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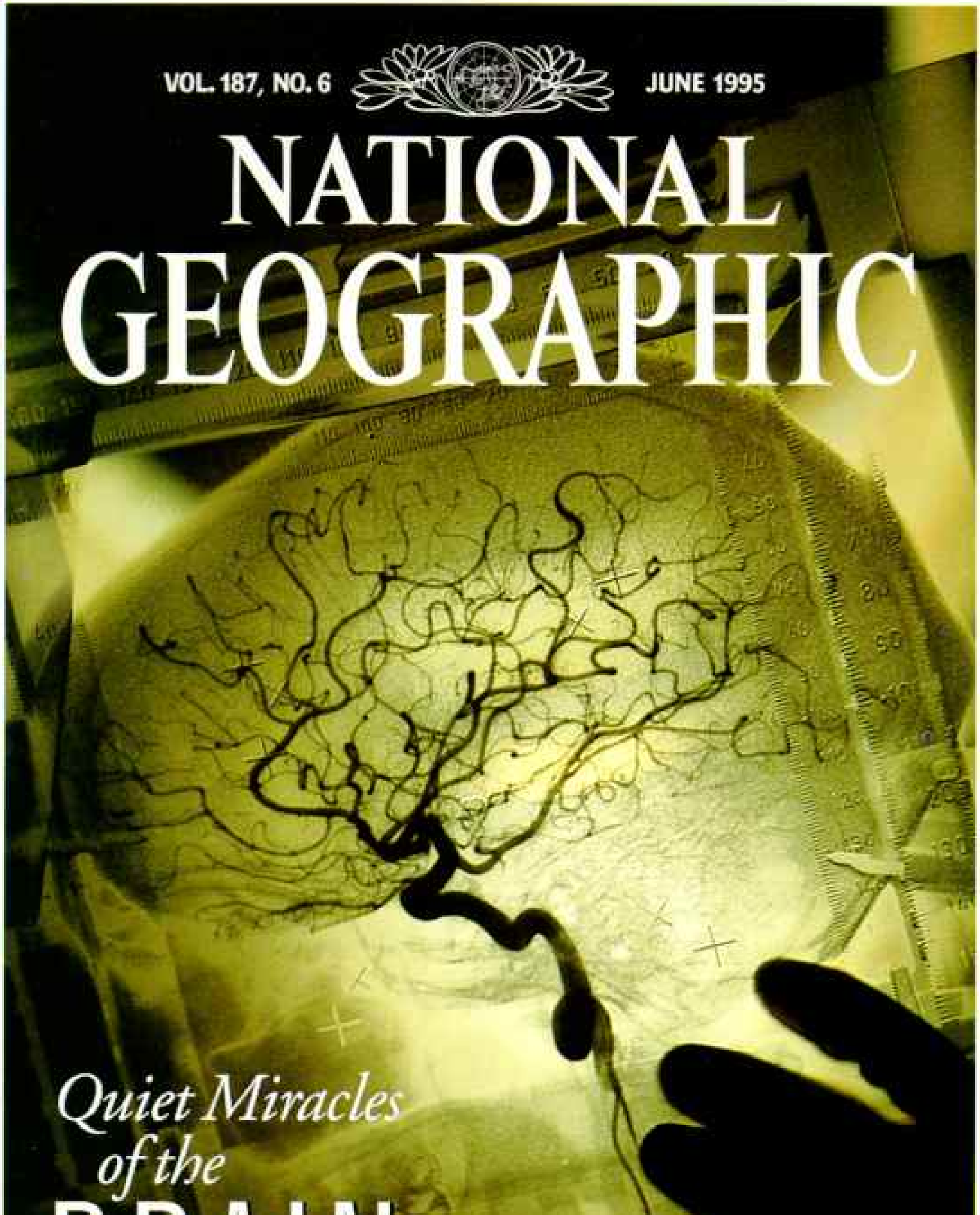

Quiet Miracles of the BRAIN

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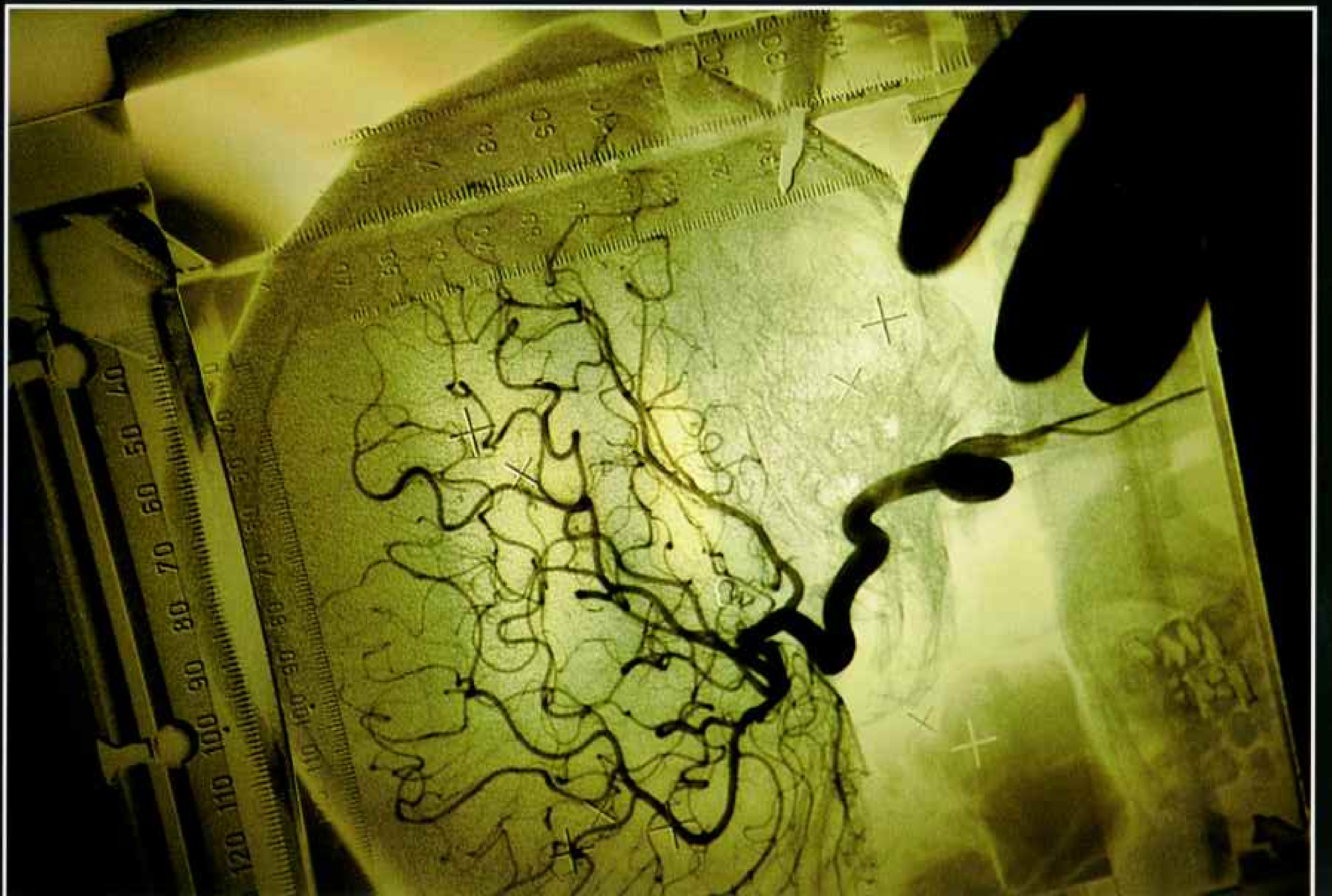
Quiet Miracles of the BRAIN

INFINITELY MORE COMPLEX THAN ANY MACHINE EVER INVENTED, THE BRAIN IS THE ESSENCE OF WHAT MAKES US HUMAN. ITS BLOOD VESSELS, SHOWN IN AN ANGIOGRAM AT RIGHT, NOURISH THREE POUNDS OF DELICATE TISSUE. ITS BILLIONS OF CELLS MYSTERIOUSLY REGULATE THE BODY, LEARN FROM A LIFETIME OF EXPERIENCES, AND SUMMON THE MEMORIES AND THOUGHTS UNIQUE TO EACH OF US.



All his parents' love and encouragement cannot enable 38-year-old Chuck Green to brush his teeth. Living in a rehabilitation facility near Boston, he has been largely unresponsive since suffering a hemorrhage seven years ago. A congenital abnormality caused a blood vessel in his brain to burst,

killing vital cognitive areas. The brain's network of nerve cells, or neurons, can form new connections as long as the cells stay healthy, but the brain cannot replace dead neurons. "We see whatever Chuck does as little miracles," says his mother, Esther, "but we hope and pray for a real big one."

ARISTOTLE BELIEVED that the center for thought lies in the heart and that the brain helps cool the body. Drowsy people hang their heads, he said, because brain-created heaviness forces the head downward. We laugh now, but many experts agreed with Aristotle as recently as the late 19th century. Indeed, we still know relatively little about the three pounds of flesh that makes us human.

This is not surprising given that the human brain, with its many billions of cells, is the most complex object in the known universe. But we have learned more in the past ten years than in all previous history, thanks to technologies that allow researchers to see inside living brains and examine brain functions at the subcellular level.

That we have entered an era of extraordinary discovery becomes clear moments after I ring the doorbell of eight-year-old Matthew Simpson's home in Albuquerque, New Mexico. The scene is a Hollywood version of how childhood is supposed to be: Bikes on the driveway, a green lawn, and next-door neighbors playing basketball.

Matt stands beside his mother as we chat on the porch. He can see that I am feeling the New Mexico heat. "Would you like a glass of water?" he asks. It is the last day of second grade, and Matt is proud of his report card. It shows respectable grades, good behavior, and steady improvement. Two years ago surgeons removed nearly half of Matt's brain.

Matt's first three years were textbook normal. Just before his fourth birthday, he began to experience seizures—electrical misfirings that impede brain functions. Medicines did nothing as seizures threatened to turn fatal. The eventual diagnosis: Rasmussen's encephalitis, a rare and incurable condition of unknown origin.

Desperation brought his parents, Jim and Valerie Simpson, to Ben Carson, a pediatric neurosurgeon at Johns Hopkins Hospital in Baltimore, Maryland. Carson recommended a hemispherectomy, removing the left hemisphere of Matt's brain. Matt would lose half his cortex, tightly packed folds that handle thought processes and most of what makes us human. The empty area of the skull, Carson explained, would fill with cerebrospinal fluid at about a teaspoon every five minutes and would remain filled.

The operation could lead to crippling, coma, death, or recovery. Carson would not guess at odds. Nor would he say how much of Matt would remain with half his cortex gone.

Although hemispherectomies were performed in the 1940s, few patients lived. Pediatric neurosurgeons revitalized the procedure in the mid-1980s, because of advances in brain scans and in ability to combat bleeding.

Several dozen hemispherectomies are performed each year now in the United States, usually as treatment for Rasmussen's encephalitis and forms of epilepsy that destroy the cortex but do not cross the groove separating left and right hemispheres. Patients can live because neither the disease nor the operation touches areas that control basic functions: the cerebellum, which coordinates movement; the diencephalon, which facilitates emotions and regulates body functions; and the brain stem, which maintains breathing, heart rate, and other life-support systems.

As Matt began to suffer worsening seizures, sometimes every three minutes, the Simpsons had no choice.

Matt's parents and half sisters, 16-year-old Stacy and 13-year-old Jamie, show me a scan of Matt's brain. I see the outline of a skull. One side has shapes in white, gray, and black. The other is all black, entirely filled with fluid.

The operation left a scar that runs along one ear and disappears under his hair. But his face has no lopsidedness. The only visible effects of the operation are a slight limp and limited use of his right arm and hand. He also has no right peripheral vision in either eye.

Matt and his mother drive out on errands. "I see a sailing ship and a huge elephant," he says, looking at shapes in clouds. She discusses

New York-based photographer JOE MCNALLY has grappled with other complex subjects for the magazine, including "Sense of Sight" (November 1992).

IS THE MOST COMPLEX OBJECT IN THE KNOWN UNIVERSE.

A violin is no toy at an institute for early development in Philadelphia. Children here take on such challenges as algebra and Japanese to maximize the brain's potential. Learning means forming new connections between neurons, a process most intense in childhood.

details with him and asks if he sees anything else. Matt describes a clown and a frog.

I appreciate such brain-stimulating games when I join his weekly session of speech and language therapy. One typical activity is word games. Therapist Joan Harden places cards in front of him. Matt turns one over. It says "fast things." He must now name as many fast things as he can in 20 seconds. "Car . . . truck . . . train . . . plane," he says. The next card says "soft things." Matt says "Butter . . . the middle of bread" and stops. A child his age should name from six to eight things each time. Matt names only four and two. Is this because he has half a brain or because he suffered seizures between ages $3\frac{1}{2}$ and $6\frac{1}{2}$? No one knows.

In the past two months Matt has made nine months' progress in language use. "In the improvement he has made it appears he is fostering and accelerating the growth of dendrites, threadlike extensions that grow out of neurons, the specialized cells of the nervous system," Harden explains. "The neurons seem to be making better connections."

More connections among the brain's estimated hundred billion neurons mean a better functioning brain. Connections come from inherited growth patterns and in response to stimuli, including internal stimuli like imagined sensations. The body receives information at the "periphery"—the neuroscientists' chauvinistic word for everything that is not the brain—and encodes it as nerve impulses. When these electrical impulses reach the brain, they trigger the release of messenger chemicals such as glutamate, which in turn

induce electrical impulses as they travel from one neuron to another. This electrochemical process, the basis of brain communication, sometimes stimulates growth of new dendrites. Thus rats raised in cages full of toys have more brain mass—probably from more dendrites—than do rats in empty cages.

The brains of infants suffering from some forms of mental retardation have fewer dendrites than do the brains of healthy babies. Brain-imaging studies conducted by Harry T. Chugani, a pediatric neurologist at Children's Hospital in Detroit, Michigan, suggest that dendrite production rises rapidly after birth and remains at a peak level from about age four to age ten. In fact, during these years a child's brain has many more connections than does an adult's and uses twice as much energy.

Until recently, experts believed that genes program most dendrite growth. People like Matt demonstrate that the brain has unexpected flexibility—what scientists call plasticity. This plasticity promises to redefine basic concepts. The left side of the brain of a right-handed person—precisely what was cut out of Matt—specializes in handling music, poetry, and mathematics. Yet Matt enjoys piano lessons, and math is his strongest subject in school. Somehow, knowledge and capability traveled from one side of his brain to the other.

Such transfers seem to defy biology. Does an undiscovered conduit exist, or does each side have dormant capacity to assume functions of the other? The ability to transfer is highest before adolescence, during the years of peak dendrite growth. But transfer, albeit limited and slow, also occurs when strokes kill portions of an adult brain.

Pursuing perfection, 15-year-old gymnast Amanda Forrest glides through moves she has practiced thousands of times at a New York gym. She began the sport as a toddler and now trains four and a half hours a day hoping to vault into the elite ranks. After so many years "skills just become instinctive," says gym floor manager Mary Anne Kenefic. Such agility likely involves changes in the structure of brain cells brought about by the movements and the will it takes to execute them.

