat the process. Either way, many viruses kill the cells they invade. If unchecked, such infections can destroy enough cells to kill the parent organism—in our case the human host. Or, as with polio, viruses can do irreparable damage. Infecting cells in the small intestine, poliovirus can spread to nerve cells, whose widespread death leads to paralysis.

Viruses probably plague every species of life on the planet. They infect monkeys and mushrooms, dolphins and dogs. They mottle the leaves of tobacco plants, blight tulips, and stunt the growth of tomatoes. Viruses even prey on bacteria. For years few looked for viruses in the ocean. In the late 1980s biologists found that a single teaspoonful of seawater may contain more than one billion virus particles.

Some viruses, such as the yellow fever virus, are transmitted by mosquitoes. Others are

Influenza's animal farm

■ In a steamy Nanchang slaughterhouse Chinese scientists prepare to take blood and mucus from pigs being processed. These samples will reveal which flu viruses have infected the pigs. Hosts for swine flu, pigs may also act as mixing vessels where strains of flu from other hosts such as ducks and humans exchange RNA. A resulting strain of human flu, radically changed, could cause a lethal pandemic.

Mucus swabbed from a farmer will help identify flu strains circulating among humans so that a new vaccine can be produced.

Threats in the wild

■ A knack for hitchhiking in animal hosts makes many viruses that devastate humans hard to control. In northern Brazil a mosquito caught in a vial (below right) may have picked up the yellow fever virus from a monkey that carried it with no ill effects. When a virus-bearing mosquito bites an unvaccinated human, a potentially fatal fever ensues —along with jaundice, which gives the disease its name. Tissue and blood samples from a monkey killed for meat by hunters (below) will help define an area of yellow fever infection so that health workers can target villages for vaccination.

A rat trapped with the utmost care in Sierra Leone (left) will provide information about the lethal Lassa fever virus, first identified in 1969. Rats carry the virus, likely transmitting it through their urine and fecal deposits in houses they infest. Do villagers inhale the virus with dried excreta or ingest it with contaminated food? The pathway remains unknown. As Ethleen Lloyd, a public health analyst at the Centers for Disease Control and Prevention in Atlanta, Georgia, notes with a smile, "We don't have any volunteers for infection." What is known: Blood and other body fluids from victims are highly contagious.

Tough problem, simple solution

■ Mother's milk, rich in antibodies, pumps Brazilian twins full of protection against a multitude of diseases —many caused by viruses—while their own immune systems gain strength.

Breast-feeding also eliminates the need for powdered formula, which infects infants with a diarrhea-causing rotavirus if mixed with contaminated water. Rotaviruses kill about a million children worldwide each year.

Clean water does not reach every home in the twins' section of Belém. Collection from a hole punched in the water main can easily lead to contamination.

carried in the air, spreading, like influenza, through the breath of infected hosts. The virus that causes foot-and-mouth disease in animals is one of the most contagious of all known viruses. Not long ago an outbreak in the French region of Brittany leaped across the English Channel to England's Isle of Wight. The virus was carried 170 miles by the wind.

Among human viral diseases, none is more widely spread than the common cold. What makes the cold so common? I asked one of the world's leading authorities, virologist Jack Gwaltney of the University of Virginia.

"At least four very different groups of viruses cause the symptoms we call a cold," he explained. "Adenoviruses. Coronaviruses. Myxoviruses. Rhinoviruses. Moreover, each of those has many varieties. More than a hundred distinct types of rhinovirus alone have been identified."

On the morning I visited Gwaltney in Charlottesville, students were actually lining up to catch a cold. Three dozen had volunteered to be guinea pigs for a promising new cold treatment in return for $350.

"Tip your head back," Gwaltney told each one. Then he raised a slender glass pipette and released a splash of pink liquid containing a dose of cold viruses into their nostrils. Technically, he was injecting a rhinovirus, named for *rhino*, the Greek word for "nose." Gwaltney called his concoction "Hank's virus"—because he had isolated it from a sneezing lab worker by that name.

Half of Gwaltney's volunteers were then given the potential cold remedy. All were confined for the next five days to hotel rooms to test the remedy's effectiveness. The results proved disappointing. Even the students who received the experimental medication suffered the sniffles and sneezes of a cold. Once again the long-sought-after cure for the common cold proved elusive.

OUR BODIES' MAJOR DEFENSE against colds—and all other viral diseases—is our immune system. Extraordinarily complex, it springs into action as soon as it detects an invading virus. Every strain of virus has uniquely shaped molecular configurations on its surface called antigens. White blood cells known as helper T cells can spot these antigens and mobilize the body's defenses. Scientists have learned that tens of thousands of different contingents of helper T cells patrol the bloodstream, each equipped to recognize a specific antigen. Such amazing diversity prepares the immune system to identify a vast array of possible invaders.

Once helper T cells spot trouble, they alert specialized agents known as B cells and killer T cells, which quickly begin to multiply. Killer T cells search out cells the virus has already invaded, chemically puncturing their membranes. Sacrificing the body's own cells, the killer Ts disrupt the viral takeover. B cells produce molecules called antibodies, which bind to the invader's surface, neutralizing the virus particle.

After the invader is destroyed, armies of long-lived T and B cells, called memory cells, remain behind, ready to spot the virus much more quickly should it invade again. The presence of these memory cells explains why many viral afflictions—childhood illnesses like measles and mumps, for instance—strike only once. After the first infection is successfully routed, the virus's subsequent invasions are

quickly put down. We have become immune.

Obviously the immune system sometimes fails to identify an unfamiliar strain of virus in time to avoid the messy battle we call a cold.

Cold viruses overwhelm us repeatedly because they exist in such diversity. No sooner have we become immune to one cold-causing strain, Gwaltney explained, than we become susceptible to another. There are plenty of strains to keep us sniffling and sneezing season after season. The large variety of cold-causing viruses also has stymied efforts to create a vaccine against the common cold.

"Most adults catch between two and three colds a year," Gwaltney told me.

Cold viruses invade and multiply in the cells in our noses and throats. Nasal secretions may contain hundreds to thousands of virus particles, which can stick to tabletops and doorknobs. Encased in protective coats, they can survive for hours, waiting for a hand to scoop them up or a finger to touch a nose or eye—ideal portals for entry.

"We probably pick up many colds just that way," Gwaltney told me. Not long ago he instructed a group of research volunteers to rub their hands with virus-killing iodine. During the course of the study those volunteers came down with significantly fewer colds than research subjects who did not use iodine. Disinfecting ourselves with iodine isn't practical. But washing hands with soap and water can help us avoid colds.

Still, it's no guarantee. Despite precautions, Gwaltney usually comes down with at least one cold a year. "I catch mine from my grandchildren," he said.

LIKE THE COMMON COLD, the influenza virus is often a repeat invader. More serious, and sometimes fatal, flu viruses evade the immune system again and again by slightly altering the shape of their antigens, so memory T and B cells don't recognize them as quickly. The viruses therefore gain time, consequently triggering the aches, pains, and fevers typical of a bout with the flu.

Even in an average year, influenza kills 20,000 U. S. residents. It is particularly dangerous to the elderly and people whose immune systems are already weakened by other diseases. They may not be able to fight off the infection, which eventually overwhelms their lungs. In a bad flu season, when a particularly virulent strain circulates, the U. S. death toll can reach 40,000 or more.

Periodically far deadlier flus strike. Unlike the slightly altered new flu strains, these killer viruses occur when their genes become assembled in an entirely new configuration that human immune systems have never encountered before and thus lack any defense against.

Five times in the past hundred years these pandemic flus have swept the globe, claiming hundreds of thousands of lives in a brief season. In the spring of 1918, with the world engulfed in war, such a virus broke out at a military training camp in Kansas. Within 16 months it killed at least 20 million people—nearly one percent of the world's population—more lives than all the battles of World War I. Less severe killer strains struck in 1900, 1957, 1968, and 1977.

"We're long overdue for the next pandemic flu," said virologist Rob Webster, one of the world's leading experts on influenza. For the past 25 years Webster, who is based at St. Jude

Dealing in deadly habits

■ A seductive mix of cocaine and heroin, called speedball, will bring Puerto Rican junkies a brief rush in a housing project near San Juan. These men, who spend their days on the streets stealing and panhandling for drug money, have learned to use their own needles to avoid infection with the AIDS and hepatitis viruses as well as other diseases.

Yet many addicts still share equipment in some 200 shooting galleries in San Juan and its suburbs. Each gallery sees dozens of customers a day, charging a dollar to rent the space and another to buy a needle.

Children's Research Hospital in Memphis, Tennessee, has been tracking flu viruses. Now he hopes to catch a pandemic flu in the act of emerging. Like most new flus, he explained, it will likely be born in southern China. To understand why, I traveled with him to the city of Nanchang—and the home of Wei Katou.

Wei and his family live on the second floor of a simple, two-story brick house. On the first floor three young pigs share a penned area with a half dozen ducks.

"These living arrangements may be the world's best breeding ground for pandemic flus," Webster told me. Most viruses infect just one or two types of animals. Flu viruses, however, prey on several, including humans, horses, pigs, seals, and a variety of birds. Since humans and animals live together so closely in southern China, flu viruses harbored by one species can mix genes with those from another, creating a wholly new form.

"So much activity!" Wei marveled as Webster and his Chinese colleagues wrestled his pigs down and inserted cotton swabs into their nostrils to collect viral specimens. Wei considered influenza nothing more than an occasional nuisance. He seemed amused that Webster also collected specimens from his ducks and then from members of his family.

We moved on, repeating this routine at more than a dozen houses. If a new flu is evolving—leaping from animal hosts to humans—Webster hopes to document that transition.

Every pandemic strain of flu consists of just eight genes. When two viral strains invade a single cell, they can mix and match genes to create any one of 256 possible combinations. Ducks and certain shorebirds, Webster has discovered, carry all the known pandemic flu genes without getting sick.

"Wild birds constitute a vast, mobile reservoir of influenza," said Webster. "The viruses replicate in their intestines and get excreted in their droppings. At certain times of

Border defenses

■ Furious at being confined, an urban raccoon faces a shot of rabies vaccine in Ontario, Canada, during a campaign to shut out an epidemic now creeping up the eastern U. S. At New York's Kennedy Airport the sharp nose of a U. S. Department of Agriculture officer will intercept imported food that might contain viruses harmful to farming. His canine colleagues work international airports across the country.

the year lakes and streams along their migration paths are teeming with flu viruses."

New flu strains may thus emerge when viruses carried by aquatic birds mix with one another. But Webster believes that the transformation more likely happens in pigs.

"Pigs can catch both avian and human forms of flu. They can also pass flus on to humans," he explained. "That makes them the perfect vessel for jumbling and reassorting flu genes into new combinations."

Since southern China is the birthplace of most human flus, Webster has concentrated his research there. However, the flu virus may have outflanked him. While he was searching in China, other researchers found just what he was looking for in Europe. Isolating viruses from pigs suffering respiratory disease, scientists in Italy have detected a new flu that contains genes from both avian and human strains.

"If that reassorted virus spreads to humans," Webster told me, "we well might have our next pandemic flu."

EVERY NEW VIRUS is an experiment in evolution. The great majority of those experiments fail. Mutants often turn out defective or too fragile to compete against sturdier strains. But some experiments in viral evolution have succeeded spectacularly.

Consider herpes simplex virus type 1, which infects cells in the lining of the mouth and lips, causing painful cold sores, or fever blisters. Contact with the sores spreads the virus. The immune system responds quickly. But the herpes virus has evolved the ability to retreat into the safety of nerve cells, where the immune system cannot detect it. Once inside, the virus lies dormant, not interfering with the cells.

Eventually the virus particles are reactivated—often by physical or emotional stress or fever. They start reproducing, spilling out of the nerve cells and once again infecting cells in the lining of the mouth and lips.

The survival strategy of rabies seems even more devious. The rabies virus invades cells of the central nervous system. From there it spreads to several organs, including the brain.

Soon it teems in the host's saliva. Meanwhile, in the brain it creates a delirium so violent that the victims often bite, thereby infecting other animals or people.

The measles virus behaves more directly. It spreads swiftly through the air. Fortunately, the immune system rallies just as quickly, destroying the virus and creating lifelong immunity. Because measles is so contagious, everyone who is not already immune in a community usually catches the disease. Thus, outbreaks within small populations die down rapidly. To sustain itself, the virus needs a large community—virologists calculate at least 300,000 people. With that large a population, after one outbreak fades, isolated cases persist until enough new susceptible children are born to feed another epidemic.

RATHER THAN SPEED, the world's newest viral plague, AIDS, relies on slow-acting stealth. It spreads insidiously, infecting its victims sometimes without causing disease for 12 years or more.

The earliest documented cases of AIDS now date from 1959. Frozen blood samples taken then from a Zairean man later proved to be infected by the virus. That year AIDS is believed to have killed a 25-year-old British sailor. His doctors were mystified by the sailor's illness, and only in 1986 did they determine, by testing a preserved sample of his tissue, that he was HIV-positive. AIDS was unknown until 1981, when the first medical reports of a fatal new disease appeared. By then the AIDS virus was seeding itself around the world. Today more than one million U. S. residents and as many as 21 million people in other countries have been infected.

Since its discovery HIV has become the most widely studied virus in history. "Unfortunately, part of what we've discovered," said Anthony S. Fauci, director of the National Institute of Allergy and Infectious Diseases, "is just how resourceful an enemy we face."

HIV probably originated between fifty and a hundred years ago in some remote part of central or West Africa, where several species of monkeys carry a closely related virus called simian immunodeficiency virus, or SIV. Monkeys have probably harbored SIV for centuries. At some point SIV managed to jump species from animal to man, perhaps when someone was bitten by an infected monkey.

Analysis of frozen blood samples collected in Africa during the 1960s and '70s suggests that HIV spread slowly at first. When the sexually transmittable virus reached prostitutes in urban areas, however, the epidemic began to accelerate. Truckers infected by the prostitutes carried the disease from city to town to village throughout the heart of Africa. Infected air travelers spread it to other continents.