Other evidence of transfer comes after amputations. Every part of the body is connected to the cortex. Touching something with your left hand, for example, activates a particular part of your right cortex, and touching something with your right hand stimulates a mirror-image portion of your left cortex. Next to these sections of the cortex, for reasons no one understands, are areas connected to the nostrils (artwork, pages 14-17). After his hand was amputated, one man reported tingling in his missing pinky when researchers dripped warm water under his nostrils. The part of his cortex connected to his nostrils had seized areas of the cortex that had received signals from the now missing fingers. Likewise, brain scans of Braille readers show that their reading fingers stimulate more cortical area than do fingers of sighted people. Presumably, extra use of these fingers prompts expansion into neighboring cortical territory.

The Simpson family says that Matt's personality never changed through seizures and surgery—an observation made by most families whose children have had hemispherectomies. "He started as a nice, caring child and he stayed a nice, caring child," Valerie says. For me, the best moment comes one evening while Matt is drawing with crayons and the adults are talking. Matt interrupts us. Jim asks him to stop. Interruptions continue. Jim warns Matt he will be punished. Matt persists. "Why are you smiling?" Jim asks me.

"Because he acts like a normal eight-year-old," I reply.

"He *is* a normal eight-year-old," says Jim.

MANY PEOPLE LEARNED in school that we use only 10 percent of our brains, a belief that may have been based on psychologist William James's assertion in 1910 that we use "only a small part" of our mental powers. People like Matt certainly indicate that much of the brain is redundant. I can imagine Matt telling his dates ten years from now, "You won't believe this, but I have half a brain."

Matt's resiliency is dramatic, yet no more so than a common occurrence: the development of new human brains. I look into a microscope at an eight-cell human pre-embryo, the product of laboratory, or in vitro, fertilization. The egg and sperm were taken from a husband and wife whose family history includes a fatal genetic disease. If scientists at the Illinois Masonic Medical Center in Chicago determine that this gene is not present, they will implant the pre-embryo into the mother.

The pre-embryo resembles a transparent bubble floating in space. Although I feel like a voyeur, I cannot stop looking through the microscope. Each cell is rounded, the cell walls are thick lines, and dark smudges are cell nuclei—exactly what I expect. But why does each of the eight cells look exactly the same? Some will grow into the brain, others into the heart and skin. Maybe the microscope is not strong enough to reveal differences.

"They *are* the same," geneticist Yury Verlinsky explains. "From each of these cells, every cell in the body will grow. The differentiation begins once the cells have divided into about a hundred, about three days after the egg is fertilized. No one knows how it happens. There is no 'master builder' cell."

DURING EARLY PREGNANCY, neurons can grow at a rate of 250,000 a minute. Perhaps half die before a baby is born. This "pruning down" may eliminate flawed neural connections. Gerald Edelman, a neurobiologist at the Neuroscience Institute in La Jolla, California, sees a tropical rain forest in which "neural Darwinism" selects the fittest neurons.

Whatever triggers brain development, it is the most sensitive part of fetal growth. Vitamin deficiency, maternal smoking, or prenatal exposure to alcohol, chemicals, or too much heat may prevent neural development or cause damage to neurons.

Women who have influenza while pregnant, some studies suggest, are more likely to have children who develop schizophrenia, as are women who suffer severe malnutrition during pregnancy. Other evidence, like family histories, indicates that inherited genetic malfunctions contribute to schizophrenia.

Advancing knowledge about the role of the brain's physical structure in mental illness should change our perceptions about such diseases. Including depression and manic depression, mental illnesses afflict more than 20 percent of all Americans.

"That's the frontal cortex of Steven Elmore, a 33-year-old schizophrenic," says Dan Weinberger, a neurologist and psychiatrist at the National Institute of Mental Health, as he flips an image onto his computer. We are in the den of his home in Washington, D. C. Weinberger flips an image from Steve's identical twin, David—who is not schizophrenic—next to the first image. "Brains normally differ more from one another than do fingerprints," Weinberger says. "But these brains are genetically identical and should look the same. They don't."

The differences between Steve's and his brother's are clear. Steve's has less cortex and larger fluid-bearing ventricles. "The part of the cortex he's missing," Weinberger says, "serves as perhaps the most evolved part of the human brain. It performs complicated tasks such as thinking organized thoughts. This might help explain why paranoid delusions and hallucinations are characteristic of schizophrenia."

Weinberger clicks further into both brains. The images also show that Steve's has a smaller hippocampus. The hippocampus, from Greek for "seahorse" because of its shape, facilitates memory storage. Such an abnormality may be why some schizophrenics have memory problems.

"The loss of brain tissue does not worsen with time, and it does not improve with medication," Weinberger says. "It may be there from birth, and it may be partly the product of genes that make a person vulnerable. It's hard to know what's really going on since schizophrenia doesn't usually manifest until late adolescence."

Writing in the fourth century B.C., Hippocrates said that "madness" comes from too much "moistness" in the brain—exactly what Weinberger has just shown me. For Hippocrates, this was a lucky guess based on the belief that four "humors"—earth, fire, air, and water—control health.

As is common when a scientific venture is in its infancy, discoveries raise more questions than they answer.

"How do genetic characteristics interact with environmental influences?" Weinberger asks me. "Why doesn't schizophrenia appear sooner? Can we devise a way to treat patients before symptoms appear?"

Western medicine used to blame schizophrenia on upbringing or the patients' self-indulgence. "Now at least we know it has *physical* aspects," Weinberger says. "The same is true of manic depression and many other so-called mental illnesses."

Such insights have led to drugs that affect brain chemistry. Key to many of these drugs is dopamine, a naturally occurring chemical in

EXPERIENCE CAN BE REDUCED TO A PHYSICAL COMPONENT.

Finely honed discipline is part of the act for the Enigma, a performer in the Seattle-based Jim Rose Circus. To swallow two feet of steel, he controls the gag reflex and muscles all the way to his stomach. "I took a couple years to get the first sword down."

the body that responds to external and internal stimuli by saying to neurons, "Attention must be paid." Neurons have at least eight different types of receptors for dopamine; each absorbs a different message. Restricting the actions of dopamine reduces schizophrenic symptoms.

This physical aspect of schizophrenia should prompt changes in our attitudes—many people still see mental illness as a stigma—and in insurance policies that grant less coverage for mental illness.

WHATEVER THE CAUSE, about one in every hundred Americans—including as many as one-third of homeless adults—have schizophrenia. At a busy corner I see telltale traits: Some homeless people stand alone and look particularly disheveled, strange even among the strange. One woman wears a wire-and-foil hat. "To keep my skull from opening," she says.

What went wrong for these people? Lack of money and bad luck are likely suspects. About 40 percent of Americans with severe mental illness receive no treatment. "I'd be on the street myself if it weren't for my family, doctors who care, and medicine," Steve Elmore tells me a few days later when *(Continued on page 18)*

Child's play perplexes Bea Olshan, a 76-year-old Alzheimer's disease sufferer in Florida. "She's lost," says her husband, Harry. "You can just see the misery in her eyes." Weekdays she goes to day care, where activities such as visits to a school keep her mind as active as possible. Most people lose some

neurons as they get older yet retain much of their brain power. In Alzheimer's disease neurons die relentlessly, and mental capacity deteriorates. Death comes when the brain can no longer direct the body. Scientists still do not fully understand what causes this condition or why risk increases with age.

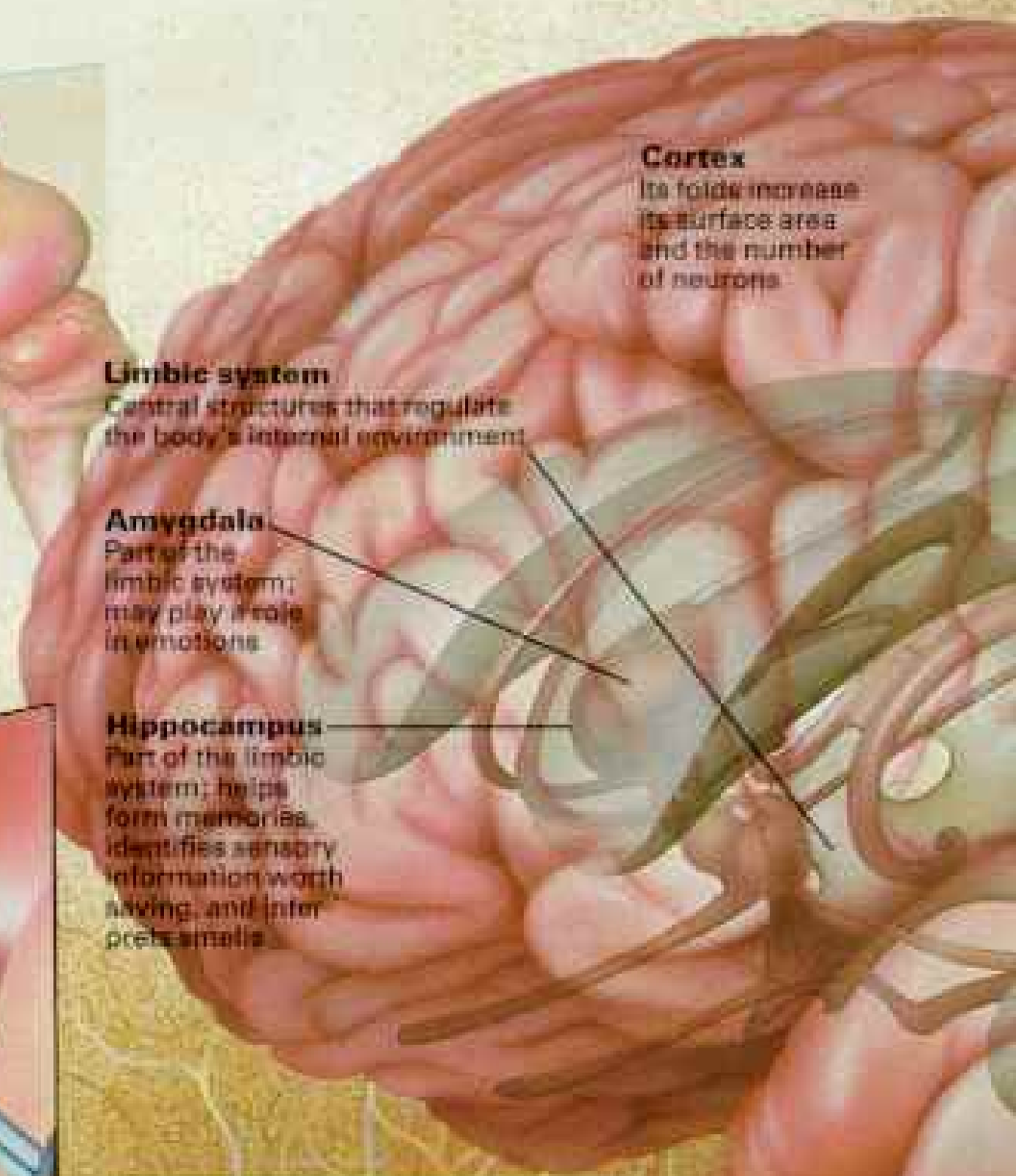
The Healthy Brain

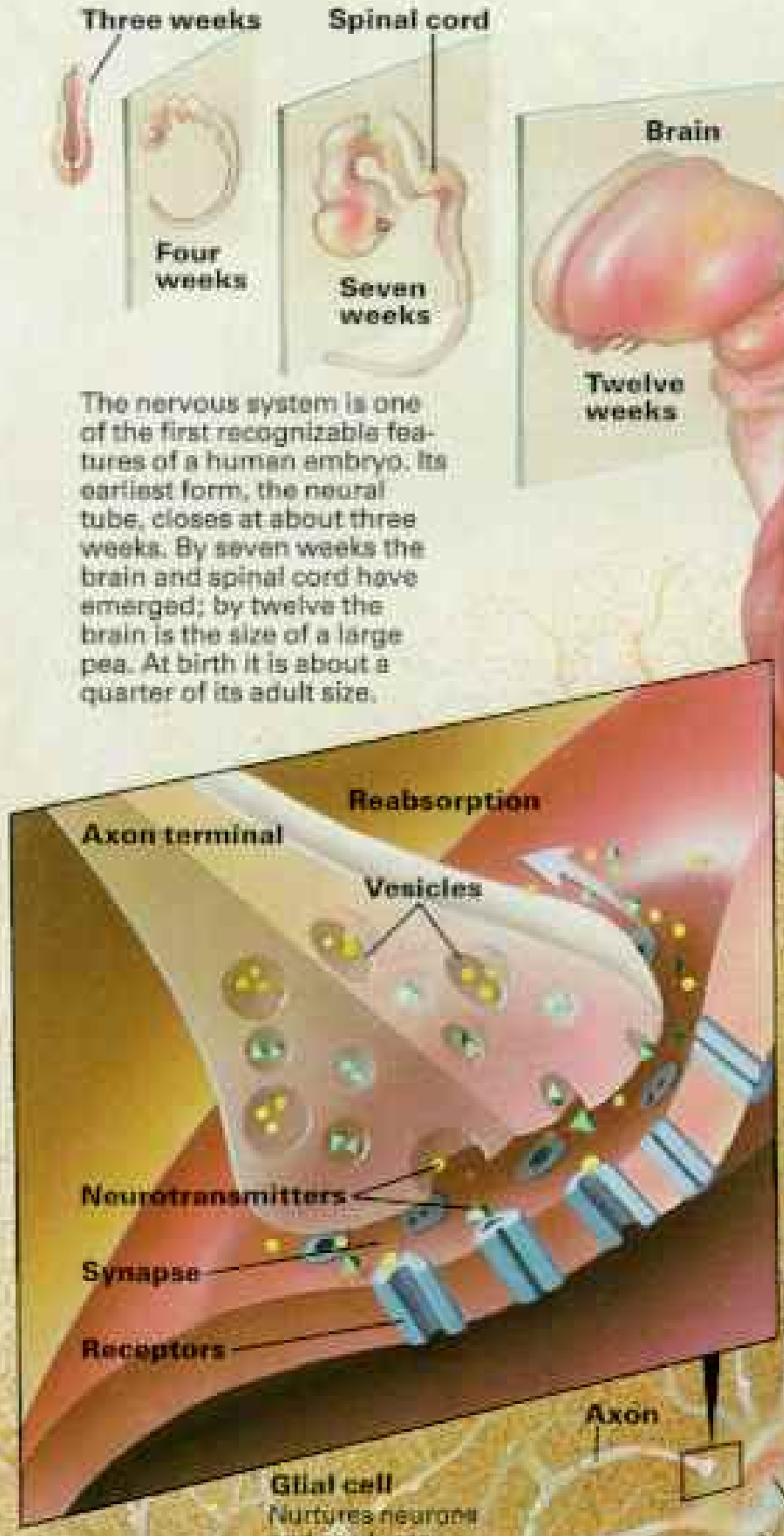
"The brain is the most difficult part of the body to study," says E. Fuller Torrey, a psychiatrist at the National Institute of Mental Health. "We carry it around in this box on our shoulders that's very inconvenient for research." Recent developments in imaging, however, have improved our view of its architecture and workings. Each of its hemispheres, right and left, controls the opposite side of the body. Regions within a hemisphere specialize in certain functions—the motor cortex, for instance, helps control conscious movement. Other structures, such as the hippocampus, which aids memory, have their own jobs. Neurons, the network communicators, send and receive electrochemical signals in mere thousandths of a second at connection points called synapses.

ILLUSTRATION BY KEITH KASNOT

BEGINNINGS

The nervous system is one of the first recognizable features of a human embryo. Its earliest form, the neural tube, closes at about three weeks. By seven weeks the brain and spinal cord have emerged; by twelve the brain is the size of a large pea. At birth it is about a quarter of its adult size.