Soon after the AIDS epidemic developed, researchers recognized the centerpiece of HIV's strategy: The virus stages a preemptive

Terms of estrangement

■ Love lights the face of 50-year-old David Castagna, dying of AIDS in a San Francisco rooming house, even though he has not seen his daughter Donn since he abandoned his family in Richland, Washington, 18 years ago.

Castagna had no contact with his daughter until 1989, when she sent him her high-school portrait. "I wish we could be together before we leave this earth," she wrote, but so far they have not been reunited.

strike, infecting and disabling the immune system's critical T cells. They realized also that HIV is relatively fragile and cannot survive long outside the body. Therefore, HIV infects new hosts through bodily fluids—primarily blood and semen.

"Initially AIDS looks much like any other infection," explained Anthony Fauci. "HIV is readily detected in the blood. Very quickly the immune system begins producing antibodies to neutralize the virus. Six months later it may be all but impossible to find the virus itself in the bloodstream."

Antibodies to the virus persist; their presence is what AIDS-testing detects. The virus, however, is hiding. Where?

Fauci showed me a magnified cross section of a lymph node from one of his patients. Pea-size nodules scattered throughout the body, lymph nodes normally act as filters, trapping viruses so that immune cells can detect and destroy them. During certain illnesses lymph nodes grow crowded with infection-fighting T and B cells. Then we call them swollen glands. A lymph node—the lion's den of the immune system—would seem the last place a virus should hide. But the lymph node from Fauci's patient was speckled with tiny black dots: AIDS viruses. Somehow, perhaps by concealing themselves in a coating of substances that the immune system itself makes, HIV incubates safely in the lymph nodes for years. Eventually the viruses multiply. Then, bloated with HIV, lymph nodes deteriorate, spilling viruses into the bloodstream.

After that the host's immune cells face a far more confounding enemy. AIDS researchers have learned that HIV mutates as it copies itself, creating an army of variant strains within each infected person.

No longer one beast but ten thousand, AIDS viruses now have an unassailable advantage. The immune system must create a new and different contingent of T cells to battle every new viral strain. Meanwhile, all AIDS viruses can attack and destroy critical T cells.

"Eventually," said biologist Robert May of Oxford University, "so many different predators simply overwhelm the immune system."

HOW DO RESEARCHERS keep track of the huge, evolving menagerie of different AIDS viruses? At the Los Alamos National Laboratory in New Mexico, molecular geneticist Gerald Myers oversees the world's largest data bank of molecular information about HIV. As I visited him at the lab's HIV Sequence Database and Analysis Unit, the newest addition was arriving. It was not a biological specimen. Rather it streamed across a computer monitor as a long string of numbers and letters. Myers was downloading information from England about the strain that may have killed the 25-year-old British sailor in 1959. The virus would be preserved on a computer disk as a sequence of chemical codes that describe the makeup of its genes.

Myers showed me catalogs with hundreds of pages of coded sequences of the various viruses in his collection. HIV has been broken into types, subtypes, and strains. The primary AIDS virus is a type called HIV-1. To date, scientists have detected at least seven major subtypes and thousands of strains. Researchers also have identified another type of the virus, called HIV-2, which usually causes a less severe form of the disease.

Nightmare in the making

■ A long evening lies ahead for women who work the brothels of Bombay, a center of India's AIDS explosion (right). Though some now insist on condom use, half the city's 100,000 sex workers have already been infected. Even with rampant warts (top), caused by a papilloma virus, an HIV-weakened worker finds clients.

Professional blood donors and lax medical procedures also spread HIV. "We need to fight this as a national emergency, not a mere health problem," says Bombay doctor Ishwar Gilada, who treats and counsels sex workers.

Computers can compare the genetic sequences, determining, for example, how closely related certain viral strains are. Such comparisons enable scientists to track the movement of HIV around the world. Recently researchers discovered that a strain of HIV that began to spread among Romanian orphans in 1989 is virtually identical to a minor strain first spotted in Brazil several years before. Myers speculates that the virus was carried halfway around the world in units of contaminated blood. In Romania it gained its first foothold in the country's seaport towns, where it remains most prevalent.

Some forms of HIV-1 may not be lethal or even cause disease at all. Researchers are following a group of patients in Australia who have been infected with a single strain of HIV for more than 12 years without showing signs of AIDS. Other strains are unusually virulent. One strain of HIV's simian ancestor, SIV, recently studied by researchers killed within a month all 30 of the monkeys it infected.

What makes one strain benign and another swiftly lethal has become the focus of intense scientific study. Could deadlier human AIDS viruses evolve? Could AIDS become an airborne disease? Could strains arise that kill as swiftly as Lassa fever?

Myers answered cautiously. "HIV is evolving a hundred million times faster than we are—perhaps as fast as anything on the planet. As the pandemic spreads, the opportunities for evolution increase. Certainly there are constraints on how HIV can evolve. A virus that becomes airborne might not be able to infect T cells, for instance. But this is an extraordinarily restless virus. I think we should be prepared for anything."

MORE THAN A DECADE into the pandemic, drugs have been found to fight many of the infections people with AIDS develop. But only a small number of drugs approved for use in the U. S.—such as AZT, ddI, and ddC—attack the virus directly. And over time HIV outsmarts each of them by generating resistant strains. Researchers hope to develop a more effective combination of drugs, each targeting a different part of the virus. Meanwhile they are testing more than a dozen potential vaccines, but no one expects an effective shot against AIDS to be available before the end of the century.

Even if an effective treatment or vaccine is found, it will have to be cheap and portable enough to reach those at risk in the world's poorest countries, many of which have been hardest hit by the rampaging pandemic.

"There are times when we haven't room for one more mat on the floor," Sister Margaret O'Sullivan said as she led me through a crowded ward at Kitovu Hospital in Uganda's Masaka district. I watched a mother feeding a young man blinded by the disease. Nearby, a woman no older than 30 and barely more than a skeleton fought for breath.

AIDS erupted early in Uganda. Years of civil war and social dislocation helped spread it. In many parts of the country one in five adults are now infected. The sick and dying have overwhelmed already burdened hospitals and rural health centers.

"Every family has lost someone," said Sister Ursula Sharpe, director of the Kitovu Mobile Home Care and Orphans Program. "Parents are dead. Aunts and uncles are dying. Children of 13 and 14 are left to manage

A lesson in staying alive

■ The opening of a condom draws a crowd of schoolboys in Abidjan, Côte d'Ivoire, as a health worker explains proper use for protection against AIDS. The city's nightclubs and street kiosks now sell condoms, some at subsidized prices, alongside beer and cigarettes. T-shirts, rap messages on the radio, and AIDS awareness parties all promote safer sex.

Convincing people to take the simplest precautions—use condoms, get immunized, drink and wash in clean water—may be the best first line of defense against viral invaders.

the household." International health officials estimate that as many as a million and a half children have been orphaned in Uganda.

In the front room of his family's once prosperous home in southern Uganda, 18-year-old Paul Wagwakku carefully opened a photo album in his lap. The room was now stripped bare of all but a few sticks of furniture.

"My mother and father," he said, pointing to the wedding portrait of a handsome, smiling couple. He showed me a photograph of his mother holding a new baby. Then a picture of his father, suddenly frail and sickly, sitting on the edge of a bed. In another photo his mother's face, once round and full of laughter, had become gaunt, ashen, her arms bone thin.

Both parents' gravestones stood a few yards from the house.

Left to care for a dozen siblings, Paul wondered how he would manage. "It is hard to think of the future," he told me.

Ten-year-old Lawrence climbed into my lap. Open sores pocked his arms and legs. Mikey, three, was beset by AIDS-related lung infections.

By the year 2000 as many as 110 million people worldwide will have been infected with HIV since the beginning of the pandemic, according to the Harvard-based Global AIDS Policy Coalition.

Researchers worry that a disaster even worse than Africa's may be unfolding in parts of Asia. India, with its population of nearly one billion, may well suffer catastrophically. The country's commercial capital, Bombay, is one of the greatest generators of new HIV infections in the world. But until recently, few officials there even talked about AIDS.

"Nearly half of the prostitutes in Bombay are infected with HIV," Ishwar Satyanarayan Gilada, the director of the Indian Health Organization, told me as we climbed a dank stairway to one of the thousands of brothels in the red-light district of Kamathipura.

"Men from the countryside come here, then return to their wives carrying the virus."

In a small room decorated with garish movie posters and brightly colored religious icons, I asked the women how many men they entertained each night. Three or four, they told me.

"If a fellow doesn't use a condom, we send him out," a prostitute named Lata told me.

Despite what they may tell visitors, many prostitutes here and throughout the world can't turn away men who refuse to use condoms. If they did, their children would go hungry. In brothel after brothel, I watched Gilada write out prescriptions for treating gonorrhea, syphilis, and other sexually transmitted diseases.

If they are spreading, so is AIDS.

The virus is also surging among the country's intravenous drug users, who have become infected by contaminated needles, as well as among professional blood donors. The Indian government recently instituted a nationwide blood-screening program. But in the city of Latur, 300 miles southeast of Bombay, the director of a blood bank shook his head in disgust. "They tell us we must screen the blood. But how? We have run out of test kits."

Meanwhile, some unscrupulous doctors buy blood from professional donors, many of whom are known to be infected with HIV, and inject it directly into their patients.

Two years ago the Indian government announced a five-year plan to stop AIDS, which includes education programs, condom distribution, and improved blood screening.

"Five years!" Gilada said angrily. For many in India five years will be too late. In 1988 fewer than one percent of people treated at venereal-disease clinics in Bombay carried the AIDS virus. By 1992 the number had climbed to almost 9 percent. Today more than 20 percent—one in five people—are infected. "What will become of us when millions of people a year are dying of AIDS in India?" Gilada asked. "How will we cope?"

AN ALL BUT INVISIBLE BUNDLE of genes, a virus called HIV, has changed the world. As we struggle to slow its spread, researchers now warn that other viral threats are certain to arise. In 1992 experts at the U. S. National Academy of Sciences identified 27 viruses that pose a danger of sparking new epidemics. The list includes familiar viruses, such as influenza, rabies, yellow fever, and measles. More exotic viruses, however, have already emerged in the U. S.

Last May physicians in Gallup, New Mexico, struggled in vain to save a 19-year-old man who had collapsed suddenly of a runaway lung infection. The youth, healthy and strong, had been a cross-country track star.

New Mexico deputy medical investigator Richard Malone felt a shudder of dread when he arrived at the emergency room. "We'd had a case just like this only a month before—a 30-year-old woman with flu-like symptoms suddenly rushed to the hospital, unable to breathe. We had no idea what caused her death."

Malone soon discovered a more chilling fact. The young track star had been on his way to attend his fiancée's funeral when he collapsed; she'd died five days before of a similarly swift, mysterious lung infection.

"A lot of us thought 'this is it—a new killer flu,' " recalled one researcher. Tissue samples were rushed to the CDC. Scientists in the Special Pathogens Branch identified a hantavirus. In Asia and Europe hantaviruses cause a sometimes fatal kidney disease, affecting as many as 200,000 people annually.

CDC researchers now believe the southwestern hantavirus, a relative of the Asian strain, has been carried for years by common deer mice that range across three-quarters of the U. S. They find hantavirus in almost 30 percent of the deer mice they have recently tested in the Southwest. Rodent populations may have exploded as heavy rains last year ended a long drought in the West. Hantavirus may, in fact, have long been present. It may have caused isolated and unexplained fatal lung infections over the years. CDC laboratory scientists have now confirmed 69 cases of the newly identified disease. They worry that new strains of the virus, capable of sparking even deadlier epidemics, could be emerging. Will we be ready?

"Certainly we're better prepared now than we were 20 years ago, when HIV began to spread," said epidemiologist Donald Henderson, who led the international campaign to eradicate smallpox. He and other experts have urged that "viral listening posts"—laboratories equipped to rapidly identify emerging viruses—be set up around the world.

Could such an outpost, alert to early signs of trouble, have detected HIV when it first appeared? Possibly. Could we have stopped it?

"AIDS has taught us humility," Henderson admitted. "That one little virus has reminded us how much we still have to learn."

Living with a lethal intruder – A family struggles with AIDS

■ Swollen lymph nodes in Fanny Tremblay's neck mean her body is still fighting the AIDS virus. Her doctor, Harold P. Katner, checks them every few weeks. At the start of his practice in Macon, Georgia, in 1985, Katner had two AIDS cases. Last year he saw some 100 new HIV-infected patients—44 percent women.

From a comfortable New York family, Fanny took up with a fast crowd while at college in Atlanta. "I had that very New York attitude," she recalls. "No one could tell me anything."

She soon dropped out of school, moved in with a bisexual drug addict whom she later married, and began to shoot up. "I fell in love with the coke, with the needle," she says.

While pregnant with her second child in 1988, she tested positive for HIV—a development she calls "devastating." Now 30, she takes 20 pills a day to bolster her failing body.

■ The fallout from an argument settles around Fanny and her family. Head in hands, her former husband, Scott, also HIV positive, was unable to kick his cocaine habit. "We had lots of fights about that," remembers Fanny, a born-again Christian now free from illegal drugs. "I would be snapping at

him, 'You can decide which way you're going to go, but you're not going to drag down our kids too.' "

Scott often landed in jail on drug charges between visits with Jasmine, seven, and Jason, four. Last fall, after this picture was taken, he died of a ruptured aneurysm in his brain.

■ A snuggle with Jason—and the knowledge that he is healthy—boosts Fanny's spirits. Like 70 percent of babies born to HIV-positive mothers, he tests negative now that Fanny's antibodies to the virus, passed in the womb, have cleared from his system.

Planning for the inevitable, Fanny has written a will and found a couple at her church to adopt Jason and Jasmine. She is also introducing the children to their roots—the Latin Caribbean side of her family in Miami, the Jewish side in New York. "I don't ever want them to forget who they are," she says. A photograph of Fanny taken a lifetime ago in boarding school connects Jasmine to her mother's childhood (bottom left).