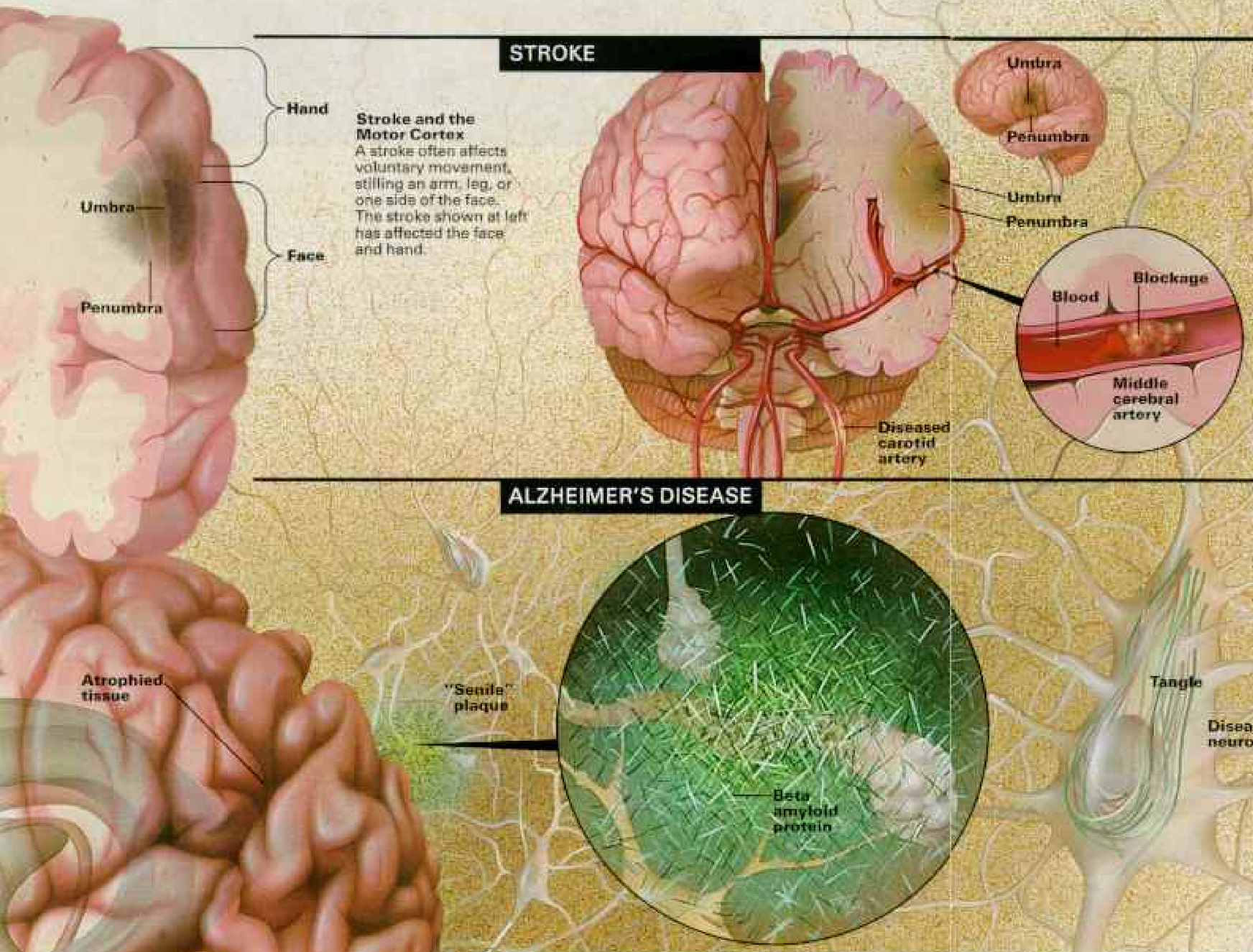




SYNAPSE

Each neuron is a single nerve cell with one or more arms, or axons, that send signals and one or more other arms, or dendrites, that receive signals. When a signal pulses to an axon terminal, spherical bodies called vesicles fuse with its membrane. The vesicles then burst open and release chemicals called neurotransmitters, which cross the minute space, or synapse, between the sending cell and the receiving cell. To end the signal, the axon reabsorbs some neurotransmitters, and enzymes in the synapse neutralize others.

STROKE



Stroke and the Motor Cortex
A stroke often affects voluntary movement, stilling an arm, leg, or one side of the face. The stroke shown at left has affected the face and hand.

■ Strokes strike quickly. In about 80 percent of cases a plug of fat or a blood clot lodges in an artery in the brain and cuts off blood flow. Deprived of essentials such as oxygen and glucose and unable to get rid of wastes, cells in the area supplied by the artery die. Fat plugs and some clots come from arteries in the neck; other clots come from the heart.

In addition, high blood pressure and abnormalities in blood vessels can cause bleeding in the brain.

Surrounding the area of rapid cell death, the umbra, lie cells that die more slowly, the penumbra. Future medical advances may be able to save these cells.

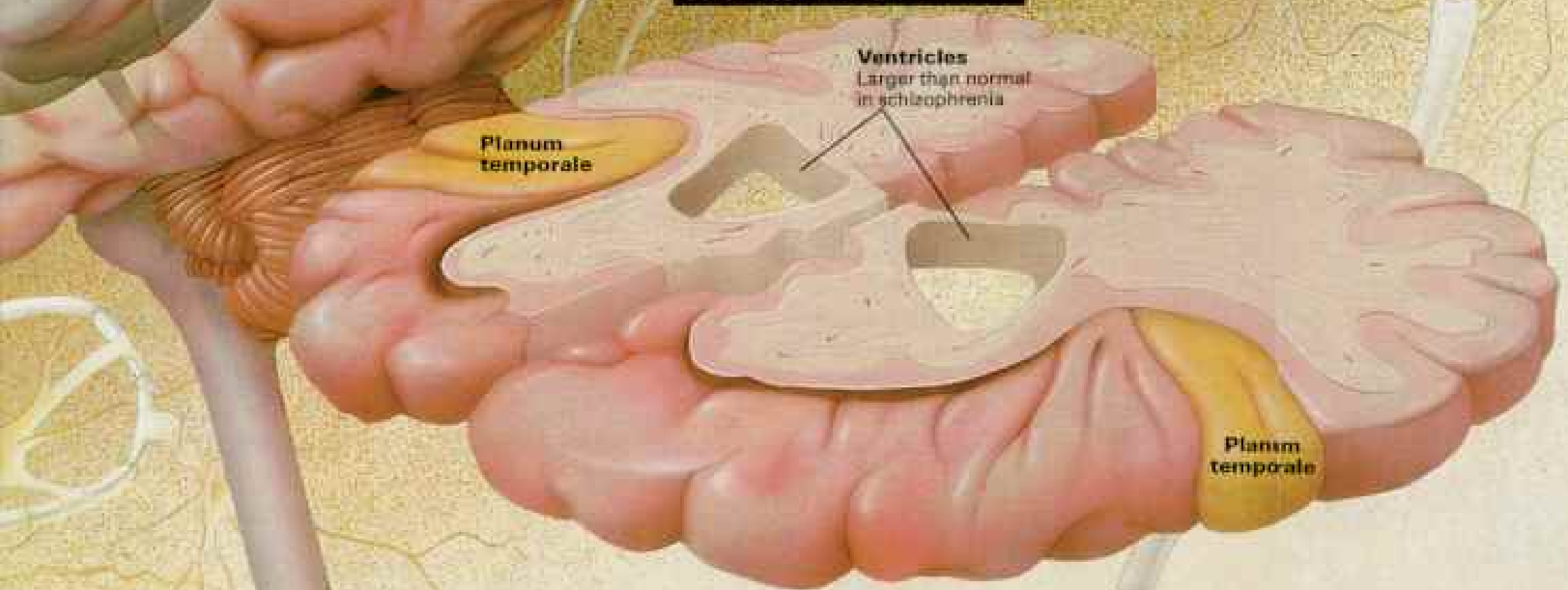
ALZHEIMER'S DISEASE

■ In Alzheimer's disease, cells die and the brain shrivels like a desiccated walnut; neural connections wither.

Inside an increasing number of neurons, tiny abnormal filaments form tangles that choke the cells. In the spaces between neurons, a protein called beta amyloid clumps together with glial cells and misshapen nerve endings to form "senile" plaques.

Tangles and plaques occur throughout the brain but are most plentiful in two critical areas: the hippocampus, which facilitates memory formation, and the cortex, which specializes in reasoning, judgment, language, and orientation. Several factors, including genes, environment, and aging, likely work in combination to cause this condition.

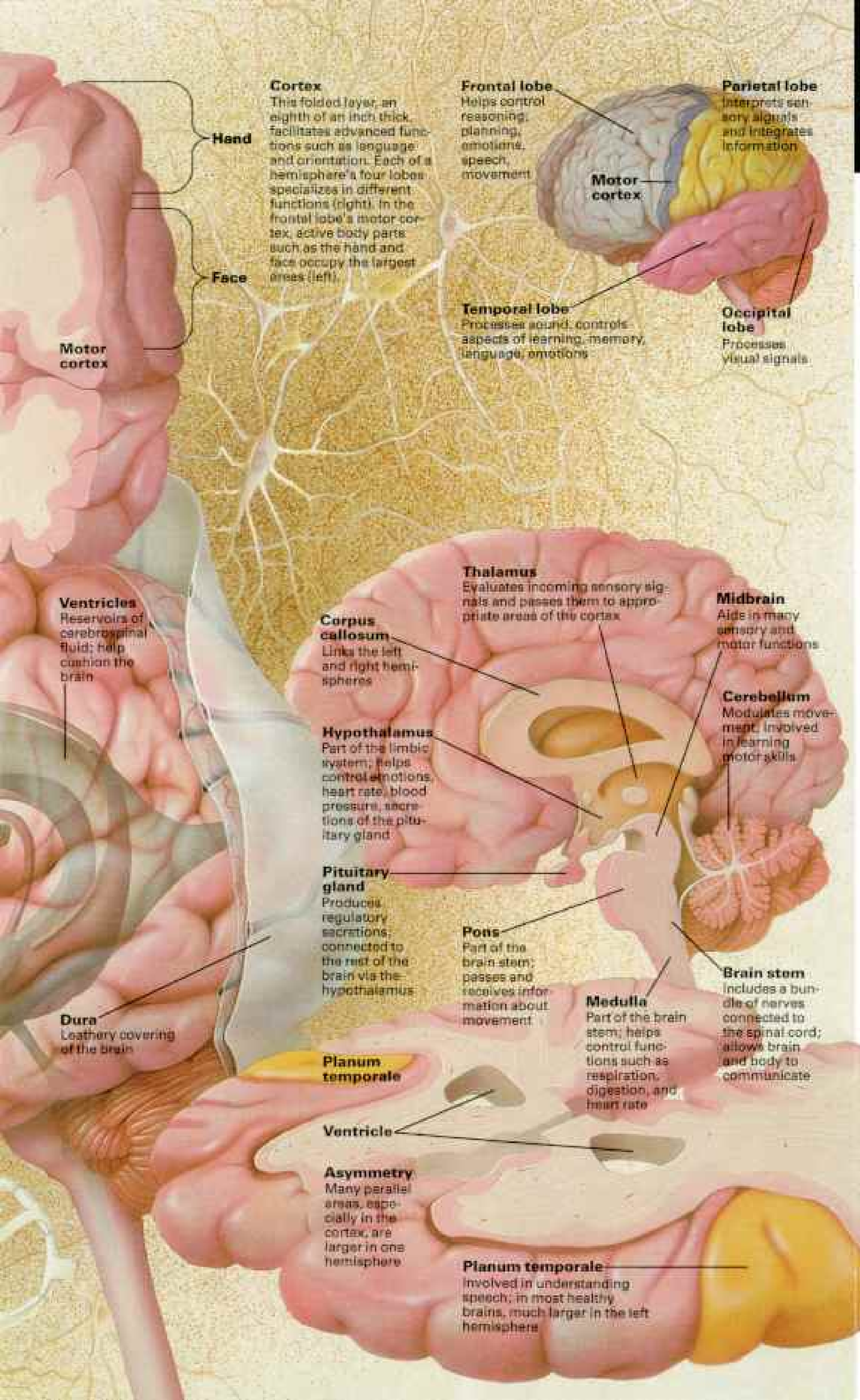
SCHIZOPHRENIA



■ Normal asymmetry – brain areas larger in one hemisphere – appears to be reversed in people with schizophrenia. The planum temporale, for example, is much larger in the *right* hemisphere, perhaps explaining their garbled language.

The Unhealthy Brain

Because many workings of the healthy brain are still little understood, malfunctions are difficult to interpret. "This is not garage mechanics," explains Johns Hopkins neurologist Stephen Oppenheimer. "It's not a question of going to the hospital for a tune-up." Some disorders, such as a stroke, cause immediate, clear damage. In Alzheimer's disease, on the other hand, neurons die in various areas over years. Schizophrenia remains an enigmatic scrambling of thoughts.



(Continued from page 11) I visit his Indianapolis, Indiana, apartment. He owns his own car, handles his own finances, and works for a mental-health agency that understands a schizophrenic's need to avoid stress.

Steve's apartment has few books, mostly biographies of the Beatles, because Steve can concentrate only long enough to read in short spurts. Shelves of rock-and-roll discs line every wall. "When an episode starts, I lie down and listen to rock," Steve says. "I feel like a nothing, like I'm falling apart, like I'm not on this planet. My brain gets stuffy, like people are trying to stuff cotton balls in it. I can feel the brain pressing against the skull. If I went off my meds, I'd be weird in about a week."

Steve asks if I have ever had to work hard at something. "That's how it is," he says. "The medicines don't do all the work. It's a struggle." That evening we stay up late. Steve describes how his life changed at 19: anger at noises only he heard, walks through the neighborhood screaming. During childhood, he said, he was a little wilder than his twin but not significantly different. I tell him about a recent study showing that home movies of children who later became schizophrenic reveal jerky body movements when compared with siblings. "Maybe," Steve says with a smile, "but I was always a better basketball player than my brother."

Steve still hears voices. "Have they been talking now?" I ask.

"Sure," he says. "I told them you manage my rock band." I take out an empty pad and ask him to write what he hears as our conversation proceeds. Soon, "Jerk," "Shut up!" "You're a creep," "Get out of here," and similar statements fill the page.

"Do you realize that no one is saying those things?" I ask.

He shakes his head, exasperated. "Maybe not," he says, "but I know the voices are likely real."

Later that night he takes out a plastic pillbox and swallows extra Stelazine, a drug that blocks binding of dopamine to receptors and helps silence the voices. Treatment of his schizophrenia as a physical illness fits in with a larger pattern: Scientists increasingly argue that everything we experience can be reduced to a physical component. These "reductionists" are the ultimate cartographers: Everything, they say, exists at a particular point on the brain map.

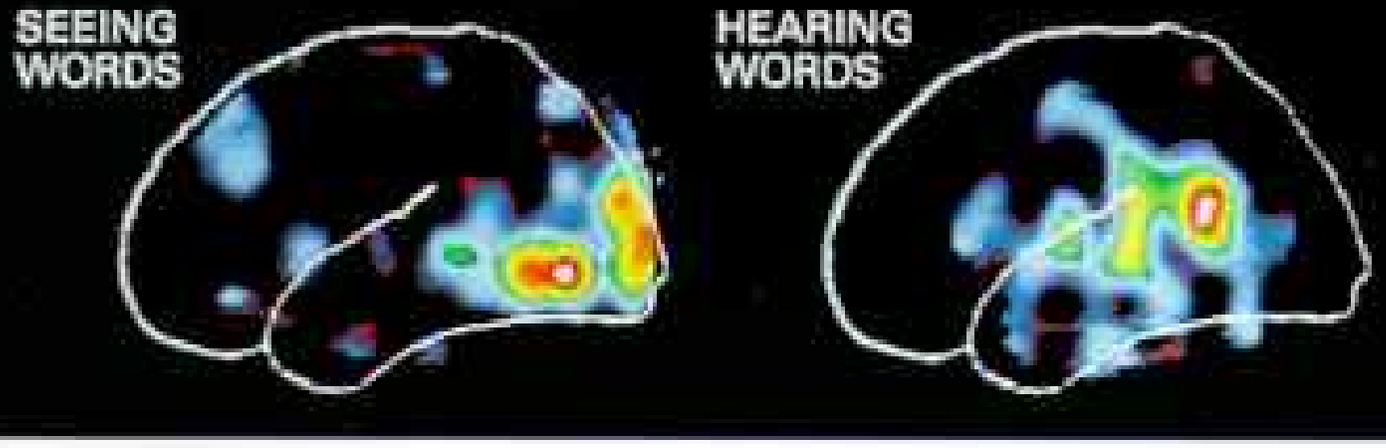
Some reductionists stake out an extreme position. Francis Crick, who along with two colleagues won the 1962 Nobel Prize in medicine for deciphering the DNA code that defines genes, says that "You, your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells."

The uniquely human "consciousness"—variously defined as language, introspection, self-awareness, and abstract thinking—eludes scientific measurement. Albert Einstein conceived of the theory of general relativity after imagining a person taking a ride in a box through space. Yet postmortem study of Einstein's brain has indicated nothing that explains how he used such visualizations to devise abstract theories.

And who will map the mixture of myth, morality, faith, pain, and joy that make up our spiritual geography? "We will never find a satisfactory mechanistic explanation" for such phenomena, said Lewis Thomas, the late physician and biologist who wrote best-sellers such as *The Lives of a Cell*. Is this because measurements are too crude or because scientists are trying to measure the immeasurable?

EXAMINING ANIMALS suggests a relationship between brain size and intelligence. Human brain size leveled off about 100,000 years ago, perhaps limited by what can fit through the female pelvis—the brain is approximately one-quarter its final size at birth; the rest of the body is one-twentieth. But among humans, no size-intelligence relationship exists.

"Bigger is not necessarily better," Stephen Kosslyn, a Harvard University psychologist who studies how the mind creates mental



Hot colors mark the areas working on various tasks in these positron-emission tomography (PET) scans, which highlight increased metabolism in the most active cells.

MARCUS E. RAICHLE, SCHOOL OF MEDICINE, WASHINGTON UNIVERSITY, ST. LOUIS

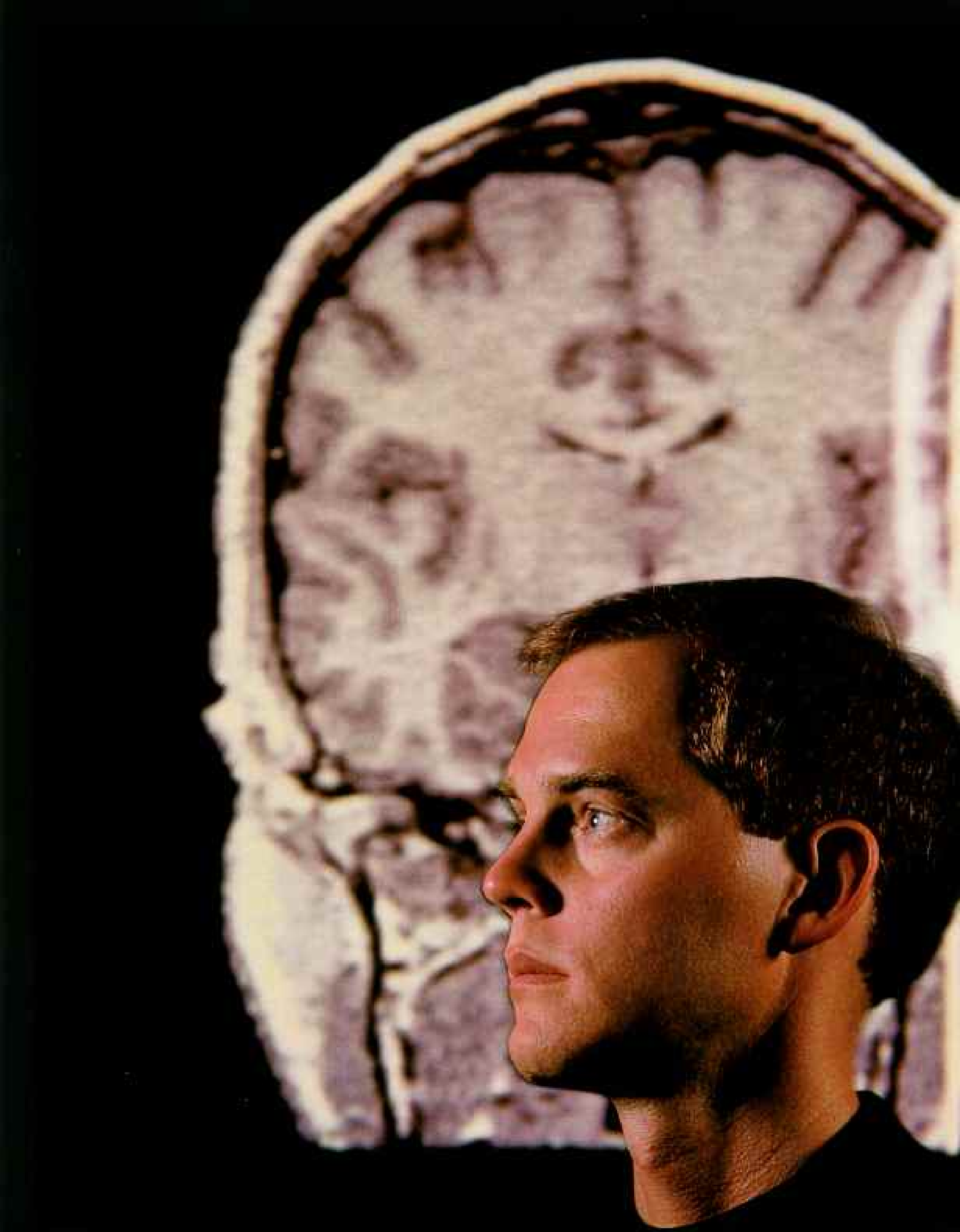
images, explains to me. "Bigger could be worse because it impedes rapid communication between neurons within the brain."

But the size of a certain brain part might be crucial. How did Michelangelo see, Shakespeare feel, and Mozart hear? One study reveals that the planum temporale in the left hemisphere, a part of the brain associated with auditory processing, is larger in musicians than in nonmusicians, and is larger still in musicians with perfect pitch.

Howard Gardner's influential *Frames of Mind: The Theory of Multiple Intelligences* argues that every individual has one or more of seven distinct intelligences—such as spatial, linguistic, and musical. Does each "intelligence" have its own physical manifestation? Gardner resists putting too much faith in physical findings. "Intelligence is a capacity," he says. "To ask 'Where in the brain is intelligence?' is like asking, 'Where is the voice in the radio?' "

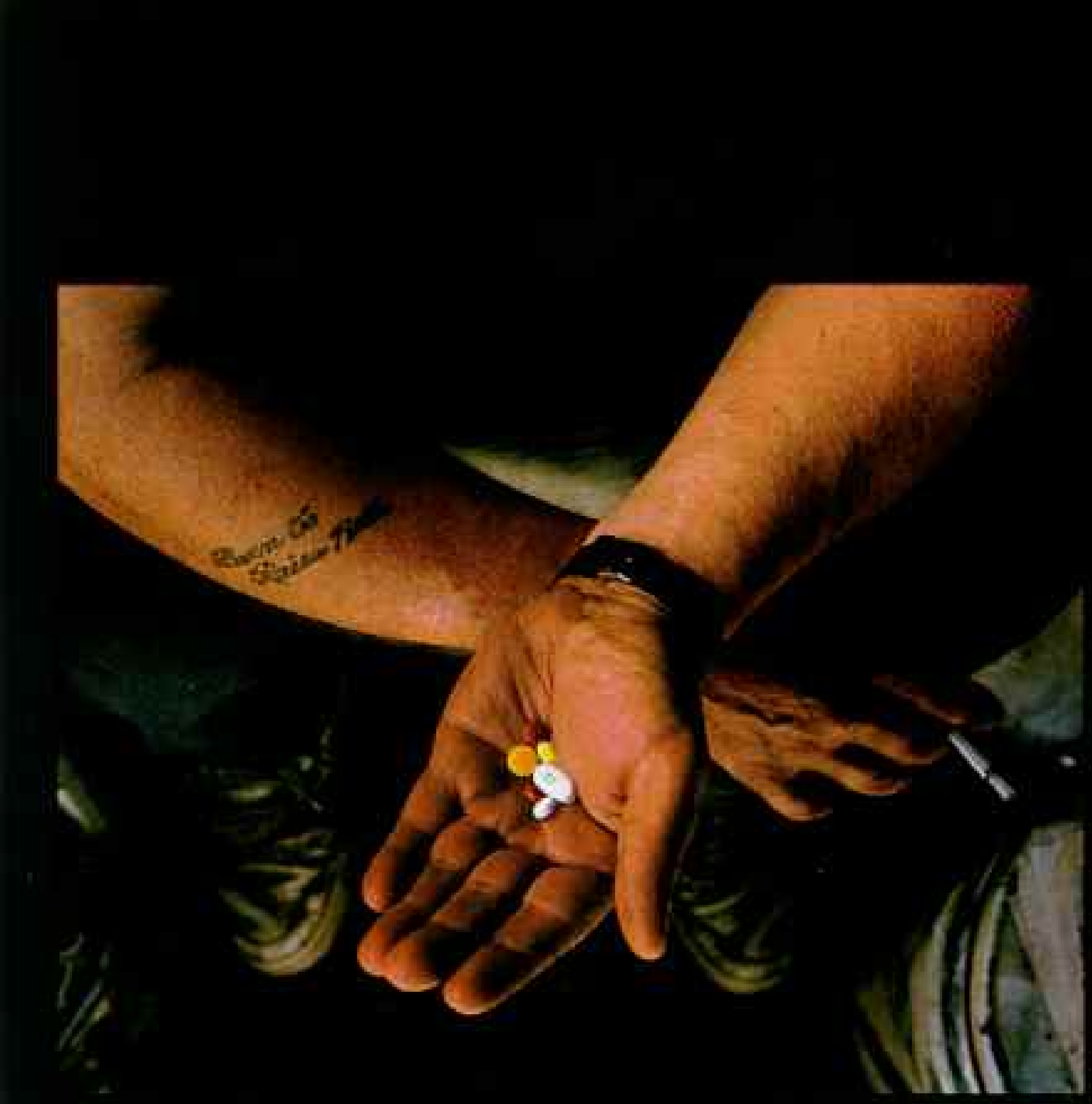
Vincent van Gogh may have suffered from temporal lobe epilepsy, which triggered electrical hyperactivity of the brain. Did it affect works, such as "Starry Night," noteworthy for their hallucinatory imagery? "Remember not to carry such assertions too far," says Harry Rand, an art historian and a senior curator at the Smithsonian Institution. "Every artistic genius does not have a brain anomaly, and everyone with a brain anomaly is not a great artist. Art is far more than something that automatically *(Continued on page 24)*

Goggles give a 3-D view of a dendrite to Caltech neurobiologist James Bower. In this computer model, which he helped develop, red shows the greatest activity and green the least in branches reaching out to 200,000 other cells. "To understand something that complex, you have to be able to see it," says Bower.



Appearances are deceptive with the identical Elmore twins. Steven, at right, has schizophrenia; David does not. Brain scans taken for a study at the National Institute of Mental Health in Washington, D. C., show subtle differences: Steven's brain is smaller, and its ventricles, the dark spaces, are larger. "People

with schizophrenia clearly are missing some tissue," says E. Fuller Torrey, who headed the study, but no one yet knows why. Steven started hearing voices and acting erratically at 19. Now 35, he is doing well on a new drug. "I'd have tried anything to get rid of those bad spells," he says.

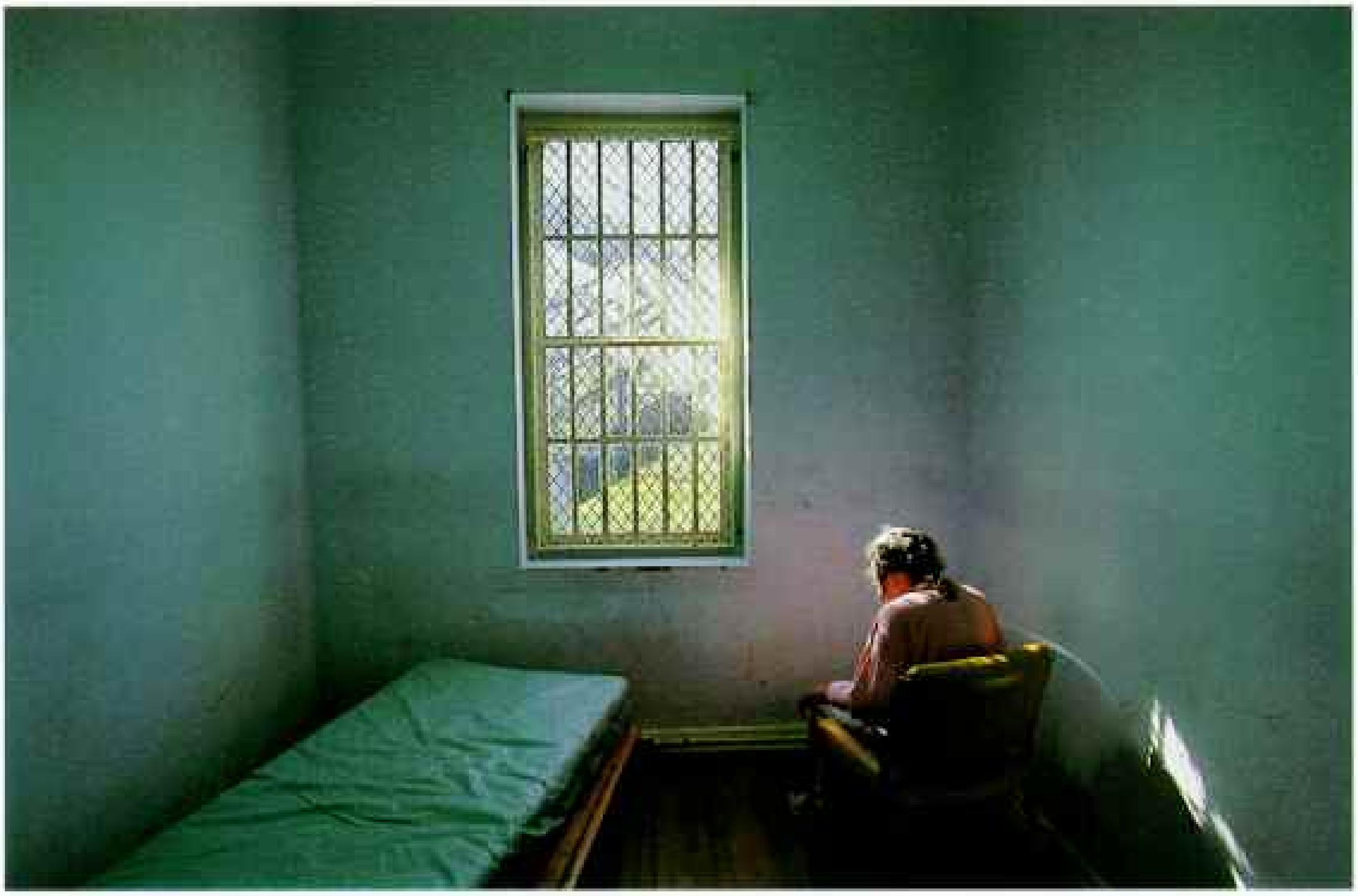


The Game of Survival

On his bad days Ron Lintz needs to be alone. Severely depressed and homeless, he built a plywood shack in a secluded area of Kansas City, Missouri, and lived there for several years. He still visits it from time to time (top right).