Every day that Fanny stays alive buys her children better preparation for the future. To raise her energy for their after-school time together, she schedules a midday nap and dose of vitamins. "Heaven sounds wonderful to me. I'm ready to go," she says. "The most important thing that keeps me back is the babies."

Encouraged by Dr. Katner, Fanny shares her story so others can learn from her mistakes—a further reason for her to keep going. After a talk at a high school outside Macon, students show their appreciation with hugs. "They can identify with me," she says. "I tell them we're all responsible for our own actions." □

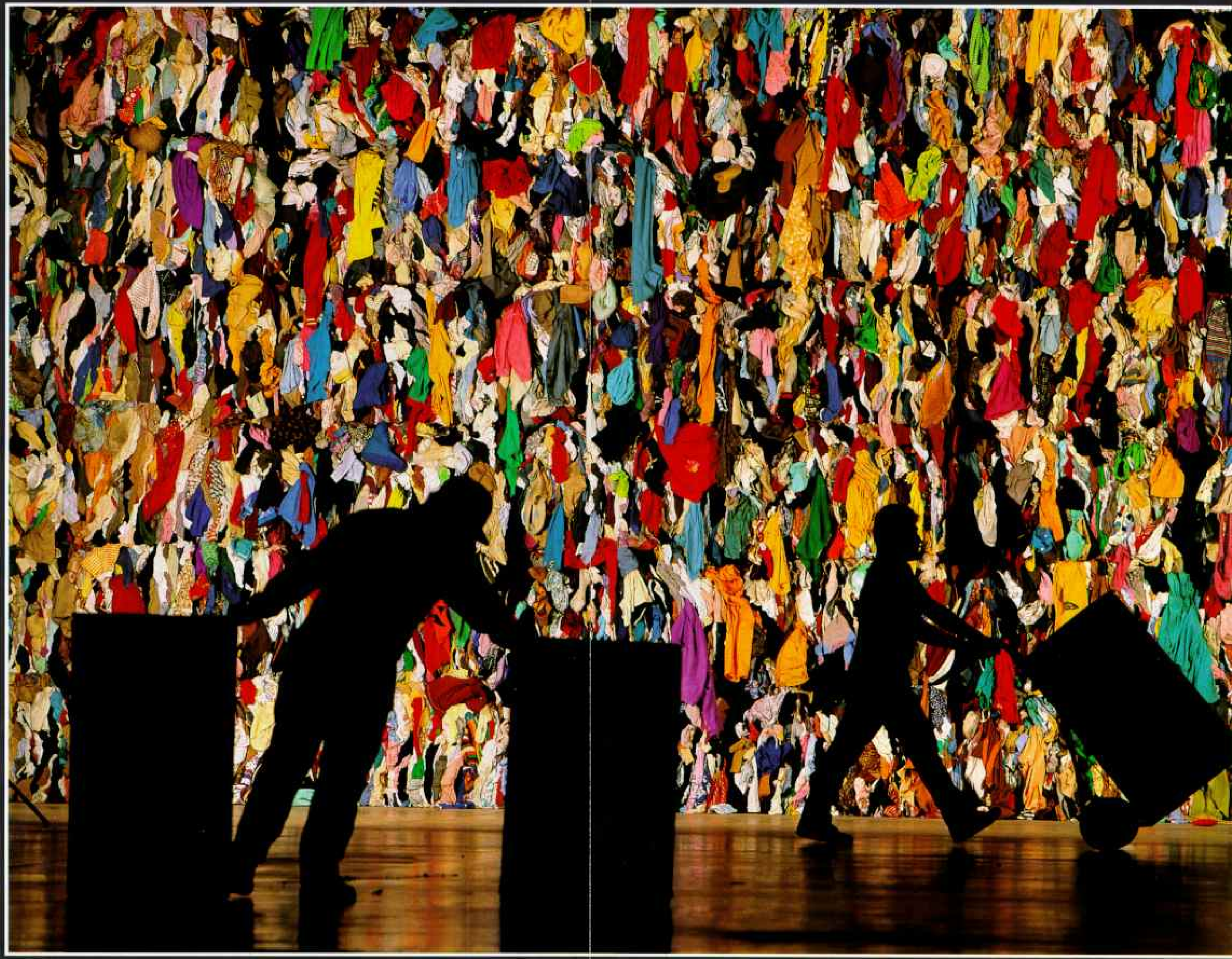
RECYC

A mountain of tires fuels a power plant in Westley, California, while in San Francisco a tunic made from old bicycle inner tubes is downright chic. Both mark an environment-saving trend: finding new uses for the things we throw away.

LINC

By NOEL GROVE

Photographs by JOSÉ AZEL



A cocoon-shaped bale of recycled nylon waste yields enough fiber for the felt skins of 20,000 tennis balls—and at 500 pounds tests the strength of two bodybuilders. In Los Angeles discarded garments

get a second chance as industrial rags and carpet underlay. Such recycling keeps clothing out of landfills, where it makes up 4 percent of the trash dumped each year.

JULIE LEWIS walks on a dream come true. Since she was a teenager, inspired by the rallies of the first Earth Day in 1970, she yearned to turn waste into something worthwhile. Now the 38-year-old is vice president of a company she founded called Deja. She calls her recycled invention the Deja Shoe.

Its cotton-canvas fabric is rewoven from textile scraps. The foam padding was designed to cushion chairs. Factory-reject coffee filters and file folders go into the insole. Add recycled grocery bags, tire rubber, and plastic trimmings left over from the manufacture of disposable diapers.

The shoes look handsome, durable, and ready for the outdoors, like Julie herself. Her Portland, Oregon, firm ships 100,000 pairs annually, sold for $40 to $70 in stores across the country. And when they wear out? Send them back to Deja to be recycled.

"I realize this is not the answer to the nation's trash problems," said Julie as we looked at her new line of born-again brogans, sneakers, and light hiking boots. "But I wanted to set an example to other industries and stimulate the demand for recycled products."

Her start-up wasn't easy. She had to beat the bushes for recycling operations to supply the materials, and most American shoemakers brushed aside her ideas. Reluctantly she gave her assembly contract to a company in Taiwan. "They make a better shoe for the money," she said. "I wanted high quality so recycling wouldn't get a bad name."

Julie's struggles with acceptance and financing typify the rapidly evolving recycling industry. But her success—ten million dollars in private venture capital so far—reflects the promise. In thousands of ways her ingenuity is being repeated across the country.

Not since World War II, when enemy submarines threatened the import of raw materials and our national survival was at stake, has the fervor for recycling run so high. Just over a thousand curbside recycling programs existed in the United States in 1988; today there are more than 5,000 such programs gathering recyclables from 85 million people. Nearly 65 percent of our aluminum cans are reincarnated, along with a quarter of our paper and steel cans and 20 percent of our glass. The renewed interest is spurred by a range of concerns: loss of landfill space, contamination of groundwater by landfills, dwindling natural resources, and, perhaps, a growing comprehension of our unmatched squandering.

The U. S. leads the world in waste production, according to the Environmental Protection Agency, generating some 200 million tons a year, enough to fill a convoy of garbage trucks stretching eight times around the globe. Each of us discards 3.6 pounds a day, almost twice as much as the average German.

Other nations feed on our high-quality leavings. Tree-poor Taiwan buys used paper to make more paper. Japan takes twisted metal and sells it back to us as cars. Scrap iron and wastepaper top the exports leaving New York Harbor. We are the Saudi Arabia of trash.

Landfills get two-thirds of what's left behind. (That's based on weight rather than volume, as are all such calculations in this story.) But much of the heavily populated East Coast is expected to run out of acceptable landfill space in this decade, and the EPA estimates that within the same

A pile of trash covers the San Diego yard of Curt and Judy McCarty and their children. At left is about what the average American family of four now recycles in a year: 1,100 pounds of aluminum cans, glass containers, plastic

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NOEL GROVE, a senior writer for the magazine, left the GEOGRAPHIC last March after 25 years to freelance. His articles have covered subjects as diverse as oil spills and Mark Twain, as far-flung as Michigan and North Yemen. This is the seventh GEOGRAPHIC byline for photographer JOSÉ AZEL, whose most recent contribution was "Central Park, Oasis in the City," in the May 1993 issue.

bottles, steel cans, newspapers, and cardboard. At right, in bags, is the 5,300 pounds of trash that is discarded. Recycling is catching on—especially in their "environmentally correct" city, but there is still a long way to go.

time span 80 percent of the landfills nationwide will close and new sites must be found. Western states have room for more, although dumps and their toxic by-products are seldom welcome neighbors. Where will our waste go?

We burn 16 percent now and could burn more. But that raises concerns about air pollution from heavy metals such as lead, cadmium, copper, and mercury, which vaporize in intense heat.

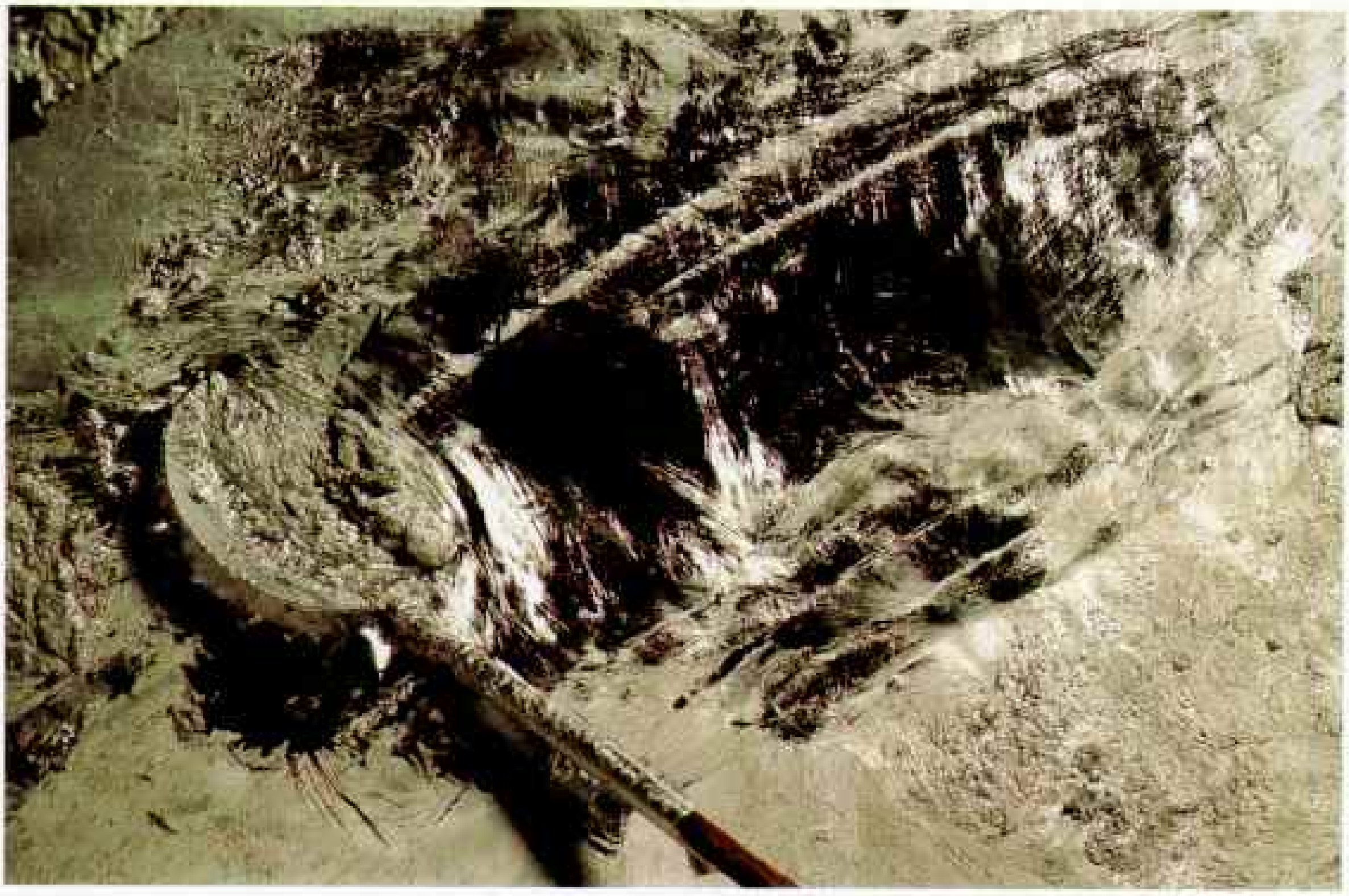
We could reduce waste by cutting down on the packaging that surrounds our products: It accounts for one-third of our trash.

And we could reuse more of it. "Recycling works, and it makes economic sense even when a material is plentiful," said Phil Bailey of the National Recycling Coalition in Washington, D. C. "Recycling glass requires less energy than making it from sand. Recycling steel is cheaper than mining ore."

Recently I traveled around the country seeing trash being reborn. I saw old tires cooked into gasoline, cows bedded down on shredded paper, and garbage turned into dirt to enrich Wisconsin cornfields. I sat

One step away from meltdown, briquettes of compacted metal still bear witness to their

previous lives as beer cans, aluminum foil, brass planters, heater cores, and wire.



in chairs made from shipping pallets and walked on floors tiled with crushed lightbulbs. I visited recycling offices that hummed with the enthusiasm of a campaign headquarters.

"I've worked for several large companies and never before seen the attitude of the people working here," said the head of a California firm that recycles motor oil. "There is a sense that we are doing something right."

Yet recycling, proponents stress, has grown beyond a feel-good trend. "Recycling is where the environment and the economy meet," said Phil Bailey. "It's becoming an integral part of business and industry."

One indicator: Later this year glass and high-grade plastics are expected to join soybeans and corn as commodities on the Chicago Board of Trade. If trading goes well, other materials will be added, and the board may offer futures contracts. The 1980s gave us the junk bond; the 1990s may bring us, in more ways than one, the junk future.