Lintz found help in Kansas City after a decade of picking up odd jobs from Florida to California. A social services agency got him an apartment, food stamps, and medication (above), which includes an antidepressant. "I'd have done this years ago if I'd known it was out there and I could have trusted people," he says.

Lintz is resourceful, collecting cans for pocket money (right). Yet he will probably always need supervision. "Some of us step up to the plate in life with a full count, and, boy, that's Ron," says his caseworker, Law French. "Chances of him striking out are real good, but we keep working with him."



A whisper of sun reaches a woman resting for a moment in a spare room at an Alabama mental hospital. Since this photograph was taken last year, the hospital has opened 20 million dollars' worth of new dorms and treatment facilities, and this old wing has been closed.

results from a physical characteristic."

Still, the mapmakers' growing success demands attention. One gene produces an enzyme, monoamine oxidase A, that helps brain cells communicate. Some men inherit an abnormal gene that fails to produce enough monoamine oxidase A. Other neurotransmitters accumulate, and the person—for unknown reasons—becomes violent when faced with stress. If a young boy is known to carry this gene defect, should he receive special treatment? Should family or society impose restrictions upon him? As brain discoveries mount, who will make such decisions?

ALDOUS HUXLEY, author of *Brave New World*, noted humankind's emergent manipulation of its basic biology in the 1950s and warned in 1961, "For heaven's sake be careful." The need for care is particularly acute as researchers discover the physical basis for what may define us most as humans, our emotions.

Candace Pert, a former National Institutes of Health pharmacologist who now heads her own research firm, has pioneered much of this work. To explain it, she takes me back to high school biology. "We were all taught that synapses, the distance between two neurons, are crucial," Pert says. "We now realize there's a communications network that operates via receptors and their 'informational substances.' Communications between cells occur via chemical reactions and transfer of electrochemical energy.

"When trying to find why morphine affects the brain," she continues, "we found that the brain also relies on neuropeptides, strings of

TRYING TO STUFF COTTON BALLS IN IT." —STEVEN ELMORE

Mild shocks to the brain keep depression at bay for a Pennsylvania woman sleeping after her monthly maintenance session. New techniques, such as monitoring brain waves on a printout, have made electroconvulsive therapy safer and more effective than it once was.

amino acids that float throughout the body and convey information by attaching themselves wherever they find a welcoming receptor. These are extraordinary, because they trigger emotions. During the 1950s, experiments revealed that electrical stimulation of certain areas of the cortex provoked emotions—exactly the areas that are filled with neuropeptides. At least 60 neuropeptides have been discovered so far."

She pauses and repeats one sentence because she knows it must sink in slowly. "Emotions," she says, "are neuropeptides attaching to receptors and stimulating an electrical change on neurons."

We traditionally perceive the brain in terms of prevailing technology. It has been a mechanical water clock, hydraulic pump, telephone switchboard, and liquid-cooled parallel supercomputer. For Pert to describe a communications network therefore makes sense. But I resist. "Joy? Grief? Love? All biochemical?" I ask. She nods, yes.

"All love, for everyone, involves the same peptides?" I ask. Again, she says, "Yes."

Pert's husband, immunologist-virologist Michael Ruff, joins us for lunch. They began to date while working together at the National Institutes of Health. "Are neuropeptides popping right now because you're next to each other?" I ask.

"Of course," Pert says, putting one arm around Ruff. He looks away, trying to hide his smile. "When I fell in love with my wife, I gave her my heart, not my neuropeptides," I tell Pert.

"Neuropeptides are in your heart too," she

says. "Experiments show that the spleen, thymus, bone marrow, lymph glands, and dorsal horn of the spine also produce neuropeptides." Neuropeptides, she says, even come from the stomach, giving new validity to the expression "gut feeling."

The mind is not only in the brain, Pert argues. It is also in the flow of neurocommunicators throughout the brain, glands, and immune system.

SOME OF PERT'S THEORIES may be incomplete, but they illustrate—as do the experiences of every researcher and patient I have met—that we must look at ourselves in new ways and accept new truths.

The blood-brain barrier is a typical example. These tightly packed capillaries, located throughout the brain, restrict access, because the brain is sensitive to small fluctuations in bloodborne material. Communications between brain and immune system, however, imply a steady flow of peptides and more openness than experts have believed thus far. Once we accept this possibility, we may better understand the dramatic increase of brain cancer in industrialized countries. Whether the brain is unusually susceptible to carcinogens remains unclear, but carcinogens do seem to cross the blood-brain barrier.

Some new truths are not as new as they seem. The flow of substances between our brain and body seems like a radical idea, but for 4,000 years Chinese medicine has said that control over the brain rests with the liver, heart, spleen, lungs, and kidneys. These organs communicate, according to Chinese medicine, via energy channels that form the basis for treatments such as acupuncture.

Likewise, modern science has just started to examine links between the brain and immune system. Eastern philosophy and the Old Testament, however, have always linked mental processes and health. "A merry heart doeth good like a medicine," says the Book of Proverbs, "but a broken spirit drieth the bones."

Thus, Pert and colleagues are on old terrain when they demonstrate that immune and brain cells constantly chatter via neuropeptides. Peptides from the brain cause immune cells to proliferate, and some immune cells release peptides that affect brain function. Macrophages, the immune cells that usually reach an invader first, are, in effect, mobile synapses, carrying and releasing neuropeptides throughout the body.

Implications are obvious. Stress, for example, increases susceptibility to disease by compromising the immune system. Thus, participation in support groups—which presumably reduces stress—may increase the longevity of cancer patients and the production of cancer-fighting cells.

A group of men and women with a variety of life-threatening cancers meets weekly in the Cancer Resource and Support Center in Pasadena, between Baltimore and Annapolis, Maryland. Their chairs are circled as they discuss symptoms, pain, and fear. Even such depressing topics evoke laughter. Al Smith, 64, whose colon cancer has spread throughout his body, gets loud roars when he describes the doctor who said he had six months to live. "That was five years ago," Al says. "My goal is to go to him in five more years and say, 'Liar, liar, pants on fire.'" Donna Seafolk-Kopp, 43, who has ovarian cancer, grabs everyone's attention with "It keeps getting bigger," and then reveals that she means a party celebrating her upcoming master's degree.

As the meeting adjourns, I notice Hugh McLeod's T-shirt: two fingers about to touch—a reproduction of God giving life to Adam in Michelangelo's ceiling in the Sistine Chapel. Hugh has thick arms, wide shoulders, a healthy aura. His story: "I'm a 41-year-old retired Air Force officer now working as a consulting engineer. For six years doctors treated me for a fungus infection under my right big toe. When the toe finally split open, they diagnosed 'level III melanoma with a large satellite node.' Four months ago they cut off the toe. They said that blood or lymph could carry the cancer anywhere, and that it is very aggressive and could appear in my brain. The doctors say scans will definitely find the new cancers, and they have no treatments to offer."

I ask what percentages the doctors gave him. Hugh strokes his beard. Silence. "Why haven't you given in to despair or terror?" I ask. He smiles. "I believe that I am fine and will stay fine," he says. Hugh then describes two weeks at Getting *(Continued on page 31)*

A Terrifying Choice

Without support from her father, Al, Jody Miller would fall off the couch in her family's Maryland home. At three and a half she suffered seizures every few minutes, the result of Rasmussen's encephalitis. "She would just topple over to the left as if she were a puppet and someone had pulled her strings," says her mother, Lynn. Jody also lost the use of her left arm and leg.

Doctors at Johns Hopkins Hospital proposed removing the diseased right side of her brain. "Basically they said, 'You can have your child the way she is now but without the seizures,' " Lynn recalls. "My mind was made up in an instant."

Patches covering Jody before she enters the operating room will allow her body functions to be monitored during the dangerous surgery.

The living brain lies exposed once surgeons cut open Jody's scalp, skull, and dura, the organ's leathery covering. "This half of the brain, which looks relatively normal, has been seizing actively and is the cause of all her problems," explains neurologist John Freeman. By removing the tissue, surgeons left

a cavity, which soon filled with cerebrospinal fluid. Start to finish, the operation took 11 hours. Since then, the Millers have counseled other families with children in need of the same rare procedure, even sitting with some during the surgery. "We know what a long wait that is," says Lynn.

A Joyous Recovery

Life begins again with Sunday school four weeks after surgery when Jody's hair is still stubble (right). Eight months later and completely free from seizures, she frolics with her mother at a local pool (below) and runs with the other four-year-olds at day care. The plasticity of a child's brain has let neurons in her left hemisphere make multitudes of new connections and take over many of the functions once performed by the right hemisphere. Therapy several times a week has helped, though it cannot restore full movement to her left side.

"She's a bright, lovely young lady who doesn't use her arm very well," says Dr. Freeman. "That's the bottom line."

Well, a behavioral medicine program in Orlando, Florida, designed to help people with the emotional and spiritual aspects of serious illnesses. "I had believed that to have emotions is a sign of weakness and illness," he says. "I have experienced an awakening that could not have happened without the illness. Whatever I deal with, relationships with my children from my first marriage, the fact that career opportunities have taken me to another city, problems with my current boss, I strive to be honest with myself and others about my feelings. This honesty helps my body protect itself. I have also learned to use mental imaging to produce anticancer chemicals such as killer T cells and interferon. I image two or three times a day."

Several years ago a friend of mine underwent coronary artery surgery. Every night he visualizes brushes scrubbing his artery walls. He then follows the yellow plaque through his kidney until it is flushed from his body. "I don't talk much about this," he once told me. "People aren't ready to understand." My friend emphasizes, as Hugh does, that he images in addition to standard medical care.

Hugh's living room has a dog-eared copy of Walt Whitman's *Leaves of Grass*. "He had a zest for life," Hugh says, opening the book to

> *The thin red jellies within you or within me, the bones and*
> *the marrow in the bones,*
> *The exquisite realization of health;*
> *O I say these are not the parts and poems of the body only, but of the soul,*
> *O I say now these are the soul!*

Hugh darkens the room, lights two candles, and sits on the sofa. When he takes off his shoes, I see that the end of one sock is empty.

"You use what works best," he explains. "Some people say they 'breathe in color.' I have created a neon bug whacker that goes into my brain." He puts his feet on the coffee table, punches on a tape recorder and closes his eyes. I sit on the other end of the sofa and close my eyes too.

Music on the tape plays in the background as a soft voice says, "Imagine an opening on top of your head. The light of stars, suns, galaxies, heavens, of love enters your body." I soon float out with the words.

Is Hugh tapping into some primal ability when the tape tells him to "take a moment to explore all the routes and highways of your brain and mind. You'll find one that has to do with your immune system, and circulation, and so on. Turn the right valves. Turn off those that carry nourishment to the disease." Or is he calming himself with a harmless exercise? All we know for sure is that he is entering terra incognita.

As I leave, I notice some pills. "What are those?" Hugh hesitates. "Muscle relaxers for my shoulder," he says. "It's been getting stiffer. I can't move my neck well. It's been going on for about two weeks. I have a scan scheduled for next week." He sees the look on my face and adds, "I sure hope it's nothing bad." I call Hugh six months later. He tells me that the shoulder pain was a pulled muscle. "Everything's going well with me," he says, "but the group lost a couple of people."

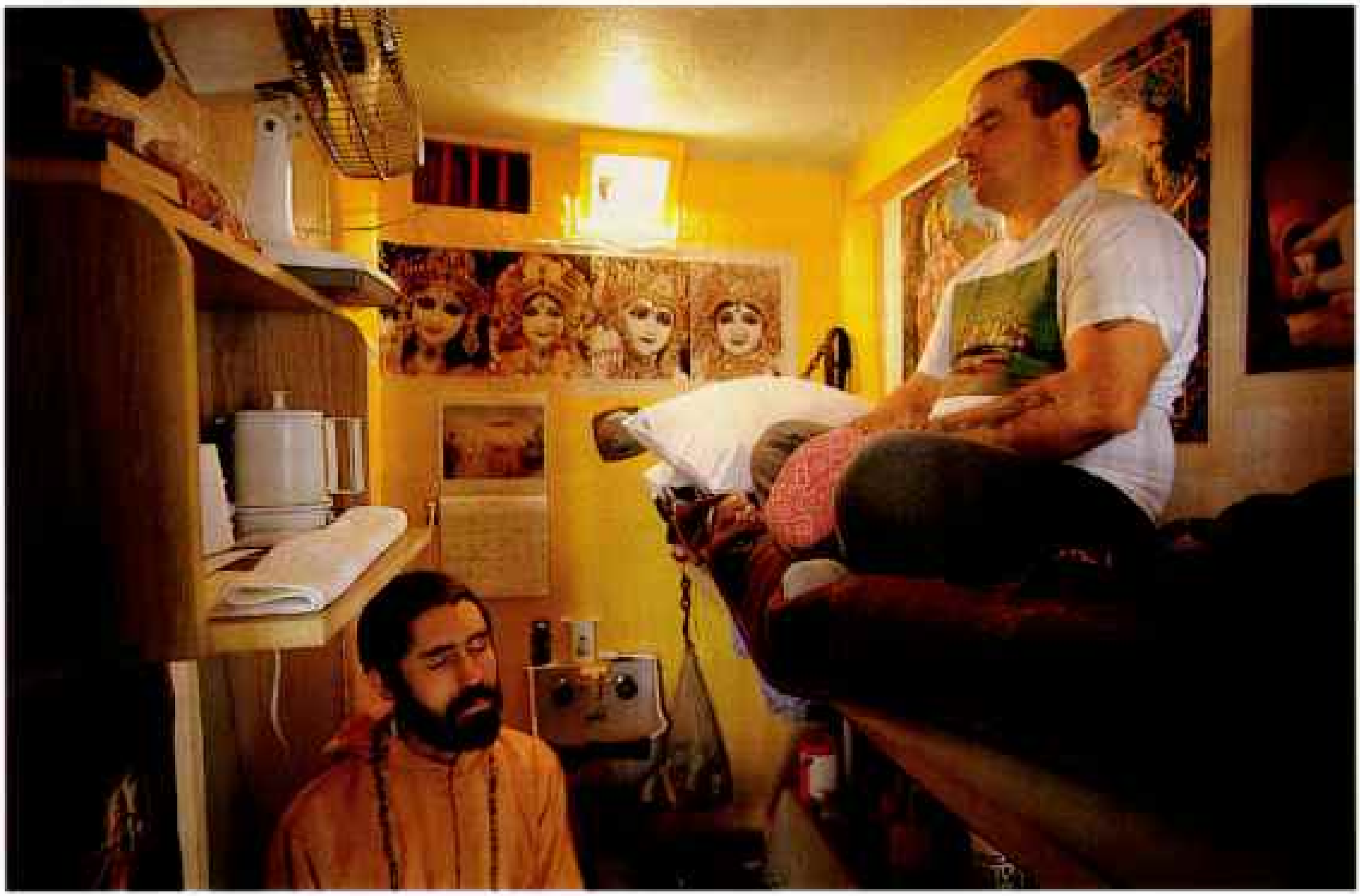
ONCE, WHEN DRIVING WITH HUGH, I asked why he so diligently puts on his seat belt. If death creeps within, why worry about an accident? He said he is working hard to live and does not want to crash his head through the windshield.