HERE'S HOW recycling works, generally. A community decides to divert waste from a landfill. In addition to the regular garbage trucks, new haulers with separate compartments must now go out to pick up newspapers, beer cans, pickle jars, detergent bottles, and other reclaimables. At a recycling center the materials are further sorted and compacted for sale to a manufacturer who makes them into new products. Yard trimmings and wooden construction debris—two of the largest components of landfills after paper—may be composted at the center and offered directly to consumers.

Some private companies pay for dropped-off recyclables, but most collection is operated or subsidized by local and state governments.

The pacesetter is Seattle. It recovers 45 percent of its waste compared with a 17 percent average for the rest of the country. Success is pinned to a "pay as you throw" program: Residents who recycle best pay the least for removal of their trash.

Aluminum

1 million tons recovered

1.7 million tons discarded

Cash crop, aluminum cans are about 20 percent cheaper to recycle than to make and require 5 percent of the energy. Car parts and home siding are other candidates for recycling.

1990 MUNICIPAL SOLID WASTE DATA FROM EPA; GRAPHS BY NATIONAL GEOGRAPHIC ART DIVISION

"Our recyclables are picked up for nothing," explained Sally Kentch, who was setting out her papers, cans, and glass and plastic bottles one morning as I rode the rounds with a recycling truck in a north Seattle neighborhood. "But we pay $15 a month to the city for a 30-gallon can for garbage that can't be recycled. If we don't recycle well, we may need two garbage cans, which costs twice as much."

With the fees charged for the garbage cans, Seattle covers its weekly garbage pickup and pays two companies to pick up the recyclables. The companies sort the materials and sell them at a profit.

PAY-AS-YOU-THROW can be hard to swallow when trash collection has been a service paid for invisibly out of property taxes. Six years ago Florida decided it had no choice. Groundwater in the fourth most populated state sometimes sits only three feet below the surface, easily affected by pollution from landfills. So the Solid Waste Management Act of 1988 ordered counties to be recycling 30 percent of their waste by the close of 1994.

None have succeeded like Palm Beach County, population 900,000. It responded with a 1,320-acre waste-processing complex paid for by annual assessments of $230 per family. Complaints about the cost were so fierce that the county felt compelled to fire the originator of the program, which now wins national awards.

Paper, glass, plastic, and metals are sorted and sold. Combustibles such as kitchen and yard waste drive a steam-powered generator supplying electricity to the center and 30,000 homes. Other yard trimmings are mixed with sludge from a water-treatment plant and dumped into 84-yard-long concrete composting trenches. Fans force air through the mixture, and clawed machines stir it once a day.

"In three weeks it's nitrogen-rich dirt," said Mike Perrotti, thrusting under my nose a handful that smelled like forest floor. "Orange growers pack it around their trees."

Leftover garbage going into the lined and monitored landfill in the complex has been cut by two-thirds.

"It's fascinating, seeing things come in as junk and go out as landscape cover," said Malcolm Burrow, who makes mulch from building debris hauled to the site. "People say, 'How could you work in a dump?' I tell them, 'Come see what we're doing and you won't call it a dump.' "

But not everyone praises recycling; I heard economic arguments against it as well. "Implementing programs is expensive, and it's difficult to sell the materials," says Lynn Scarlett of the Reason Foundation, a Los Angeles think tank. "Sure it works sometimes, but it doesn't make sense to ship recyclables to markets halfway across the country from areas where there is still landfill space."

Programs that look promising on paper sometimes flounder in practice. In Germany, for example, lawmakers were praised in 1991 for requiring manufacturers to recycle their packaging—not literally to take it back, but to pay a second party to recycle the volume of packaging they were producing. Many businesses signaled their compliance by marking their products with a green dot. But

Steel

Nothing stands in the way of recovering steel, which is 100 percent recyclable and can be reprocessed almost indefinitely. Like aluminum (above left), steel is sturdy and has a long shelf life, making it ideal for food containers. Environmentalists say solid-waste woes would disappear if other materials were as easy to reuse as aluminum and steel.

1.9 million tons recovered

10.4 million tons discarded

without any system of enforcement, some dots appeared that were not backed by recycling contracts. And the packaging piled up beyond the recyclers' ability to process it. Green dots began showing up in landfills.

"Implementation of the law has been faulty, but the concept of manufacturer responsibility is good," said Bette Fishbein of INFORM, a New York environmental research group. "It changed the way German companies think about preparing and wrapping their products."

Laundry detergents were made more concentrated to fit into smaller boxes, toothpaste tubes went on the shelves without boxes, and plastic wrapping was reduced.

In the U. S. the first surge in recycling was also marked by mountains of unclaimed bottles and paper. The gluts have shrunk but not vanished. Supporters say it just takes time for regional markets to evolve and close the loop from manufacturer to consumer and back to manufacturer again.

"We underestimated people's response to recycling," said David Dougherty, director of the Clean Washington Center, a state agency in Seattle that develops markets for recyclables. "They did it so well an oversupply resulted. But seeing those materials go begging has made people realize the need to create markets for them."

Manufacturers actually pursue the materials collected at the city recycling center of Bloomsburg, Pennsylvania. Carol Webster, the manager, oversees an operation as organized and blemish free as the checkbook of an accountant, which Carol happens to be. "Recycling is a business," she told me. "It's out of the hands of Boy Scouts and volunteers.

"My books show a profit because our markets are well established," she said. "We know we can sell our product because the manufacturers know it's clean and well sorted. I just wish the markets could be closer, to lower my shipping costs."

Months later a paper-recycling mill opened within an hour's truck ride, and Carol began shipping to it this spring.

"These local industries popping up will make recycling work," said the National Recycling Coalition's Kathleen Meade, who followed markets for four years as the editor of *Recycling Times*, an industry newspaper published in Washington, D. C. "New mills, new ideas like Julie Lewis's shoes, a guy making garden hoses out of recycled rubber—they will all be part of the solution."

20.9 million tons recovered

52.4 million tons discarded

Paper

Giant success, environmentally sound bathroom tissue rolls off the line at the Fort Howard Corporation. Made of 100 percent recycled paper, this spool will be cut into 80,000 rolls like the one held by CEO Don DeMeuse. Each year the company recycles enough paper to cover a hundred-acre landfill 18 feet deep.

IN THE SALVAGING FRENZY of World War II, car radiators became carbines and an electric iron was said to equal the steel in two GI helmets. A vintage poster shows a Nazi plane in flames beneath the headline, "Your scrap brought it down."

Compared with the 12,000 community recycling programs now under way, more than 21,000 salvage committees were created for the war effort, out of about half today's population. Aluminum gum wrappers were stripped for airplane fuselages, and cooking fat fueled explosives.

The habit hung on after the war. From my boyhood on an Iowa farm I remember rag rugs, jelly jars turned glassware, and shirts my mother made out of bright, floral feed sacks. My brothers and I went to school looking like we'd just been to Hawaii instead of the barnyard.

Our disposal habits were less virtuous. Once a year we hauled a truckload of cans, bottles, and other solid waste to an obliging neighbor's pasture, where we dropped the tailgate and pushed it into a gully. The trickle of water below turned tea-colored and stank.

As the postwar economy boomed and memory of sacrifice faded, our castoffs graduated to a county dump. Now my brother Maryl, who still farms the homeplace, drives 15 miles to drop his trash in county recycling bins. His wife, Agnes, first removes the labels from steel cans that might be refashioned into bicycles or nails. When I pointed to county instructions saying removal wasn't necessary, she shrugged and said, "Well, can't hurt."

"A certain practicality endures in the Midwest, an attitude of 'why throw these things away,' " said Kate Cooper, state director for solid-waste programs in Madison, Wisconsin. "Also, communities with fewer people can make decisions fast."

Half an hour north of Madison, rural Columbia County went from relying on open-air dumps to a disposal system that verges on magic. At

Turning out to paint their town, San Diegans sort old latex and oil-based paints at a recycling-day collection site (above left). Tested for PCBs, toxic-free pigments are remixed and used in public

beautification projects.

"Volunteers provide the people power, and we provide the paint," says councilman Juan Vargas, who, with area residents (above), wipes out graffiti one stroke at a time.

the recycling center I saw the usual stacks of baled paper and cans, the piles of bottles. But the centerpiece of the program is the county's answer to the remaining organic waste and perhaps to soil erosion as well.

"At the time we decided to recycle, a committee member saw an article in the GEOGRAPHIC* about a composting program in the Netherlands," explained Bill Casey, director of the center. "On vacation in Europe he visited similar operations, and we adapted them for our own use."

Two revolving steel drums lie on their sides like supine silos, 11 feet high, half the length of a football field, slanted at a 3 percent grade. Into the upper ends goes anything that once lived—leaves, grass, food scraps, some paper, and, at the moment I approached, three road-killed deer. Broken down by bacteria, water, and air in the churning drums, all emerges a week later at the other end as dirt, black and crumbly as you'd want in your garden. And probably more germfree.

"The decomposition creates temperatures of 150°F," said Casey. "Within three days that kills any pathogens that might exist."

*See Peter T. White's "Fascinating World of Trash" in the April 1983 issue.

The pay dirt is windrowed for sale to local farmers. What Columbia County sends to the landfill—plastic trash bags and other inorganics screened out in the silos—is 40 percent of the total fed in.

BUT WILL WHAT WORKS for rural Wisconsin, Palm Beach County, and Seattle play in a community of seven million? Not, very easily, in New York City.

Trash creates one of the wonders of the Big Apple: Fresh Kills Landfill, among the world's largest man-made structures, a 3,000-acre mountain range of garbage 150 feet high at its tallest peak.

Destined for trouble? A train heads across New York Harbor to pick up sludge from sewage-treatment plants for delivery to a test ranch in West Texas. There, disposal company reps say, the waste revives depleted rangeland. Antisludge activist Bill Addington disagrees: "This isn't recycling. It's an 80,000-acre dump."

The city launched an extensive recycling program in 1989 because state law required it. Three years later 29 of its 59 community board districts had some sort of recycling. The state supreme court ruled that the city was dragging its feet and ordered a renewed effort.

The mayor's office blamed the delays on citizen resistance, low prices for recyclables, and union regulations. And there is a physical challenge in urban recycling that not even Seattle has solved—collecting from high-rise apartments.

A city commissioner reported that recyclables cost $300 a ton to gather and process, compared with $200 a ton for incineration or landfilling. He recommended building more incinerators.

Recycling groups disputed the accuracy of his figures and pointed out that the report ignored damage from air and groundwater pollution. Finally the city revised its estimates, dropping recycling costs to $240 a ton, with reasonable prospects of further reductions.

As people learn to sort their waste, and the pickup of both garbage and recyclables becomes more efficient, recycling could actually be cheaper. Besides, I found, people want to do it!

Perched like peacocks in the snow, Adirondack chairs made of discarded skis are

popping up around Aspen, Colorado, a recycling mecca where old skis go to retire.

Conducting my own poll, I strolled in the Park Slope community of Brooklyn, a test case for intensive recycling. Residents emerging in late afternoon to sit on the steps of their low-rise apartment houses talked enthusiastically about sorting their trash—paper in the green can, plastic, glass, and metal in the blue one, bagged food waste in the black one.

"We live surrounded by concrete, and sometimes I wonder what I can do about the environment," said Leslie Newman, holding an infant while two older children romped around her. "Well, I can sort my trash."

A dissenter shared the stoop with her. "I just moved here, and, hey, I've got enough to deal with," he said with a put-upon shrug. "I try, but if a thing is a little more work, you might not do it, right?"

"I disagree," countered Leslie. "It's a little more trouble, but I feel good about it."

By late 1993 all 59 districts were taking the trouble to recycle.

0.4 million tons recovered

15.8 million tons discarded

LOOK ON THE BACK of the next birthday card you buy. Odds are it's printed on recycled paper. The cereal box you reach for each morning might be reclaimed from newsprint. Paper—37 percent of our nation's waste—is one of the easiest materials to recycle. Of some 70 million tons made in 1990, more than 20 million tons were recycled in the U. S. or exported for recycling.

"Why cut down a tree to make a newspaper with a lifetime use of just over 20 minutes, then bury it?" asked David Dougherty of Clean Washington. "You can use it six times over, then burn what's left to create energy."

Paper is usually made from chipped wood, softened into a wet mush and formed into a thin sheet. Recycling repeats the process with the paper itself, removing the ink, glue, and coating. But that process breaks down some of the fibers, requiring the addition of new pulp to maintain

paper strength. "Recycling paper will never completely eliminate cutting down trees," said industry consultant William Moore of Thompson Avant in Atlanta, "but it could mean cutting fewer trees."

Nearly half our newspapers find new life, most as newsprint, some as cardboard boxes. Recycling advocates want to see even more newspapers become newsprint again, to delay the journey to the landfill or the incinerator. Papermakers, geared to produce newsprint from virgin pulp, are slowly coming around.

Legislation is helping to force the change. Twelve states and the District of Columbia now require that newspapers be printed on paper that contains some recycled fiber. In 15 more states publishers have agreed to do this voluntarily. Scrambling to meet the demand, newsprint makers in Canada (where about half our newsprint originates) and the U. S. have invested more than three billion dollars to add de-inking facilities.

For magazines "it's possible to make recycled paper that matches the quality of paper made from virgin pulp," said Moore, "although the extra processing raises the cost. Your magazine could be printed on recycled paper, if there were enough of a supply."

At the moment, there isn't. The cover of NATIONAL GEOGRAPHIC is printed on recycled-content paper, but it will be several years before suppliers can find sufficient amounts of de-inked fiber to meet the needs of the entire magazine, some 50,000 tons annually. At current prices this will add two million dollars a year to the GEOGRAPHIC's paper bill.

After corrugated boxes and newspapers the biggest paper component in landfills is office paper. Within arm's length of my desk sits a cardboard recycling box. Into it flows a steady stream of old correspondence, reworked manuscripts, and memos. White office paper brings a premium price on the recycling market, about $140 a ton. But little of it will pass over my desk again.

"Most of it goes into tissues and paper towels, one step away from the landfill," said Alan Davis of Conservatree, a San Francisco marketer of recycled white bond. "Governments will have to require using recycled office paper to make companies change."

I found other small but growing markets for used paper. Near Seattle, retired building contractor Ed Story is pushing paper as insulation. "Paper—cellulose—was a major player in the industry until fiberglass took over in the 1960s," he told me. People thought that the new material would be more fire-retardant. "But I've seen tests," says Story, "and I'm convinced that cellulose can be even more fire-retardant than fiberglass and can insulate much better."

It was a damp winter day when I helped Wisconsin dairy farmer George Plenty scatter bales of shredded paper around his barn. "It's cheaper than straw," he said, "but if the price were the same, I wouldn't go back. Paper keeps my cows drier and less prone to disease."

When sodden with manure, the paper is spread on fields and returned to the soil. The manager of the local recycling center that supplies the paper bales told me he cannot always keep up with demand.

Plastic

Stones won't shatter *this* glass house, actually a window constructed of scratch-resistant plastic blocks. Developed by Glass Alternatives, the blocks are made from recycled headlight lenses.

Yet recycling plastic has its problems: The many varieties are difficult to sort, and chemicals stored in plastic containers can contaminate reprocessed material.

ON A WARM AFTERNOON in Orlando, Florida, I drained a plastic soft-drink bottle and tossed it confidently into a recycling bin. Plastics account for 8 percent of our trash, third behind paper and yard clippings. Made from a wide range of natural gas and petroleum recipes, they do not mix easily for remaking into new products. And, as with the paper market, the plastics industry favors making plastic out of raw materials. As a result we recycle only 2 percent.

Soft-drink bottles are the exception. Made of polyethylene terephthalate (PET), they can be melted down and regenerated into a cottony fiber used in jacket insulation, pillow stuffings, and car interiors, or molded into bottles again. "If you can gather quantities of PET bottles unpolluted with other kinds of plastics, you never have trouble selling them," a recycling marketer told me.

I decided to follow my empty on its journey to a new life. You may now be walking on it.

My bottle was baled and trucked two hours north, past pastures where Thoroughbred horses grazed, to a new plant called Waste Alternatives in Ocala. Chopped into flakes, it was packed with other PET confetti and shipped to a factory northwest of Atlanta.

There I watched as it was melted and spewed into long fibers. The fibers were spun into yarn. A tufting machine punched the yarn through a web of backing and tied it. I left my bottle, now part of a roll of deep-pile carpeting, in a warehouse awaiting shipment. I noted one rug tagged for Dubai in the United Arab Emirates.

A hundred-million-dollar-a-year business, Image Carpets in 1976 began making carpets out of nylon and polyester, then changed to PET because of its consistent high quality. "We worried that people might resist buying the carpets if they knew they were recycled," said sales manager John Richmeier. "Now we advertise that fact as a marketing strategy."

Second to PET in plastics recycling is high-density polyethylene (HDPE), the standard milk jug. Waste Alternatives, one of some 120 HDPE recyclers nationwide, reduces HDPE containers to tiny pellets that are bought by the makers of shampoo and detergent bottles. A rebirth into milk jugs is difficult under the safety standards set by the Food and Drug Administration, which worries that people might store gasoline or insecticide in the containers before discarding them. Waste Alternatives is experimenting with plastic lumber as another possible outlet.

NOVEL IDEAS are popping out of landfills all over the country. South of Oklahoma City a skilled tinkerer has built a machine that makes petroleum out of old tires, a disposal problem nationwide. Harold Barrington led me from his farm home to a Rube Goldberg oven made of scrap iron, 60 feet long and 18 feet high. "I've produced as much as 1,800 gallons of crude oil in five hours," he said. "I distilled some into gasoline to run my machines and sold the rest to a refinery, as though I had an oil well here."

Success has not brought a flood of investors. "I guess money's tight, and they think it's too risky," he said.

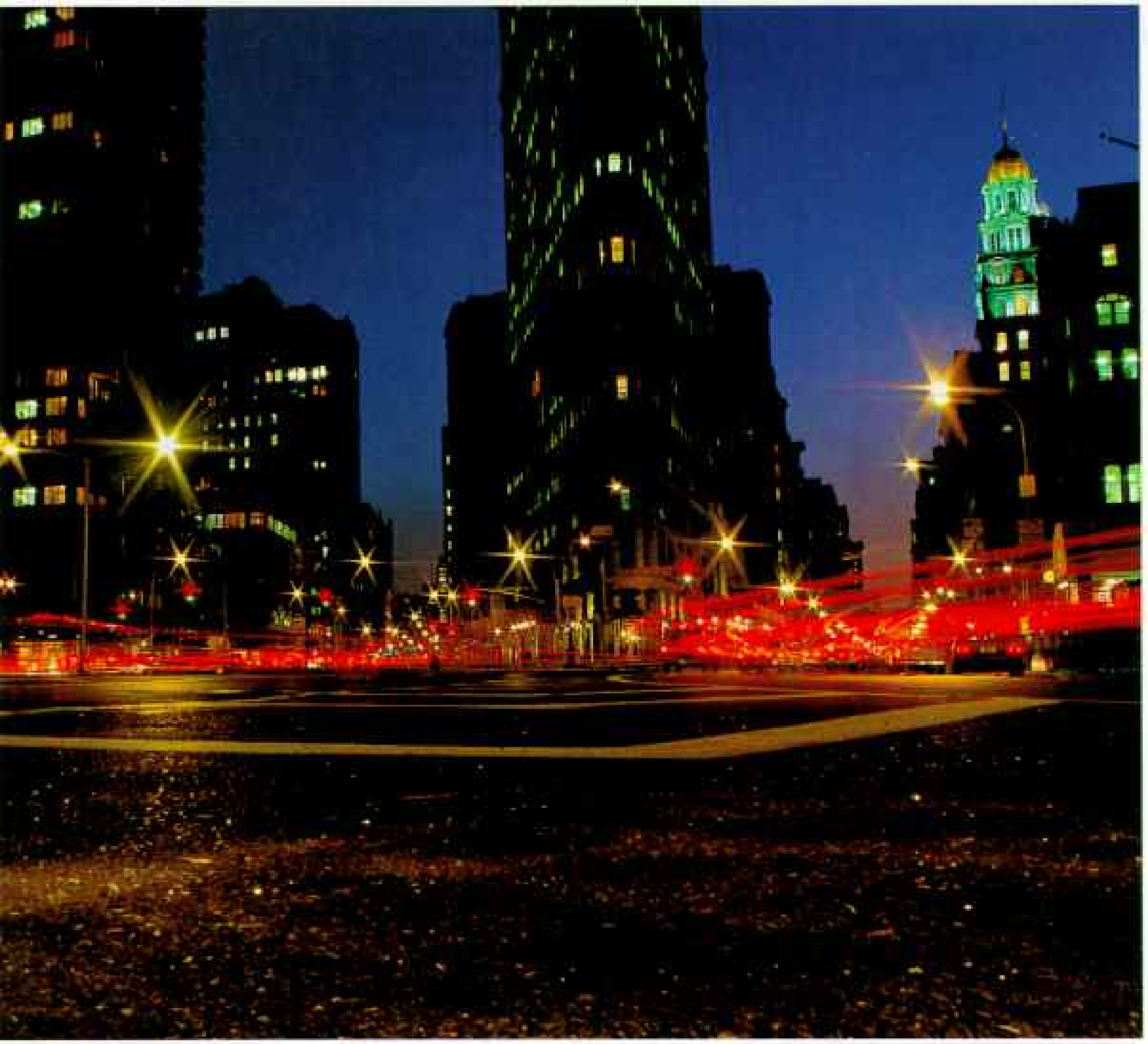
In California the Evergreen Oil Company recycles oil itself. Nearly a tenth of all lubricating oil now sold in the state has already seen duty in a vehicle engine.

"We gather it from filling stations and industrial sites," said Evergreen's chief executive, David Camp, at the company refinery in Newark, near San Francisco Bay. "Oil re-refined by distillation and hydrotreatment is indistinguishable from virgin oils. And since only 3 to 8 percent of crude oil is suitable for lubricating oil, we're saving a valuable resource."

The new ideas at the recycling center of San Rafael, California, are as old as animal husbandry. President Joe Garbarino employs 400 goats as "digesters." They scamper over dumped yard clippings, nibbling leaves

2.6 million tons recovered

10.6 million tons discarded



Glass

"Glasphalt" glitters on Manhattan streets paved with a mix of recycled glass bottles and asphalt. Such innovations move recycling along an upward path, as consumers exchange rampant waste for environmental awareness.

off branches, making the wood drier fuel for a local power plant. In a nearby pen, hogs oink for food waste from supermarkets and wholesalers. Feeding the pigs instead of the landfill, the center then recycles the pigs as well, selling 300 last year for pork.

"Kids love this part," said Joe, tossing the porkers a pile of pizzas. "I show young people how we bale paper, cans, bottles, and automobiles, and take in leftover paint to make new paint. I show them charts demonstrating ten years in which we've kept 21,815 truckloads of trash from going to the landfill.

"Those kids go home and say, 'Mommy, why are we throwing this away?' We've got to raise them with the idea of recycling."

And change a few adult minds along the way, says David Dougherty of Clean Washington. "We've got to do it right, create local markets, make recycling a natural part of the economy so it becomes a part of our lifestyle.

"Of all the environmental concerns that have come up through the years, this is the most personal. People are uncertain what they can do about saving whales or the rain forest. But they can recycle their waste every day of their lives." □

Article and photographs by
MICHAEL S. QUINTON

ALONE WITH THE NORTHERN GOSHAWK

Fledged at last! For ten weeks I've lived on intimate terms with a pair of goshawks as they incubated their eggs and brooded their young. Now one of those three chicks is perched, talons tight on a branch, working its wings, ready to fly.

Day after day I've watched the female turn the eggs, change her position, resettle to brood, try to get comfortable. I'm 35 feet up a tree in a small blind trying to do the same: It's wet; it's cold; I'm cramped; I'm still in the first season of my fieldwork.

But through all this, I'm coming to know this largest of our native accipiters, or hawks of forest habitat. Can the northern goshawk hold on as ever more western timber is logged? So far, there's no answer.

THE TRUTH IS, I wear the same blue clothes every single day. Of course, I wash them from time to time. Wearing identical clothes is part of my strategy to keep an unchanging routine so I can habituate this goshawk pair to my presence. Here, in the second year of my study, I'm photographing a female perched on a small branch (below) and silhouetted against the sky. I keep my distance; I don't make fires; and when I climb into my tree blind, it's before sunup, so as not to disturb the birds.

Only when I'm out of the blind and on the ground do I have any chance of observing the female hunting prey on the forest floor beneath her nest. She rarely goes far afield when she's raising her young. Usually she perches close to the nest and gives a wailing call (right), which seems to signal her mate to deliver prey. Just back from the hunt, he has ranged far to find the food for their survival.

My tent is pitched less than ten yards from a clear-cut section in national forest. It lies within a larger mosaic of heavily logged acreage, tree plantations, and old-growth stands on the Idaho side of the Centennial Mountains along the Continental Divide. My first year's study site was just over the divide in Montana, where conditions are closer to real wilderness.

Northern goshawks range widely across North America (map, above) with varying success. These are adaptable birds—to a point—but they seem to do best in mature forest habitat. Many who love these splendid raptors worry for their future in the West if clear-cut logging goes on chewing up prime nesting territory.

MICHAEL QUINTON wrote and photographed "The Great Gray Owl" for the July 1984 issue. His photographs also appeared in "The Common Loon Cries for Help," in the April 1989 GEOGRAPHIC.

Quick as a rocket the male attacks. I make one shot with my camera and drop to the floor of the blind as he swoops by. I've been a bit careless in showing myself, and the goshawk proves its reputation

as a fierce protector of the nest. With short, rounded wings and a long tail for maneuverability, goshawks sprint through dense forest canopy to hit prey or defend territory.

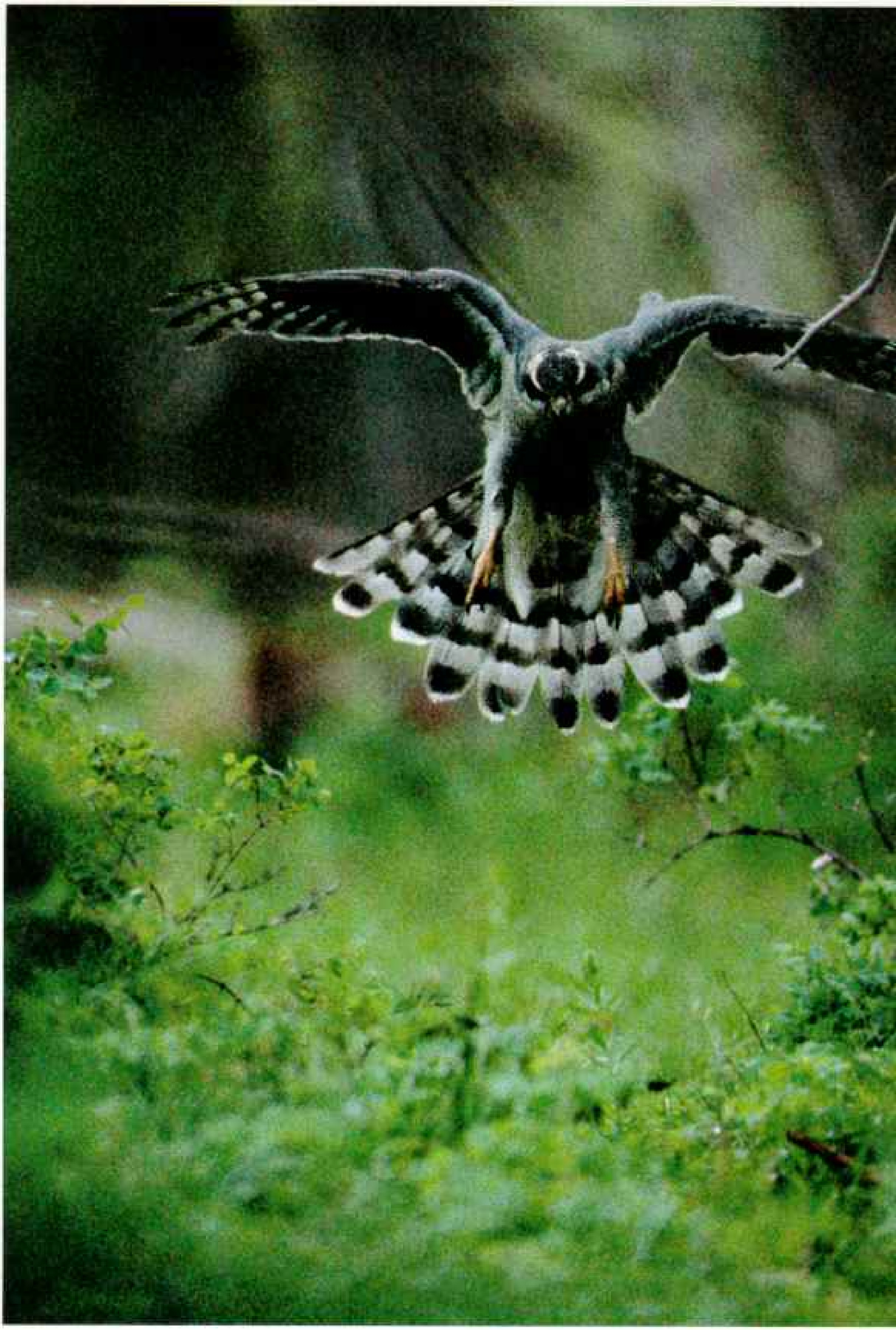
PREENING tail feathers as she incubates her eggs, the female at the Montana site (above) won't be at ease for long. On constant alert for danger, the goshawk mother remains on the nest until her mate brings prey to a perch close by. Then the male takes a turn at incubating while she eats.