Hugh is right. Despite increased use of seat belts and helmets, brain injury disables or kills someone in the United States every two and a half minutes. Although the brain is the only organ covered mostly by bone, it floats in a thin cushion of fluid and can bounce against the skull. Even shaking a baby can cause permanent brain damage.

On October 13, 1986, Patsy Cannon was driving her nine-year-old daughter to school when another woman's car collided with them. Only Patsy was hurt. Her seat belt came loose and her head hit the windshield and then the side window.

Patsy awoke several hours after the accident. She felt fine but had severe amnesia. Her amnesia is "retrograde": She has no difficulty remembering events after the accident but can remember nothing from before. The only visible evidence of injury is a slight indentation along the top of her forehead.

A photograph taken a week before the accident shows Patsy between two other young women. All are laughing. "I apparently was a



Leaving his prison cell for a peaceful place in the mind, inmate Charles Peacher meditates with Brother Rasa, a Hindu minister in West Virginia. "Anger is probably the dominant emotion in the prison," says Rasa. "Meditation lets the men get that anger under control."

workaholic in corporate America," Patsy says. "That person is dead; I am a new person." Ironically, Matt Simpson lost half his brain and kept his personality. Patsy has all her brain and lost her entire self.

Patsy stayed in Birmingham, Alabama, her hometown, and reinvented herself as an advocate for people with brain injuries. United Cerebral Palsy of Greater Birmingham has hired her to design and direct supported living and employment programs that allow adults with brain injuries to regain control of their lives outside institutions. She invites me to join a group for young adults.

"We took a lickin' and keep on tickin'," one tells me. As they discuss failures and triumphs, I witness the hardest type of courage—not the flash of bravery but the daily resolve not to quit. For my slow-speaking companions, courage is willingness to speak, write a poem, get an apartment, hold your hand to make twitching stop, ride a bicycle, ask a question, laugh, and, most important, let yourself be who you are.

Patsy and I visit the Spain Rehabilitation Center, a not-for-profit facility of the University of Alabama Hospital System. An automobile accident survivor who recently emerged from a two-month coma wears a hospital gown and a baseball cap. Neurons can resprout dendrites throughout life, so hard work and encouragement could restore much of his brain function. But he slumps in a wheelchair, his eyes unmoving. Drops of spittle edge down his chin. "He doesn't respond much," a nurse says. Patsy kneels. Her lips unleash a stream of chatter, part purring and part pep talk. His

WAYS AND ACCEPT NEW TRUTHS.

Expressions of the true self, painted in group therapy, mask faces constrained by society. This and other exercises, such as visualization and laughter, at the Getting Well center in Orlando, Florida, aim at freeing the mind to enhance healing in people fighting serious illness.

mouth moves, but nothing comes out. By shaking his head, he communicates a strong preference for the Auburn University football team over the University of Alabama. He accepts her offer of an alphabet board so he can point to letters, and spells the names of his two children. Patsy does not tell him that the automobile accident killed one of them.

Shortly after one of my visits with Patsy, my nine-year-old son, Aaron, comes home with a bad headache. He had banged his forehead and apparently lost consciousness. He has no outward injuries, but six hours later his headache and dizziness are still getting worse. At the emergency room his name goes on the chalkboard followed by "head injury." When the doctor says "a concussion, no brain damage," I hug Aaron—and realize why people I have met on this story hug so often. They know too well how fragile we all are.

For Patsy, fragility means the need to relearn everything. "I learned to speak through tapes and friends," she says without emotion. "Once a friend told me it was 'raining cats and dogs,' and I panicked. I ran to the window expecting to see flying animals." Four months after the accident she was hospitalized again with bleeding ulcers. "No amount of learning," she tells me, "could silence the internal screams."

Relearning love came hardest. "When I saw my nine-year-old daughter, Leah, I felt nothing," Patsy says. "It could have been any child off the street." She squints as though trying to see through some fog that separates us, and asks, "How do you explain love to someone who has no memory of love?"

Leah describes her mother's return from the hospital. Patsy and Leah's father were divorced before the accident, and no other adult was around. "Can you cook?" Leah asked. Patsy said "show me" and almost burned the house down. Leah easily convinced her mother that children never do homework and all mothers take their daughters shopping every day after school. "At the mall my mother bought herself dresses with floral patterns," Leah tells me. "It scared me, because I realized she was a different person. The mother I knew wore only black and blue basic suits." Before, Patsy hated bananas. Now she loves them. Such changes after head injuries are mysterious but common.

Patsy is still learning about human failings. Walking through a Birmingham park, we encounter statues showing fire hoses knocking down civil rights demonstrators. Across the street is the church where a bomb killed four young girls in 1963. Patsy knows nothing about either event. "A few years ago someone asked if I thought they should hire a 'colored' nurse," Patsy says. "That's when I learned about racism. I said I did not understand the problem. They then told me about colored bathrooms. I *still* did not understand. I said my home has three colored bathrooms, and I enjoy all three."

The accident may have biochemically destroyed Patsy's memory. The more likely explanation is that it disrupted connections to the hippocampus, which seems to play a

OFTEN. THEY KNOW TOO WELL HOW FRAGILE WE ALL ARE.

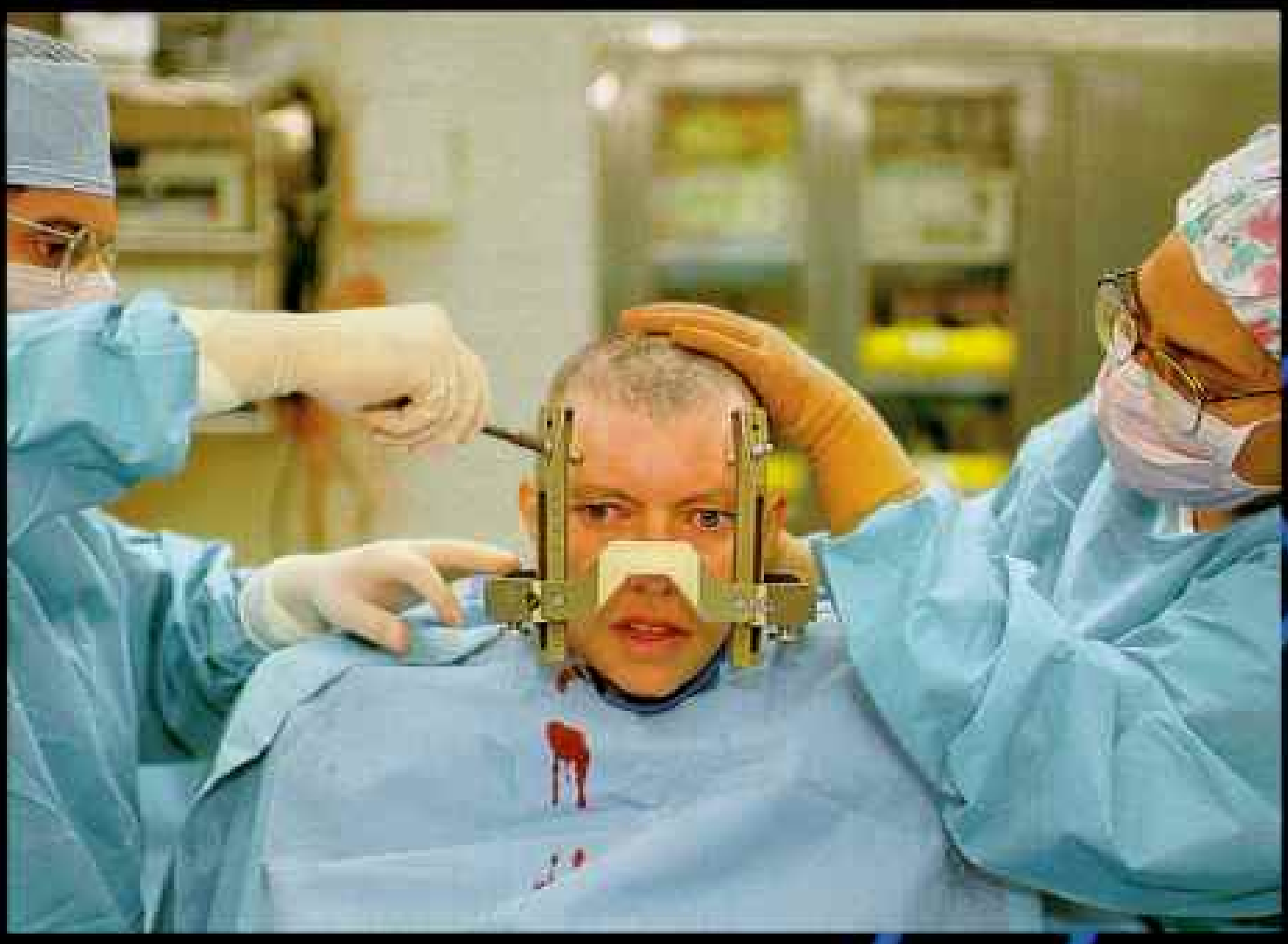
Gently but firmly, family and friends repeat crawling moves with ten-year-old Brooke Miller, who began to walk only a year ago. Prenatal lack of oxygen to the brain likely caused the Massachusetts girl's delayed development. To overcome this, Brooke follows a rigorous schedule of physical conditioning. "We'll do it until she can run like any other kid," says her mother, Liz, who supervises the day's routine (below).

crucial role in the long-term storage of information. Different aspects of memory reside in various parts of the brain, images in one place, for example, and emotions in another. People like Patsy help researchers map this geography. When shown a picture of a rhinoceros, one stroke victim, for example, says, "Enormous, weighs over one ton, lives in Africa." But he cannot say what it is. When asked what "rhinoceros" means, he responds "animal."

These various memory centers cannot function unless connected to the hippocampus. This means the old Patsy may still be inside but unable to assert herself.

Do pieces of old Patsy appear in dreams? "No," Patsy says, "and I don't worry about her. I'm happy with the person I am now."

NO ONE KNOWS what memories are. Several decades ago, scientists looked for what they called the "grandmother neuron." Then they concluded that one neuron holds grandmother's face, another her smell, and still another the sound of her voice. Now they think she is in none of these places. Memory of grandmother's face, they say, probably does not reside in a particular neuron. It exists in the changed connections between different sets of neural networks. Why do we remember some things and forget others? "Memory is not a video camera or a tape recorder," says Ulric Neisser, an Emory University psychologist. "There is no 'total recall.' All memories, even very vivid ones, are more or less accurate reconstructions.

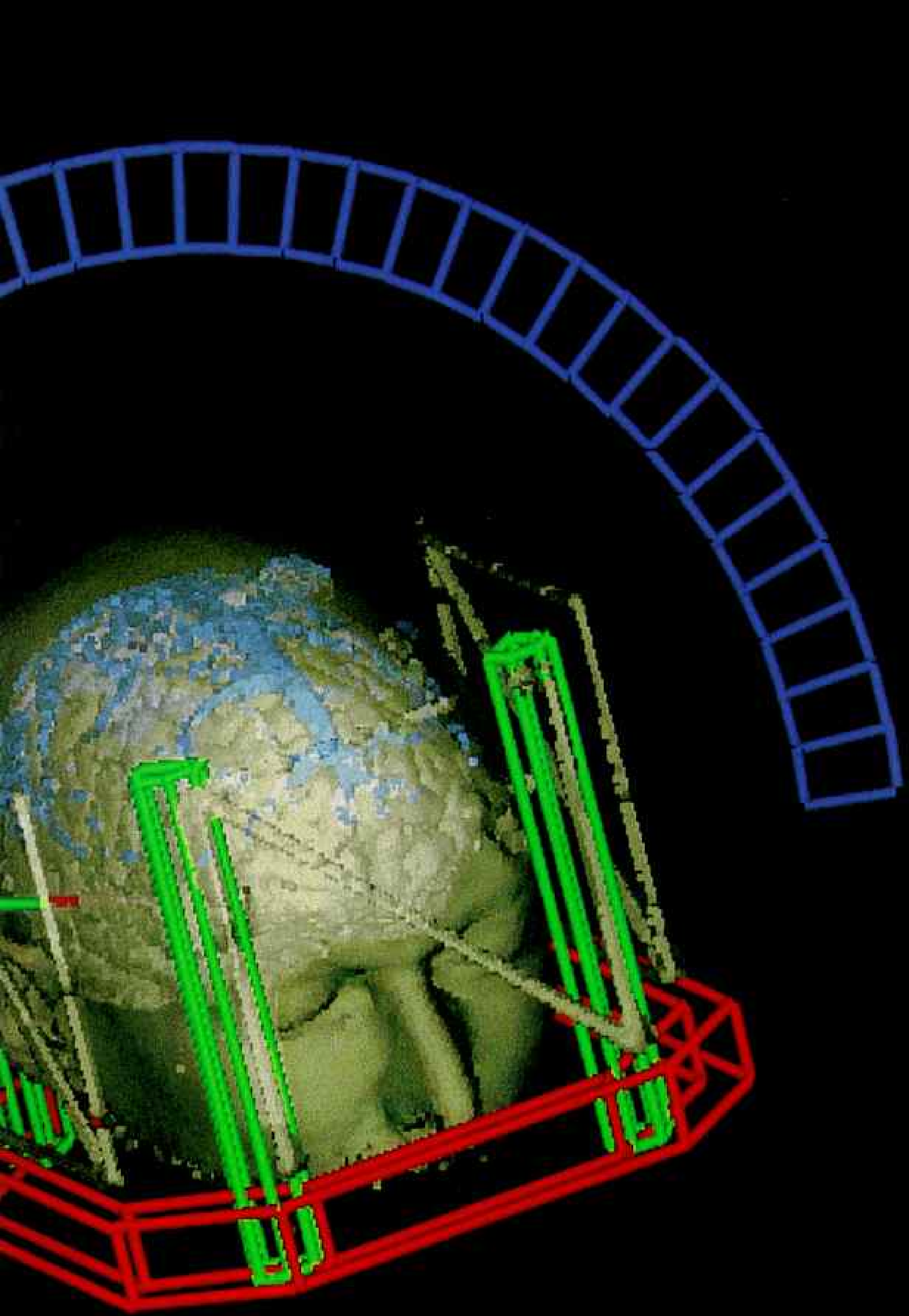


Plotting a Path Into the Brain

"It's all very painful" despite the anesthetic, says Tana Linkous, describing the application of a calibrated frame to her head at the University of Virginia Medical Center. Somewhere in her brain neurons are sending storms of signals, causing epileptic seizures. Doctors need to pinpoint the location of this abnormal area before they can remove it.

A series of scans provides a three-dimensional computer image of the brain, bracketed by the frame for points of reference accurate to a millimeter. Doctors plot the trajectory of an arc-supported probe (right) that will insert diagnostic electrodes deep into the organ. "We're able to treat people now that we weren't able to in the past," says neurosurgeon Neal Kassell, who has helped develop this image-guided approach.

JOHN GOBLE, NEUROVISLAB, UNIVERSITY OF VIRGINIA



Through a hole in Chris Cotter's head a surgeon places a grid of electrodes on the brain's surface for epilepsy tests at Johns Hopkins Hospital (top). Wires connected to the grid surround the sutured hole (above) and transmit information about brain activity during seizures. By moving his fingers and toes and performing other tasks as doctors briefly stun different areas of his brain (facing page), Cotter helps identify crucial areas that should not be removed.

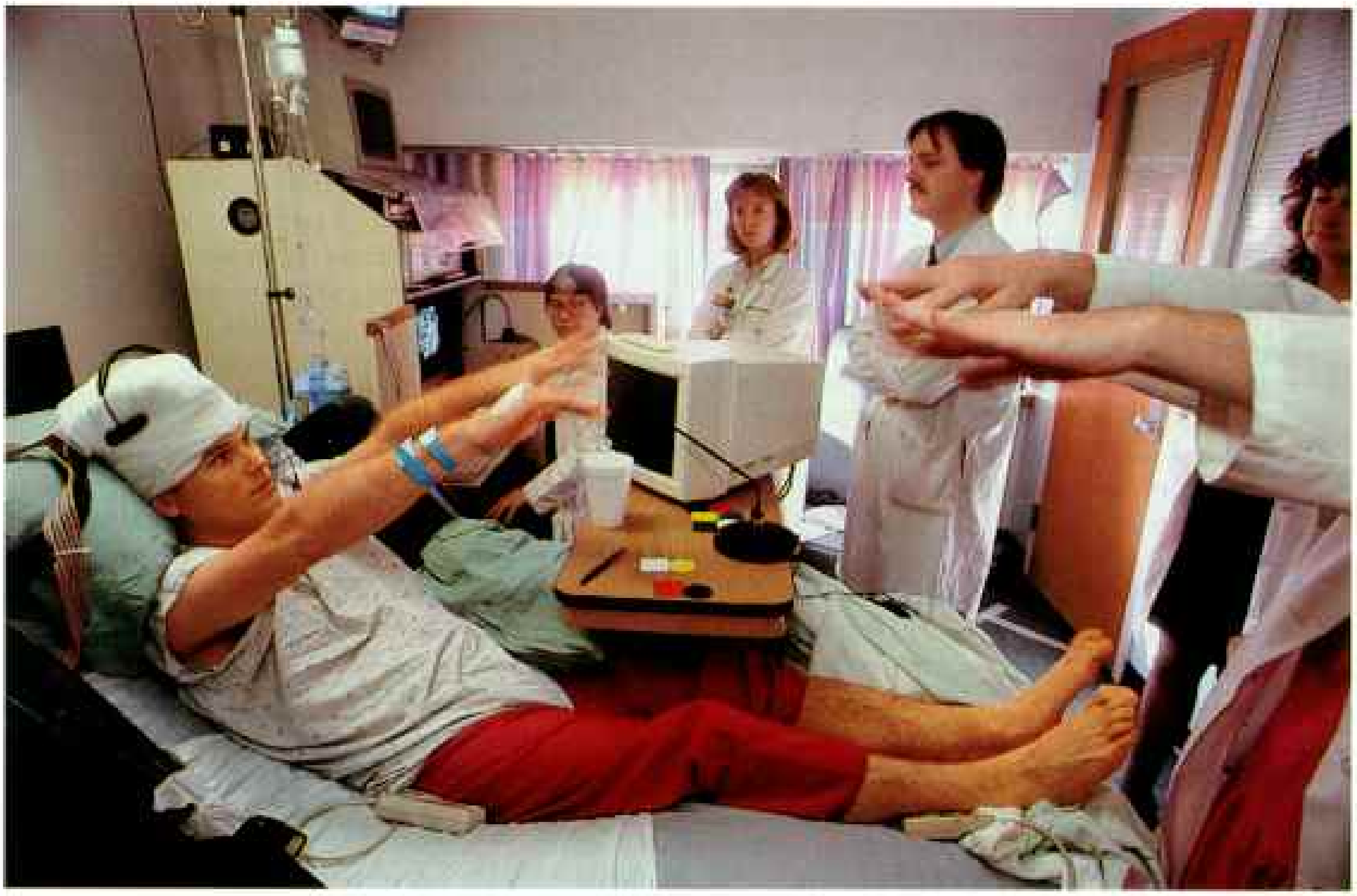
Unusual experiences tend to be remembered better, because they are less confusable with other events. But even they often change to fit what we later believe must have happened."

Smell and taste are associated with many memories, because neural pathways link them directly to the hippocampus. You smell a perfume and flash back to a high school date. Novelist Marcel Proust once tasted a madeleine—a little butter cake—and was swept away by memories that resulted in the eight-volume *Remembrance of Things Past*.

"I fail to see why a chap needs 30 pages to describe how he tosses and turns in bed before falling asleep," one publisher's rejection letter said. But Proust's work is a literary classic. "After the people are dead, after the things are broken and scattered," he writes, "taste and smell alone, more fragile but more enduring, more unsubstantial, more persistent, more faithful, remain poised a long time, like souls, remembering, waiting, hoping, amid the ruins of all the rest."

Most of us fear losing memory. We know the name of a famous artist but can say only "the guy who went to Tahiti." Then we think, "I'm getting old."

Not necessarily. Neurons die every day, starting from the day we are born. "Even though many types of human cells—for example, the skin, liver, immune system, and stomach lining—renew themselves, the body never replaces neurons," says Pasko Rakic, a Yale University neurobiologist. "New neurons would have none of your memory. They would



be another person, with a different life history. Some songbirds develop new neurons in adulthood but must relearn parts of the same songs every spring."

As brain research progresses, however, the no-new-neurons assertion cannot be made with absolute certainty. Evidence indicates that our brains may contain "progenitor cells" that could become neurons if exposed to growth-stimulating hormones. Would they perform only tasks that require new learning? No one knows.

Neural loss is continuous as we age. Older people, however, retain capacity to generate new connections and to keep old ones via mental activity. Major memory loss with age usually indicates illness or injury. My uncle's mind remained clear until his mid-70s, when he suffered small strokes during heart surgery. He began to confuse words. A "lid" instead of a "cork" sealed bottles of wine. Simple addition frustrated him, and he no longer knew the rules of chess.

THE MOST COMMON KNOWN CAUSE of severe memory loss, or dementia, is Alzheimer's disease—brain lesions first identified by German neuropathologist Alois Alzheimer in 1906. It strikes between 5 and 10 percent of all people over 65 and one-quarter to one-half of those over 85.

Genetic mutation is a suspect but accounts for only 10 percent of all cases. "Early-onset" Alzheimer's, which begins around 40 or 50, runs in some families. Some Alzheimer's in older people is associated with defects in another gene that makes a protein, apolipoprotein E, that ferries cholesterol in the bloodstream and helps regenerate nerve cells. No one yet knows how it relates to neural tangles and nerve cell death.

Environment may also be significant. Studies of identical twins where one develops Alzheimer's and the other does not provide additional proof that Alzheimer's is a disease and not just the inevitable consequence of aging. Whether genetic or environmental,

among primary biological suspects are tau, a protein that may play a part in forming tangles that choke neurons, and amyloid, a protein that sticks to neurons like glue. Amyloid accumulates when neurons, for unknown reasons, begin to generate more than the brain can flush out, forming plaques.

No effective treatment exists, although Allen D. Roses, a neurologist who heads the Duke University research team that discovered a gene associated with Alzheimer's, says, "In 10 or 15 years we hope to have a safe medication that a 50-year-old could take every day to prevent Alzheimer's."

If they live long enough, Alzheimer's victims forget how to chew food. Until then, the disease slowly steals the tissue that defines them. A diseased heart can be replaced with another, and life goes on, but our brains, filled with ever shifting collages of memory, define us. "It is," says one minister who works with people who have Alzheimer's, "almost as though the soul of the person changes."

I stand in the back of the room at a day-care program run by the Greater Palm Beach, Florida, chapter of the Alzheimer's Association. The room is sunny with comfortable chairs. Approximately 20 patients listen as a volunteer reads to them from the morning newspaper. Nothing outward indicates illness, except that they wear name tags and keep looking at their own.

"We try to provide mental stimulation," Mark Cornett of the Alzheimer's Association whispers. I show him a recent newspaper story. An 84-year-old man, exhausted from caring for his Alzheimer's-afflicted wife, killed her and himself. "Maybe people feel as if they're losing whatever makes them human," I say.

Mark shakes his head. "Look around," he says. "There's a lot of happiness left."

The patients do not remember their spouses or children but know the names of state capitals and other information they learned at a young age. Long-term memory is the last to go. Likewise, the brain may encode music in areas that resist Alzheimer's. Everyone joins hands and sings "I'm Looking Over a Four Leaf Clover" and "Let Me Call You Sweetheart." A man taps my shoulder. "Have you seen my letter?" he asks, holding it out.

Dear Dave,

You are in a day-care center. There are many people there who are your friends and will take good care of you.

Please cooperate with everyone, and you will have a pleasant day.

I will pick you up at 3 o'clock.

Jeannette

I am going full blast with "when the moon hits your eye" when Dave asks again, "Have you seen my letter?" The moment a conversation ends he has no memory of it.

What impresses me most is the dignity people retain. My lunch partner wears a suit and has a neatly trimmed mustache. His expressions suggest a successful business deal. He sounds earnest and sincere, but his sentences are incomprehensible. "It gets 20 to 40 percent just for them to get what they want. They will do the same things as they gave. Then nothing comes out of them." He touches the window. "If you feel this," he says, "then you get the idea. Boy, do I get it."

I comfort myself by thinking that such people forget their own deterioration. But Alzheimer's is unforgiving: It allows enough awareness to torment its victims. One man bangs his head on a table. His wife watches, love on her face. She tells me about courtship, raising children, running a business, and then, this. "We're talking about you," I say to him. "Do you know that?"

"Of course," he says, still banging.

"Your wife looks like she wants to give you a big smooch."

He smiles at her and says, "I know." Then he asks her, "What's happening to me?"

I HAVE BEEN SEEING quiet miracles: the brain itself, growing medical mastery of it, and, perhaps the greatest, the power of courage and of love. All form the foundation for the new era we are entering.

New clinical treatments will emerge amid dissolving distinctions between "physical"

COLLAGES OF MEMORY, DEFINE US.

and "mental." Mapmakers will redefine inner geography, forcing us to reexamine how we perceive ourselves and raise our children. At the same time, our brain maps will constantly change as new discoveries challenge old truths.

The brain's marvelous adaptability, especially during childhood, is firmly established. This adaptability, coupled with the brain's immeasurable potential, encourages faith in dreams—no matter what our age or life circumstance.

Valerie Simpson calls with an update on Matt. He is doing well in third grade—lots of B's and some A's. He gets along well with other children and is happy.

Matt can use his right arm better. He still limps, but less. Brain scans show that control over his right arm and leg has settled into the cortical area that controls his left arm and leg—the brain seems to have a strong sense of consistency. He is enjoying school, but there are those who insist that he will never do as well as his contemporaries. They make Valerie angry. "Who's to define the sky for Matthew?" she asks.

Who's to define the sky for any of us? □

The woman she once was is a stranger to the Patsy Cannon of today (at left), who runs a rehab program in Alabama. Nine years ago injuries suffered in a car crash erased her memories. Since then she has had to relearn all the skills and emotions that form a life. Her new, astonishingly different self is a testament to the brain's miraculous abilities.

Blur of fur and bubbles, a sea otter cavorts in the kelp forest off Monterey. Hunted to near extinction, these sleek, agile swimmers are rising again—though slowly.

ENHYDRA LUTRIS NEREIS, DAVID DOUBILET

The Fragile Recovery of CALIFORNIA

By RICHARD WOLKOMIR

Photographs by SISSE BRIMBERG

SEA OTTERS

CASY HAS A COUGH.

"He came in wheezing," says Julie Hymer, who looks after orphaned California sea otter pups brought to the Monterey Bay Aquarium.

I am squinting through a peephole into Casy's nursery, where he is supine on his water bed. Only five weeks old, he looks like a furry brown mitten. Gleefully he juggles an abalone shell with his hind flippers and forepaws.

"His attitude is good," Hymer says. "But we could lose him."

I have come to Monterey to learn how California sea otters are doing in their comeback from near extinction. As many as 20,000 sea otters once dived for abalones and urchins in the Pacific off California. But Russian fur hunters, followed by Americans and the English, decimated them. By the early 1900s only a few California sea otters remained. Since then—legally protected—the population has grown. But the slowness of the otters' return worries biologists. Today fewer than 2,400 wild sea otters swim in California's kelp forests. Casy embodies their predicament: He can charm your socks off, but he is threatened.

With so few otters, any unlucky day a major oil spill could kill most of them. Meanwhile, fishermen view otters as competitors and lobby to limit their range. But the otters have more friends than foes. At the Monterey Bay Aquarium, for instance, humans are acting as surrogate mothers for orphaned otter pups, teaching them to survive in the Pacific. The goal is to return orphaned pups to the wild.

These oceangoing cousins of river otters once flourished from Oregon to Baja California. Now they inhabit only a 250-mile stretch of California's central coast. To the north live their two close relatives, the Russian and Alaska sea otters. The three subspecies are separated mainly by nuances of skull shape. Also, the northern sea otters sometimes catch fish, while their California cousins eat only crabs, abalones, urchins, and other invertebrates. All three races are about the size of basset hounds, with comical bushy mustaches.

Sea otters are the most recent land mammals to return to the ocean, and they still look like a prototype, with floppy flippers in back and forelegs resembling a human baby's arms. Their dark-brown fur often pales to California blond on their heads. Their liveliness is exhilarating. And they look—how else to say it?—sweet, like aquatic teddy bears. To see them is to be smitten. I was.

Even a hard-bitten biologist once told me, "Otters have a high cuddle factor." And so it seems to me that sea otters are a gauge of our performance as earth's self-appointed stewards. If we let these engaging animals disappear, alarms should go off, sirens wail.

Coexistence with humans is the issue. And it bodes well that California sea otters are flourishing in the heart of their range, the Monterey Peninsula, because it is chockablock with people. Monterey is a contrapuntal arrangement of mountains and the green Pacific: cypresses, surf, seals, and seaside glass-walled mansions, with

Grooming itself, a laid-back sea otter seems the picture of ease. But looks mislead. Lacking blubber, this seafaring mammal must constantly preen its plusher-than-mink fur to saturate it with air bubbles—insulation against cold Pacific waters.

JEFF FOOTT

Freelance writer RICHARD WOLKOMIR's interest in endangered mammal species inspired him and his wife, Joyce, to co-author *Junkyard Bandicoots & Other Tales of the World's Endangered Species*. GEOGRAPHIC contract photographer SISSE BRIMBERG most recently illustrated "When the Greeks Went West" (November 1994).

insouciant mule deer grazing on the lawns and gray whales spouting in the coastal fog. Along harborside bike paths, Rollerblade skaters glide like terns, while just offshore sea otters paddle on their backs in the undulating brown kelp, looking with sharp black eyes at kayakers and scuba divers.

I stand one evening on Monterey's Coast Guard pier, watching a mother otter teach her pup job skills. She ignores the anglers and tourists milling on the pier as she dives for urchins and crabs, her pup following her down to learn. I can see her showing him how to insert a searching paw into rock crevices. Surfacing, she bangs her prey against a flat rock resting on her chest until the shells crack. Wham! Wham! Meanwhile, Junior exuberantly pounds an imaginary clam against a make-believe rock on his own chest.

It seems an idyllic life, here in the protected harbor. Mother otters do backstrokes, each with her pampered pup riding dry on her belly like a prince or princess aboard a royal barge. Another otter pulls a strand of kelp over her chest, as if it were a blanket, and beds down beside an anchored sloop. But beyond the calm harbor, otters diving in the kelp at the Pacific's wave-churned edge have enemies. Great white sharks attack. But far more threatening is the sea itself.