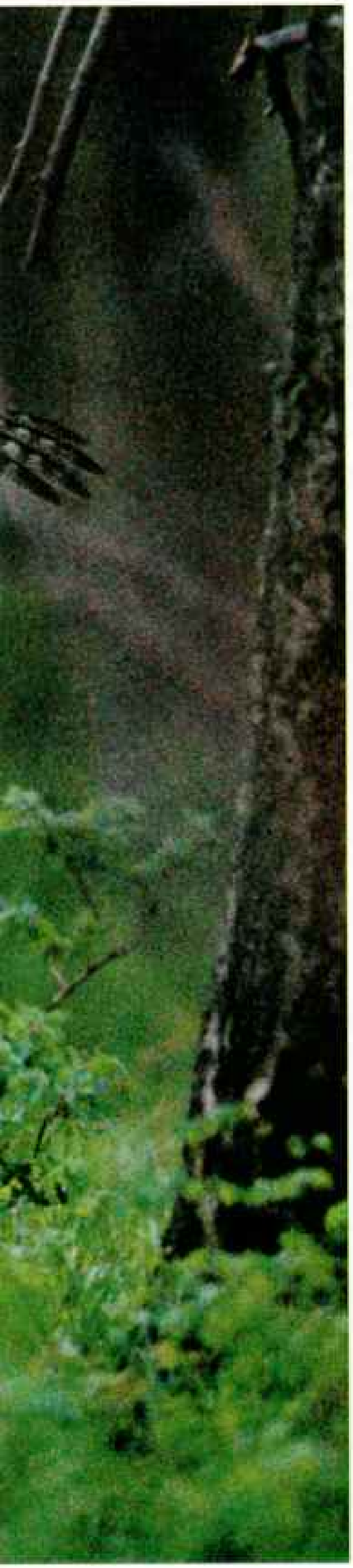
When finished, she returns, and the pair share the nest for an instant as they change shifts. Here the Idaho female (right, at right) quickly settles in, and the male speeds off to the unending hunt.

Smaller than the female, the male goshawk preys mostly on small-to-medium-size birds such as flickers and robins, which he delivers to his mate partly plucked and ready to eat.

I began my nest watches in May, when there was still plenty of snow on the ground. Glacier lilies were in bloom in Montana when the eggs began to hatch in early June and I got my first sight of the chicks (facing page).

The goshawk pair worked nonstop, though the female took time to watch intently as a mule deer came bounding by underneath with a coyote in pursuit. Soon the red Indian paintbrush blooming among the greens of the understory was spattered white with droppings from the fast-growing chicks.





ONCE the chicks have gained some size, the female begins to hunt. Her technique is different from that of her far-ranging mate. She sticks near the nest, going after small mammals in the style of an owl.

That technique involves making short flights in order to secure a perch right above prey. Then she floats down, almost hovering (left). When her talons strike home, she pumps them, quickly killing the quarry, mostly ground squirrels. She also takes red squirrels (below), which are abundant, and chipmunks.

Meanwhile, the male keeps bringing plucked birds to his mate. While the hatchlings are still very young, the female tears the prey into tiny pieces, giving them the meat and taking for herself less digestible portions such as skin and feet. Though a chick may tug at a foot (bottom), that is too big an order.

Nest defense is another duty, and the most frequent dust-ups involve red-tailed hawks, whose territory overlaps the goshawks'. When one would fly by, the female goshawk would utter her aggression call—*kack, kack, kack*—then light out after it. One time she smacked a redtail so hard she knocked it clear to the ground. That was one astonished redtail.

One of the dangers nestlings face is each other, and pecking order goes by size. As chicks begin to mature, parents drop prey in the nest and let their young fend for themselves. That leads to conflict, and at the Montana site one chick, notably smaller, got worked over by its nest mates.

The first one to grab prey gives the *kack, kack* call, which makes the others turn away. Once the smallest hawk ignored that law and tried to feed when a sibling was in control.

The larger chick attacked for about ten minutes (opposite), until the mother returned. The small one lay in the nest for an hour without moving. I expected it to die within a day, but it—I should say he—survived the attack of his big sister.

As the birds grew, the male chick managed to get enough of the food to reach the "brancher" stage. That's when the fledglings hop out on branches to test their wings before they actually start to fly.

There's the male, still the smallest one, standing on the nest (below). Even after they learn to fly, the young hawks stay in and near the nest for about a month, and the adults continue to feed them, at least part of the time.

GLOWING EYE and fierce bearing of a female at full maturity, her talons clamped on prey: That wild power has long thrilled dedicated birders and falconers, both of whom greatly esteem goshawks.

What lies ahead for these superb raptors seems to be closely tied to how much and what kind of forest habitat will be left for them. Year after year goshawk pairs return to the same territory to nest. One researcher told me of an area where nests had been recorded for 50 years. That's home to a lot of young.

As one who has lived with two goshawk families for months on end, through every kind of mountain weather, I hope the generations that follow will have their place for return. □

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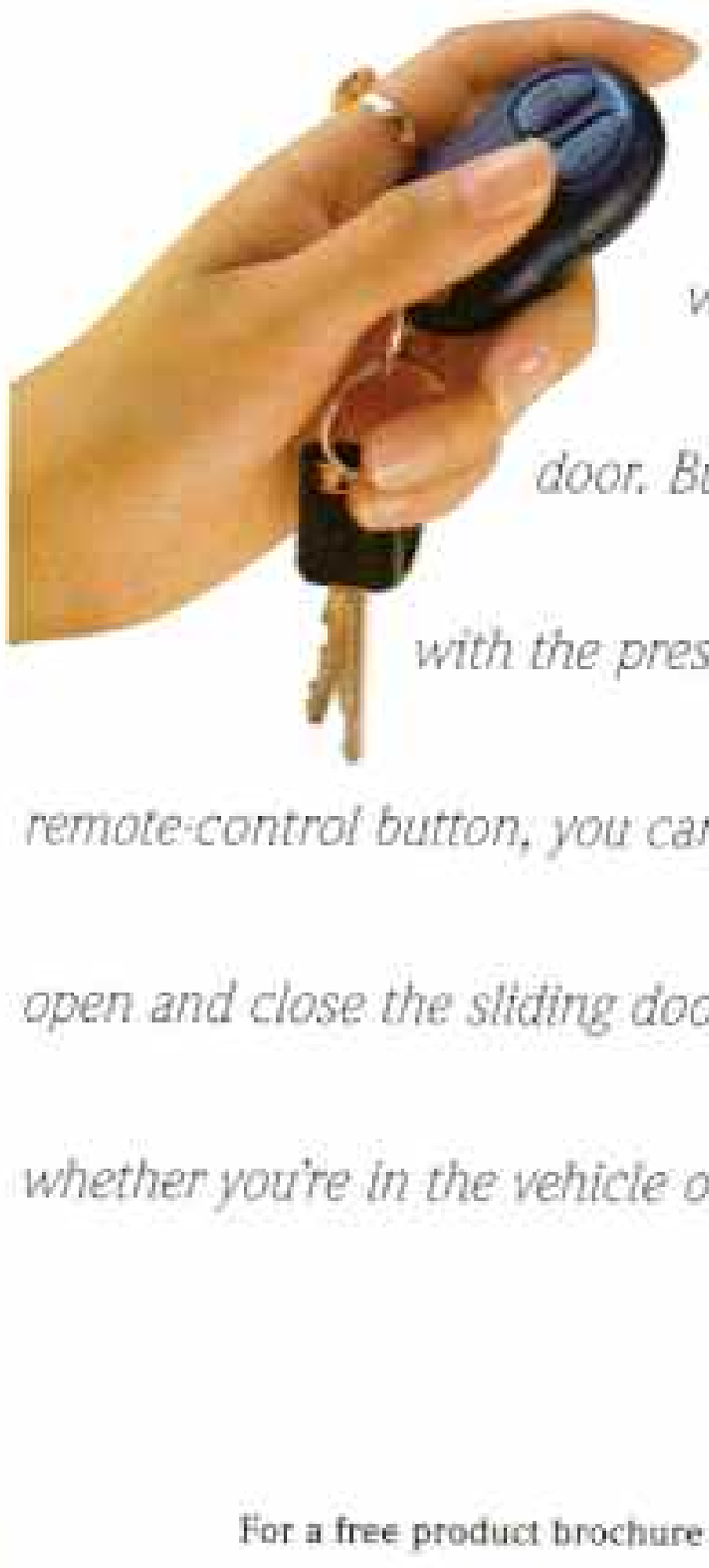

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Eighth Air Force in World War II

Thomas B. Allen's "Wings of War" (March 1994) was an accurate, touching account of the men of the U. S. Eighth Air Force. Militarily speaking, however, strategic bombing in the European theater was of questionable value, relative to Allied losses. It destroyed more civilian and nonessential targets than military ones. It arguably strengthened German resistance, just as the London Blitz did for the British [see GEOGRAPHIC, July 1991]. Most analysts today agree that those brave aircrews and ingenious machines could have been better used for tactical bombing, which was most successful in the Korean and Iraqi wars.

THE REVEREND PAUL C. BENNETT
Royal Oak, Maryland

The color photographs by Gerald R. Massie of young airmen were dramatic. At first glance I was positive they were from a movie set or reenactment. They take us to a moment during the war and show us that the sky was just as blue, the colors just as bright, and that these airmen were just like us with the same hopes for a bright future.

RICK PERRY
Abell, Maryland

As a navigator with the 398th Bomb Group, I had the experience of flying in the First Bomb Wing of the Eighth with the 91st and the 381st Bomb Groups. On December 24, 1944, the Eighth flew 2,046 four-engine bombers in tactical support of Allied troops during the German counterattack known as the Battle of the Bulge. This was the largest number of aircraft flown in a single mission during any wartime period.

RALPH H. MCINTYRE
White Lake, Michigan

The article was very good, but I was irked that it implied that the Eighth Air Force was the only factor involved in bombing missions over Europe. The 15th Air Force in Italy bombed targets in Germany, Austria, Romania, Czechoslovakia, Hungary, and Poland. Knocking out the Ploieşti oil fields in Romania was a factor in winning the war.

EDWIN C. WADE
Huntington, West Virginia

I would stress the ages of the flyboys. In the summer of 1944 as squadron operations officer, I had to give out ballots for the November presidential election. Fewer than half the crew members were old enough to vote (21 in those days).

ARTHUR C. JORDAN
Fair Oaks, California

On page 98 an airman is quoted as saying 1,300 Gypsy kids aged six to ten were killed by the Germans [at Buchenwald]. This is hearsay and an outright lie. No country or people in the world would do a thing like that.

CECIL ARNOLD
Jamestown, Michigan

The Nazis' own records, as well as reports by camp employees and survivors, confirm details about many of the people exterminated in the death camps. Such atrocities did occur.

It would have been nice to acknowledge the part played by the B-24s in helping to "turn the tide of World War II." There were about 13 groups of B-24s in England, and your article does not give a representative picture.

BALDWIN C. AVERY
Fort Myers, Florida

One more survivor of the gallant 91st was a B-17G named *Shoo Shoo Baby*. This well-worn lady was eventually restored to battle condition by the reservists of the 512th Military Airlift Wing at Dover Air Force Base, Delaware. *Shoo Shoo Baby* now resides in the Air Force Museum at Wright Patterson AFB in Ohio. She and the *Memphis Belle* are the only two surviving B-17s of World War II with combat records.

HENRY M. WILDASIN
Dover, Pennsylvania

Shanghai

The gorgeous photograph of the sea of poncho-wearing bicyclists lends testimony to the importance of this mode of transportation in this crowded city and worldwide. To me the tone of the caption reinforces the West's perception that bicycles are a problem. I wonder what the city would be like if these six or seven million benign vehicles were replaced with large, polluting automobiles.

WAYNE PEIN
Chapel Hill, North Carolina

Regarding Father Bao-Zhi's comments about abortion in China, there can be little doubt that he is a member of the government-approved "Catholic" Church. There are two Catholic Churches in China: this, and an underground one that recognizes papal authority and heeds the church's teaching that abortion is intrinsically evil. Its members are frequently subject to police raids and arrest.

MICHAEL ORT
London, Ontario

I lived in Shanghai in the early 1920s and went back in the '30s but had no desire to return after the revolution. After reading William Ellis's article and studying the pictures, I decided a return visit would

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be most interesting, but imagine this little old gal of 83 riding a bike or coping with the pedestrian mobs—not a ricksha in sight.

CAROLYN DUNBAR
Hockessin, Delaware

Simón Bolívar

You showed Simón Bolívar more as a dictator than as the liberator he really was. Despite the quotation of future President William Henry Harrison, Bolívar never planned to turn Gran Colombia into a monarchy, nor did he want to be its emperor. He wrote to Antonio L. Guzmán in December 1829: "I shall not be King of Colombia not even in an extreme situation, nor will I make myself liable to having posterity take away the title of Liberator given to me by my fellow citizens, a title which fulfills my greatest ambitions." He also used to say "Liberator or dead."

It is true that he had to assume power as a dictator more than once in order to save the republic, as was done in the ancient republic of Rome, but this was always temporary and previously approved by congress. Democracy or dictatorship? In Venezuela as in other countries liberated by Bolívar, we all believe his greatest legacy was democracy.

JACOBO DIB, JR.
Caracas, Venezuela

Nobel Prize-winning author Gabriel García Márquez in his novel *The General in His Labyrinth* presents a literary portrait of Bolívar as he made his last trip along the Magdalena River. The hero is demythicized and presented as a man—sick, disillusioned, and hopeless, practically drowned in his own dreams.

IVELISSE MARTÍN-YUNQUÉ
Coamo, Puerto Rico

Trinidad and Tobago

The article depicts the people of my country as being decadent, with a daily routine of rum drinking and limin' (hanging out). These activities do form part of the lifestyle, but my people are also disciplined, productive, tolerant, humorous, and very talented in many spheres. Even in these harsh economic times, the country is one of the most progressive in the Western Hemisphere with a standard of education and literacy rate among the highest in the world.

STEPHEN D. BARCANT
Ajax, Ontario

On a Canadian International Development Agency project, I spent several months interviewing people in Paramin to learn about their agricultural practices. Despite terrible problems of soil erosion that could mean the end of agriculture in Paramin, the village residents were the warmest, most cheerful people I have ever met. Frequently at the end of a hard day, I would enjoy their hospitality by limin' with them for a few hours.

NICOLA WOLTERS
Rosemère, Quebec

To portray calypso legends like Lord Kitchener and the Mighty Sparrow as calypso singers "vying for acclaim" is akin to describing Mozart as "that piano player." The Mighty Sparrow is internationally known as the Calypso King of the World, while Lord Kitchener is renowned as the Grandmaster, a fitting tribute to one whose intricate melodies and compositions have steered the musical direction of the national instrument, the steel drums, for 50 years.

IRWIN BARRY
Couva, Trinidad

I was surprised there was no mention of the opportunity the nation provides for exploring nature. One famous location is the Asa Wright Nature Centre. Trinidad and Tobago's efforts to establish effective conservation should be supported.

CHARLOTTE ADELMAN
Wilmette, Illinois

High Road to Hunza

I enjoyed the article by John McCarry, especially the last three paragraphs. I once lived in a remote area of China and understand why that old man was grateful for changes brought by modern development. Such people have been struggling for survival from the beginning of their history. Their communities were never Shangri-La as depicted in Western literature. It is not they but some Westerners who regret the changes. Please remember that people are not living specimens of an anthropology museum for outsiders to preserve and enjoy. They too have the right to pursue a better life, even though that will result in the disappearance of their old culture.

LI HUO
Boston, Massachusetts

I bicycled through the Hunza Valley in August 1982 when the highway was still closed to cross-border traffic, and I felt like a special visitor in Shangri-La. Gilgit was a real Wild West city with building and road construction, but in the valley was the serenity of lovingly tended fields and orchards. May the tourist onslaught not corrupt the enterprise and quiet friendliness of Hunza.

ANN SORREL
Newark, New Jersey

"High Road to Hunza" is exactly why I receive your magazine. I would never have known the Hunzakuts existed had you not brought them to my doorstep. Thank you.

STEPHANIE HORNE
Watauga, Texas

Letters should be addressed to FORUM, National Geographic Magazine, Box 37448, Washington, D. C. 20013-7448, and should include the sender's address and telephone number. Not all letters can be used. Those that are will often be edited and excerpted.

Geographica

Earliest Lincoln Portrait? Controversy Abounds

LINCOLN IMAGES © ROBERT AND JOAN HOFFMAN

Is this daguerreotype (left), thought to have been made in 1843, the earliest known portrait of Abraham Lincoln, then in law practice in Springfield, Illinois?

Yes, asserts Robert Hoffman, who bought the mirror-image likeness in 1992 from an antique dealer who acquired it more than 50 years earlier from descendants of Lincoln's private secretary, John Hay. Yes, insists Joseph Buberger, a "dag" specialist who knows of two daguerreotypists plying their craft in Springfield in 1843.

Definitely, says computer whiz Allen Phillips after reversing the image (top, left) and blending it digitally into an 1865 photograph of the Great Emancipator. "With reasonable scientific certainty," agrees forensic anthropologist Albert Harper, who compared the man's features, from earlobe to nose width, with other Lincoln images.

Maybe, ventures Harold Holzer, a Lincoln authority. "If it wasn't Lincoln, why was it in John Hay's possession?" he wonders.

But a leading scholar on Lincoln images, portrait artist Lloyd Ostendorf, emphatically disagrees: "The hair is too light, his forehead is too low and narrow, he's got a pointy chin, his whiskers look blond, and Lincoln wouldn't have been caught dead in that Napoleonic pose."

Getting to the Bottom of Moscow's Past

In the largest archaeological project ever undertaken in Moscow, excavators reached down to the 12th-century beginnings of the city, 21 feet below the surface. The nine-month dig last year was spurred by plans for a complex with stores, galleries, and a parking garage beneath Manege Square (right), next to the State Historical Museum and the Kremlin (NATIONAL GEOGRAPHIC, January 1990).

Over time Manege Square has housed everything from a nunnery to an open-air bazaar. Among the artifacts now being analyzed are black-glaze jugs, coins, glazed stove tiles, a copper cross, a gold chain, 12th-century glass bracelets, and an 18th-century ear scratcher.

Many objects shed light on "the lively, busy, chaotic district of small traders, artisans, and inn and tavern keepers crowding the right bank of the now buried Neglinnaia River" in the 16th and 17th centuries, says Nicole Prévost Logan, leader of an Earthwatch expedition whose volunteers helped out for a month.

NICOLE PRÉVOST LOGAN

To Alexander Veksler, general director of the Moscow Center of Archaeological Research, the most surprising find was a 14th-century bronze book clasp bearing an Asian dragon. "This is proof of highly developed trade and indicates a literate population," he says.

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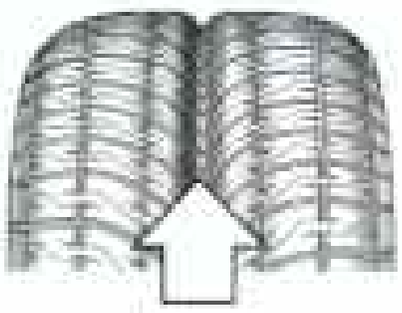

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Geographica

Creatures Great and Small Formed Lucy's Family

Humans come in many sizes, from towering male basketball stars to tiny female gymnasts. So, it seems, did the first upright-walking hominids, *Australopithecus afarensis*.

TIM WHITE

The species is best known from the bones of a little female called Lucy—discovered at Hadar in Ethiopia—and from fossils found at Laetoli in Tanzania, although some experts doubted that larger specimens were *A. afarensis*. But new discoveries at Hadar and at Maka, 45 miles to the south, clear up the mystery.

The Hadar fossils include the first nearly complete *A. afarensis* skull, three million years old. The 3.4-million-year-old Maka finds yielded teeth, jaws, and limb bones from nine individuals. These confirm that males were on average larger than females, but with enough variation that Maka, Hadar, and Laetoli bones all fit within the same species. Lucy's lower jaw (left, at top) is almost identical to the lower jaw of a Maka adult male, at bottom. Lucy's jaw is smaller, as befits a creature less than four feet tall. The Maka male was perhaps a foot taller (drawing, right). One bone fragment indicates an arm as small as Lucy's, but another arm bone and teeth rank among the largest *A. afarensis* remains.

WILLIAM H. BOND

WINT BRONAUGH

Woodman, Measure That Tree! Is it a Champion?

"Only God can make a tree," wrote poet Joyce Kilmer. But anyone can nominate a potential champion—largest of its species in this country—like this hundred-foot-high American elm (above) in Louisville, Kansas.

The 1994 National Register of Big Trees lists 799 champions and co-champions of native or naturalized species. Big is determined by a point formula that includes height, girth, and crown spread. Some champs live in remote old-growth forests; others shade farms or busy streets. "Most are nominated by a few unofficial big-tree hunters," says Deborah Gangloff of American Forests in Washington, D. C., which has published the catalog every two years since 1940. It includes the General Sherman giant sequoia, 275 feet tall and 82 feet around, and a 13-foot-tall American snowbell in Texas.

The current list crowns 143 newcomers—seven replacing Florida trees blown down in 1992 by Hurricane Andrew—but 158 species of American trees still lack champions. So if you know of an unusually large western burning bush, elephant tree, Texas Hercules'-club, or myrtle-of-the-river, start measuring.

Storms in a Bottle: Understanding the Basics

Huge storms rage across continents; ocean-born hurricanes slam into the land. To understand how these forces work, a physicist at Los Alamos National Laboratory re-creates them in a controlled laboratory setting, using a covered, water-filled cylinder a little larger than a coffee cup.

Robert Ecke duplicates the sun's warming effects by heating the jar, which he rotates once every ten seconds to simulate earth's spin. Lighting and videotaping the action, he produces false-color images of roiling hot and cold vortices that mimic those within a storm.

"This demonstrates that a storm system can be created with only thermal buoyancy, rising hot air, and rotation," Ecke says.

—Boris Weintraub

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Walter Mossberg noted in *The Wall Street Journal* on January 13, 1994, "Getting multimedia hardware and, especially, software to run on a typical IBM-compatible computer can be a frustrating—even impossible—task.... In general, users of Apple's Macintosh computers face very few of these problems, because a single company—Apple...has made sound, graphics and video a priority."*

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BOTH BY JANE MARIE FRANKLYN

WSPA official Victor Watkins and his team penetrate Gypsy camps with hidden video cameras to discover captive bears. Handheld cameras record dangerous raids with Greek and Turkish police to confiscate the animals.

In one night action, 12 bears chained to trees in a park in Istanbul are rescued. A spotlight shines on Black Cloud, and the cub is freed to begin a journey to a new life—in a sanctuary akin to his natural habitat.

To Gypsies the trade of dancing bears is an ancient tradition. One owner says, "I want my sons to do the same work I do. If they take the bears away from us, I don't know what we'll do. I don't know how we'll live."

WSPA supports long-range plans to find Gypsies other kinds of work, but Victor Watkins vows that if dancing bears reappear in Greece or Turkey this summer, Operation Libearty will act again to end the macabre dance.

"Last of the Dancing Bears" airs July 10 on EXPLORER, TBS Superstation, 7 p.m. ET.

Dancing to a Requiem: Lament for the Bears

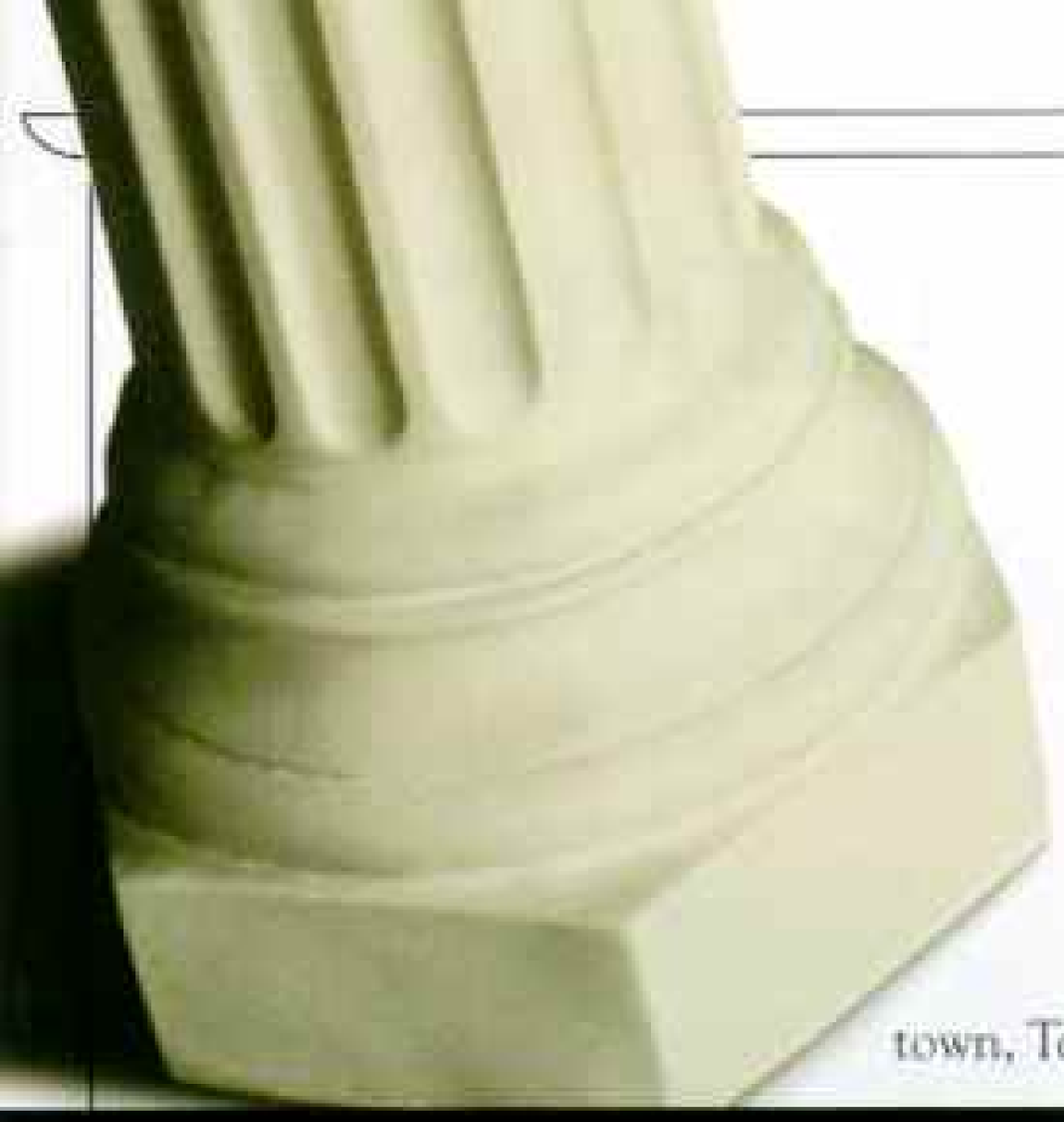
In the cool mountain forests of western Turkey, a brown bear nurses at his mother's side. Poachers appear. The mother is killed and the cub sold to Gypsies, who pierce his nose and insert a steel ring, probably the first of many in a hard career. The animal's ordeal has begun; next he must submit—likely beaten into obedience.

Black Cloud, a nine-month-old cub undergoing training (above right), will soon join other bears, such as a chained older veteran (above), and earn his keep dancing on the streets of Istanbul.

Producer Sarah Cunliffe first learned of the bears' plight through a newspaper advertisement sponsored by the Libearty Campaign. This international effort was launched by the World Society for the Protection of Animals (WSPA) to rescue dancing bears, many of them starving and blind.

A common spectacle in medieval Europe, dancing bears still shuffle on city streets in eastern Europe and Asia. Tourists pay about $15 for a snapshot, encouraging a system that is both illegal and cruel.

EXPLORER's "Last of the Dancing Bears" goes undercover to expose this aspect of the illegal trade in brown bears, whose numbers have been severely reduced by poaching and habitat loss. The film reveals the hideous conditions that exploited bears must endure.



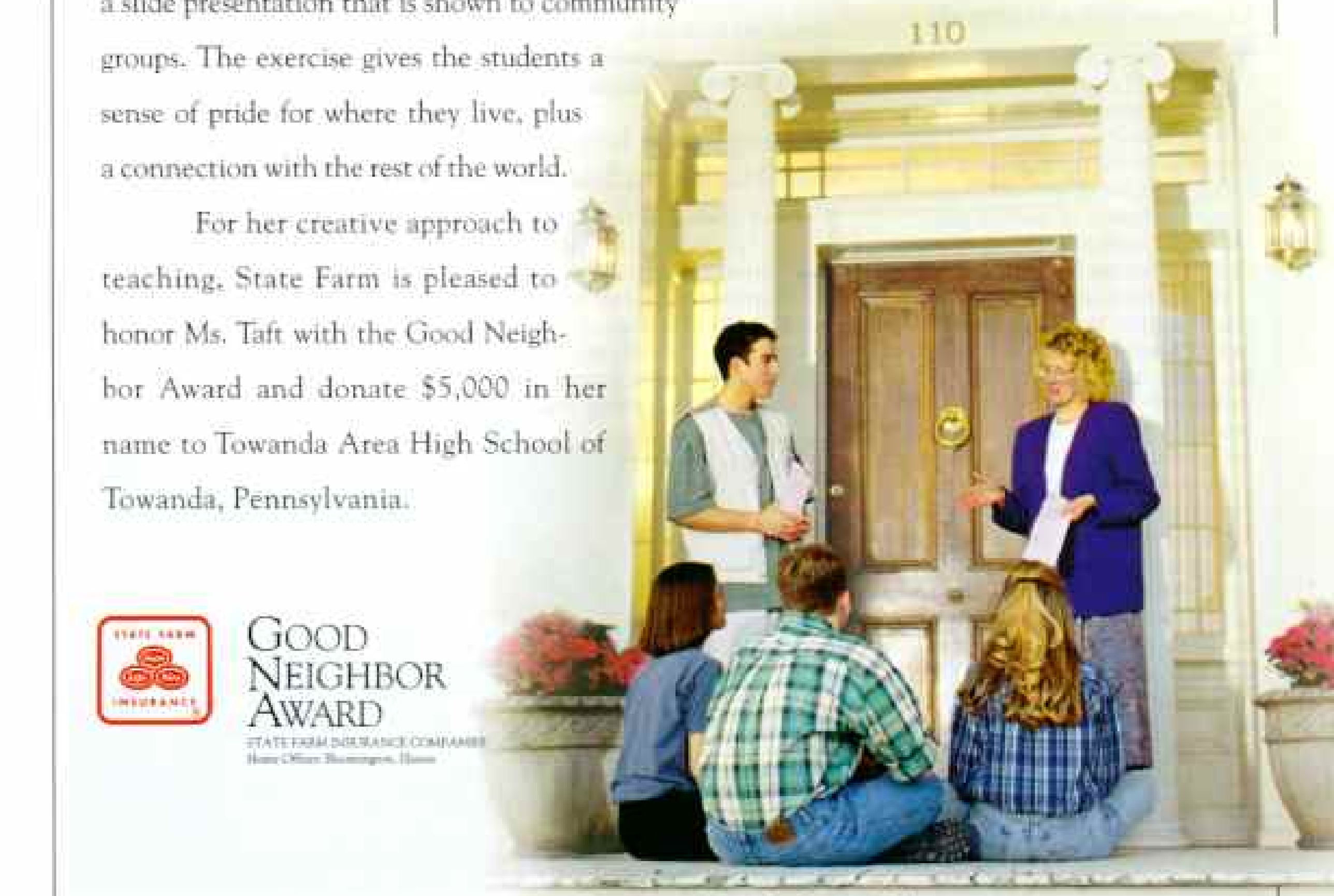
Ms. Taft's Students Study A Few Of The Greek Classics In Geography.

Why would sophomores study Greek Revival Architecture in geography class? Ask Ms. Lou Taft's students. To them, geography is more than knowing locations on a map.

All because Ms. Taft has them study their own town, Towanda, Pennsylvania. They begin by investigating its architecture, exploring everything from Greek to Gothic Revival. In the process, they discover the influence of other countries right in their own backyard. They learn about their community, and about other cultures.

Working together, they create a map for a walking tour of their town. They also produce a slide presentation that is shown to community groups. The exercise gives the students a sense of pride for where they live, plus a connection with the rest of the world.

For her creative approach to teaching, State Farm is pleased to honor Ms. Taft with the Good Neighbor Award and donate $5,000 in her name to Towanda Area High School of Towanda, Pennsylvania.



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MARIA STENZEL

A Cab Fleet That's Clean, Green—It's a Natural!

When lobbyists and members of Congress are whisked around Washington, D. C., in a Clean Air cab, they don't get an earful about the Redskins or the weather. "Our drivers tell them about the power of natural gas," says Jim Doyle (above)—because that's what runs his Clean Air fleet.

In the trunk of each 1993 Chevrolet Caprice, two large cylinders hold a novel fuel supply—natural gas under high pressure. The gas runs to a regulator that lowers the pressure, the only adjustment needed for the V-8 engine.

More than 30,000 natural gas vehicles (NGVs)—mostly government and company cars—are now rolling nationwide. More are due by 1998 when, under federal law, some government and private fleets must be converted to alternative fuels. The five cabs owned by Doyle and his partner, Todd Ruelle, are among 650 NGVs in the Washington area, including school buses and Washington Gas Light Company vehicles.

NGVs spew out fewer smog-producing hydrocarbons than do gasoline-powered vehicles. Natural gas also costs less than gasoline and delivers comparable mileage. But while Doyle says there's "enough natural gas here in America to last 200 years," only about 800 U. S. service stations pump the clean fuel.

Reining In the Impact of Wild Horses on Islands

Legend holds that horses aboard a Spanish galleon that foundered off North America's mid-Atlantic coast swam to barrier islands and proliferated. But the National Park Service says that many of the 500 or so horses roaming its coastal lands today descend instead from those brought by 18th- and 19th-century farmers to the Outer Banks, Assateague, and Cumberland. Their grazing and trampling is damaging some marsh and beach ecosystems.

A three-year study is under way "to determine the number of horses that can be maintained before there is serious damage," says Bruce Rodgers, a Park Service biologist. As part of the project a contraceptive is being injected into mares on Assateague. An annual auction of foals helps limit a separate herd there—the famous Chincoteague ponies (below)—to about 150 animals.

AL PETTERAY, NGS

National Geographic, July 1994

LOPHIUS AMERICANUS, HERB SEGARS (BOTH)

Tricky Angler, Goosefish Itself Attracts Fishermen

The black sea bass never had a prayer. The ocean floor, greenish brown and seemingly empty of danger (above), suddenly gaped: A cavernous mouth created powerful suction and engulfed the hapless bass. Often described as mostly mouth with a tail attached, the American goosefish had struck again.

Four feet long and weighing about 50 pounds, this species is one of more than two dozen in the goosefish family of anglerfish. All have a built-in fishing pole, a long spine atop their massive head with a fleshy end that wriggles like a worm. With it the goosefish entices fish, lobsters, and even diving ducks.

But the tasty meat in the goosefish's tail, sold as monkfish and billed as poor man's lobster, is luring more commercial fishermen. With groundfish such as haddock and flounder severely depleted in Atlantic waters, fleets of trawlers seek new species to exploit; they hauled up some 17,600 tons of goosefish in 1992. These bizarre bottom dwellers, biologists fear, will soon join the list of overfished species.

Hot Reading: Notes From the First Atomic Bomb

Contamination of a renowned archive has spurred the invention of a new radiation detection device, a "waffle iron" that scans paper.

Since World War II, artifacts and documents from the Manhattan Project, which designed the first atomic bomb, have been stored in the Chicago branch of the National Archives. Two years ago a physicist there found an eight-inch metal rod in a box. He sent it to nearby Argonne National Laboratory for analysis. "It was a uranium rod," says health physicist George Mosho.

The unsettling discovery prompted examination of all the project's material, including 1,504 notebooks. Radiation contamination was suspected, but no one had ever built a detector for paper. Mosho and colleagues developed the waffle iron, with sensors mounted in top and bottom frames (left, with senior technician David Jones). About one-third of the notebooks were radioactive. Although not considered a health risk, they have been replaced in the archives by copies.

GEORGE JOCH, ARGONNE NATIONAL LABORATORY

When a Tree Falls in the Forest, Wildlife Hears

"There's life in dead trees," says Melanie Lupien-Payer, a volunteer for an unusual wildlife real estate partnership—Animal Inn. The "inns" promoted by the partnership are dead or dying trees that birds and animals, such as this marten (below), need for shelter and to raise their young.

Animal Inn, which began as a U. S. Forest Service project in 1988, now has eight private and public partners. The goal: Make a landowner think twice before felling that stately old snag, unless it's a hazard to people. Lupien-Payer points out that such trees benefit more than 1,300 species of birds, mammals, reptiles, and amphibians.

MARTES AMERICANA, STEPHEN J. KRASEMANN, ALLSTOCK

—John L. Eliot

National Geographic, July 1994

On Assignment

JOEL SARTORE

Wing to wing with an eagle, photographer JOEL SARTORE, noted for his whimsical eye, takes a break with Boston College mascot Brian Falvey during coverage of the Massachusetts capital for this month's issue. "I'm always running into eagles," says Joel, who documented the real thing for "Eagles on the Rise" (NATIONAL GEOGRAPHIC, November 1992).

Joel ruefully recalls Bostonians' pride in their cuisine. From hushed hotel restaurants to rowdy street festivals, he says, "I never met a bowl of chowder I didn't like." As a result, he took away a lot from this assignment: "I gained ten pounds."

R. MICHAEL COLE AND KEITH A. MOOREHEAD, NGS

Staff photographer EMORY KRISTOF (lower left) feasts his eyes 170 feet below the surface of the South China Sea, as he and author Franck Goddio examine the remains of the Spanish galleon *San Diego* for this issue.

During 31 years at the magazine, Emory has shifted from early underwater work as a scuba-diving shooter to pioneering the use of lighting and remote-control photography in the deep ocean. With Society technicians he designed and operated cameras that recorded life in the 12,000-foot-deep Cayman Trough and beneath the North Pole.

He was also the first to use a submersible as a wildlife blind to photograph deepwater sharks (November 1986). More recently, he used camera-laden robots directed from the surface to explore life in the teeming depths of Japan's Suruga Bay (October 1990).

"People call me the Nintendo diver," says Kristof. "But I'm happy to do it with machinery these days. I'm there for the images."

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Hawaiian Hawk **Genus:** *Buteo* **Species:** *solitarius* **Adult size:** *Body length: 46cm (female); 39cm (male)* **Adult weight:** *600g (female); 440g (male)* **Habitat:** *Lowland agricultural areas to upper native rain forests on the island of Hawaii* **Surviving number:** *Estimated at 1,600* *Photographed by Jack Jeffrey*

WILDLIFE AS CANON SEES IT

Its Hawaiian name is 'io, and some islanders consider it to be a spiritual guardian of their families. The only hawk endemic to the Hawaiian Islands, the 'io is often seen soaring above the forested volcanic slopes. Hawaiian hawk populations are at present stable, but preserving what remains of its island habitat is crucial to the long-term survival of this native bird of prey. To save endangered species, it is vital to protect their habitats and understand the role of each species within the earth's ecosystems. As a global corporation committed to social and environmental concerns, we hope to foster a greater awareness of our common obligation to ensure that the earth's life-sustaining ecology survives intact for future generations.