One morning I help Monterey Bay Aquarium research assistant Barbara Hrabrich check on the location of tagged otters off the town of Pacific Grove. Peering through my spotting scope at an otter bobbing on its back in sullen gray swells as it chews on a crab, I remark that it looks pathetically small in so huge an ocean.

"Tourists romanticize the life of the otter, but they're not here on

Otters' comeback

Devastated by fur traders until a treaty halted the slaughter in 1911, fewer than 2,400 California sea otters live along a 250-mile stretch of shore south of San Francisco. Geographically isolated and genetically distinct from the 140,000 or so sea otters in Alaska and Russia, their compressed range troubles biologists, who fear that a major oil spill would leave few survivors.

PAT HATHAWAY COLLECTION, PACIFIC GROVE

winter nights during terrible storms, when the waves are so huge they come over the street," says Hrabrich. "From my house I hear pups screaming for their mothers, and the mothers screaming for them, and the screams getting farther and farther apart."

Probably it was such a storm that orphaned Casy, the pup with a cough. He arrived on Easter Sunday.

A ranger had called the aquarium from Garrapata State Park, a few miles south of Carmel, to report an infant otter washed up on the beach. The otter program's staff member on duty, Marcie Tarvid, telephoned volunteer Bob Huettmann, who lives near Garrapata, then rushed to the beach in a pickup truck. She found Bob sitting beside the panting pup, shielding it from the sun with his shadow. Ashore, otters can die of hyperthermia. The week-old pup looked like a forlorn kitten. Marcie laid him in a kennel cooled by an ice pack in the back of the truck and began the 20-minute drive back to the aquarium. All the way, the pup shrieked piercingly for his mother.

The newcomer was given the name Casy, after a preacher in John Steinbeck's *Grapes of Wrath*, who taught a gospel of love. Otter rescue program volunteers tended him around the clock, feeding him from a bottle and constantly grooming his fur.

The aquarium's otter program is mainly humanitarian. But it is a hedge too—albeit a weak one—against a major oil spill that could wipe out most of the wild population. If people can teach pups to forage for themselves after a devastating spill, they might be able to return them to their natural habitat. But it is tricky, because otter pups learn so much from their mothers. Meanwhile, for Casy, the immediate worry is his cough.

Given up for gone by the early 1900s, California sea otters stunned the public in 1938 when a rancher spotted this small band of survivors near Big Sur. "Had you reported dinosaurs," a marine biologist told him, "we couldn't have been more utterly dumbfounded."

Rising through soaring stems of kelp with a sea urchin in tow—plus a tool for smashing its sharp spines—a sea otter heads topside for a meal. Otter, urchin, and kelp coexist in an equilibrium of appetites, scientists have

JEFF FOOTE

discovered. By keeping the urchins in check, the otters help preserve the kelp-forest habitat upon which the urchins—and California's 50-million-dollar-a-year kelp harvesting industry—depend.

IN THE OTTER NURSERY five-week-old Casy suddenly realizes that his human mother has left the room. As all baby otters do when they are separated from their mothers, Casy screams. It is an unnerving scream: piercing, imperious, pitiful.

"That's a weak cry," Julie Hymer tells me, shaking her head.

Could so tiny a pup shriek louder? Hymer insists the cry is sickly.

She chews her lip, and abruptly telephones Tom Williams, a Monterey veterinarian who helps provide the aquarium's medical care. "This otter is going downhill rapidly," she says.

A few minutes later we are racing across Monterey in Hymer's pickup. Casy sits on her lap, screaming. I am driving like a demon through unfamiliar streets.

At the veterinary clinic Casy squeals as Williams draws blood. He diagnoses a throat infection and prescribes antibiotics. A week passes. Now Casy's cough is gone. He is eating and gaining weight. Healed, Casy is ready to learn to be a wild otter.

That, I learn from Marianne Riedman, then the aquarium's chief otter biologist, is a difficult course of study. I watch a mother dive for a mussel, then crack it open on the rock she is carrying under her "arm." With a strikingly human gesture, she passes a morsel to her pup. Both otters then chew with seemingly joyful grins. Riedman tells me that when otters appear to grin, they are cracking shellfish with their molars, pulling back their lips to avoid sharp shell edges and urchin spines.

Eating is more than a pleasurable necessity for otters; it is an obsession. Every day an otter must eat an amount of food equal to about 25 percent of its body weight. For a human, that would be like eating more than a hundred hamburgers a day. "They probably wish they could take a break from eating," says Riedman.

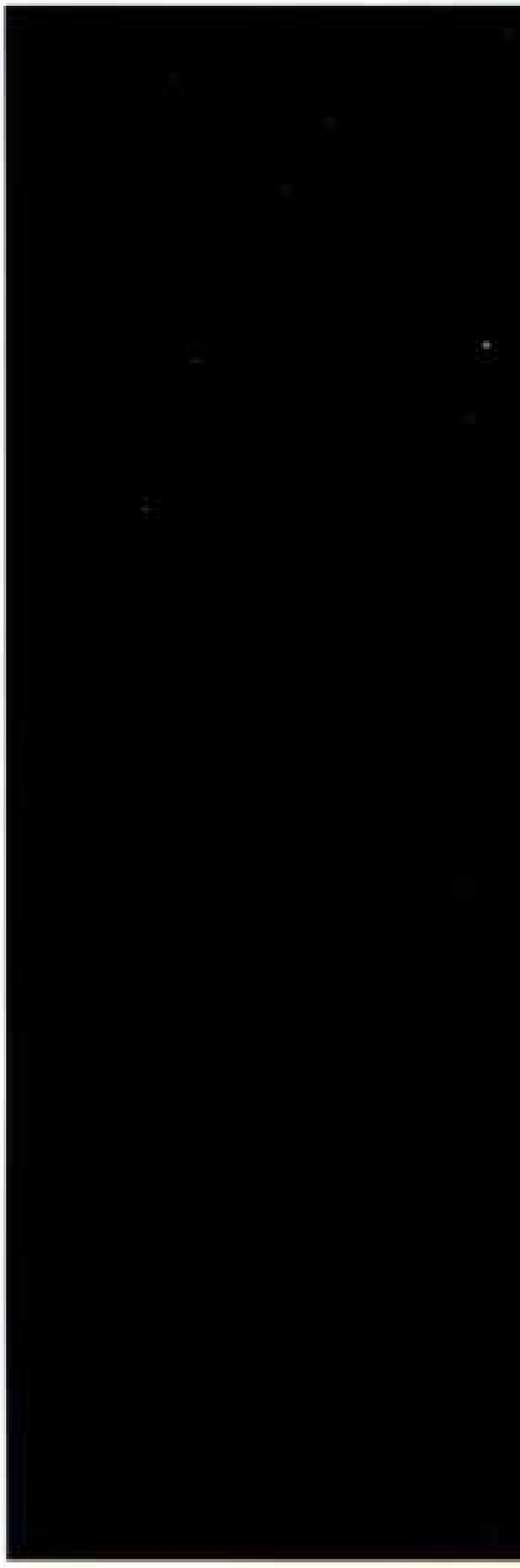
Otters eat so much because they are live wires, full of pizzazz. Between meals they barrel roll and somersault, busily pawing their fur. It looks like games. But the otters are cleaning their fur and grooming it with oils from their skin. In the process they saturate the fur with air bubbles, their only insulation. Unlike seals and whales, they are skinny. To keep from freezing in the cold Pacific, they depend on the bubble-holding capacity of their uniquely thick fur: as many as a million hairs per square inch. Dogs have a maximum of 60,000 hairs per square inch. The average human head has merely 100,000 hairs. If an otter's fur is matted—an oil spill will do it—it quickly freezes to death.

Grooming comes naturally to young otters; what the aquarium's "otter school" must teach orphans is diving, foraging, and shell cracking. Pupils' survival depends on how attentively they study.

"When we started trying to save orphaned otters, our success rate was zero," says Tom Williams, who began studying sea otters after he set up his veterinary practice in Monterey in 1971. At first he kept orphaned pups in his bathtub in seawater. "They'd only live a day or two," he says.

Feeding unweaned pups was the biggest problem. Williams milked six mother otters and found that sea otter milk is 25 percent fat, six times as fatty as human milk. Fat keeps baby otters warm. So Williams concocted an "otter milk shake," blending chopped squid, Manila clams, half-and-half, a saline fluid, cod-liver oil, vitamins, and minerals. It worked.

"In the wild, no more than 50 percent of the pups survive to age



One of some 60 sea otters tagged and tracked during a decade-long study by the Monterey Bay Aquarium, this female had her nose blood-ied during a mating encounter.

Gathering in rafts to sleep (right), sea otters were easy prey for early fur traders, who found them naturally tame and "innocent as sheep."

one," Williams says. "But our survival rate for rescued pups is now 92 percent."

Returning pups to the Pacific has proved much harder. One of the surviving orphans, Roscoe, now 64 pounds, is the largest of the aquarium's three exhibit otters. He was the aquarium's first try at returning an orphan to the wild. When released in November 1986, he kept swimming back and forth in front of the aquarium. Finally he vanished. Six days later he was found eight miles away at Pebble Beach, starving and exhausted.

After Roscoe, three more releases failed. Then in 1988 the aquarium tried a new approach: otter school. Every day a staff member would take the pups swimming in Monterey Bay. As real mother otters do, they would forage on the bottom while the baby watched.

PICO WAS "OTTER PREP'S" first graduate. Fingers were crossed when he swam out to sea on February 14, 1989, carrying a battery-operated radio transmitter under his skin. As aquarium researchers followed him by van, boat, and plane, Pico swam south to Pebble Beach, then north again, crossed 20 miles of open bay, and joined other young males in bachelor buddyhood. He was a graduate, summa cum laude.

Of the first 13 pups released after the start of classes, two had to be retrieved, three died, three were lost, and five successfully returned to the wild.

Tracking is critical after an otter release. So I fly with aquarium biologist Michelle Staedler on an otter-locating mission. We are looking for the radio signal from Benji, released in October 1990. Our goal is simply to make sure that Benji is still alive and to check on his location. We pick up the beeping of his transmitter near Santa Cruz. Staedler notes his location in her log. As we fly on in search of other released otters, I look far up the coast. Once otters ranged all along California. Now no otters live north of San Francisco.

In the wake of explorer Vitus Bering, Russian fur hunters began taking Russian and Alaska sea otters in the 1740s from Kamchatka and the Kuril and Aleutian Islands. After bringing them to near extinction, the hunters moved south. By the 1830s California sea otters were all but gone. Scientists who knew of isolated rafts of otters kept mum, even after the 1911 International Fur Seal Treaty gave the sea otter protection. But on March 19, 1938, a rancher at Bixby Creek, 13 miles south of Carmel, looking through his front-porch telescope, saw animals he could not identify swimming in kelp. The scientists' secret was out: California still had sea otters.

Helped by the 1972 Marine Mammal Protection Act and the 1973 Endangered Species Act the otters have multiplied—but very slowly. California has fewer than 2,400, compared with 20,000 Russian otters and more than 120,000 Alaska cousins. Moreover, Alaska otters are increasing as much as 20 percent a year, while the annual increase for California sea otters is just 5 percent. Hoping to find out why their population growth is so slow, scientists are probing otter behavior. In particular, reproduction patterns intrigue them.

"Look—a mated pair," says biologist Marianne Riedman, peering through her spotting scope at the kelp beds in front of the Monterey Bay Aquarium. I look through her scope and see a male repeatedly bumping a female.

"Now he's pushing his hind flippers in her face," she says a few

Tense seconds tick by as veterinarian Tom Williams and team scramble to stabilize a sea otter pup discovered stranded on a beach wailing for his missing mother. Treated for dehydration and placed in the Monterey Bay Aquarium's nursery (below), the seven-week-old orphan soon became fast

friends with Marcie Tarvid, one of a dozen caregivers who feed, groom, and cuddle the infant otters in round-the-clock shifts. "We basically become their surrogate mothers," says Tarvid, who admits to skipping lunch breaks to keep her pup content. "If that pup is unhappy, you are unhappy."

Diving into her lessons, a sea otter named Jody learns survival skills in the Great Tide Pool, a halfway house for orphaned otters at the Monterey Bay Aquarium. Pups attend school four hours each day for six months, celebrating milestones along the way before graduating to life in the wild. "You should see them when they touch bottom for the first time," says teacher Julie Hymer. "It's like they have a smile on their face."

BILL FORTUNATO

"I just rolled up my sleeves and decided we were going to stop it," declared Margaret Owings in 1968 when dead otters washed ashore with knife and bullet wounds. She founded Friends of the Sea Otter, a citizens group, to fight a bill legalizing the shooting of sea otters. "We won," she revels.

minutes later. "If I were a female otter, I might mate with him just to get him to go away."

The couple perform the standard otter mating maneuver: The male bites down on the female's nose (a sign of sexual maturity in females is nose scars) and rolls her onto her back and onto his belly. Occasionally, males accidentally drown their partners while mating.

AFTER PUPS ARE BORN AND WEANED, the young females tend to stay in their mothers' territory. Often a group will drape themselves in kelp and sleep together in a "raft." For weaned males the pattern is different. They swim to the perimeters of otter territory, where they join bachelor groups. After five years or so of bachelor life a male is mature. Now he becomes solitary, staking out a strip of water, perhaps a half mile long, chasing rival males away and patrolling for females in estrus.

When otters mate, they may engage in one-night stands or two-week flings. Six months later the female gives birth to one pup. Males take no interest in pups, except occasionally to kidnap one until the pup's mother offers an abalone or crab as ransom.

Females dote on pups, but sometimes they must administer discipline. "When two pups start playing, they usually don't want to stop," says Riedman. But playtime must be short, because pups have so much to learn. "Often a mother has to grab her playful pup by the scruff of the neck and haul it away."

By the time an otter pup is weaned at six months or so, it has followed its mother to the seafloor on thousands of foraging dives, learning to turn over rocks and to crack open shellfish. Sea otters as a group eat some 40 different kinds of prey, but individual otters specialize. Riedman has found they tend to eat what their mothers ate, and even to use the same sorts of tools. One female Monterey Bay otter, for instance, learned to use a cola bottle to crack shellfish.

WILL CURTENGER

Riedman later observed that otter's daughter using a bottle too.

"Otters are smart—at least as intelligent as dogs," says veterinarian Tom Williams. One measure of intelligence in an animal is the ability to change its behavior to gain an advantage. Marianne Riedman studied one male otter that—unlike other sea otters—learned to catch seabirds. Other otters have learned to bite open soda cans lying on the bottom to extract tiny octopuses hiding inside.

Biologists admire and often delight in the resourcefulness of sea otters. But they worry over otters' inability to cope with the world they are reclaiming. Tankers endlessly pass back and forth along the coast, and many conservationists predict that a spill is inevitable. The *Exxon Valdez* spill killed as many as 5,000 Alaska otters, more than double California's entire otter population. California is now building a five-million-dollar otter rehabilitation center at Santa Cruz. After a spill, oiled otters will be brought there for cleaning. But California Fish and Game biologist Jack Ames argues that it is far more effective to prevent spills than to try to rehabilitate oiled otters afterward. "*Exxon Valdez* proved that," he says, noting that despite valiant efforts, only a few of the Alaska otters were saved.

If California sea otters were reproducing more successfully, their advocates would be less concerned about oil spills. "We have no concrete ideas why their population growth is so slow," says U. S. Fish and Wildlife Service biologist Glenn VanBlaricom. "Pesticides have been suggested. Or perhaps the habitat is somehow just not as good as in Alaska."

Researchers are much further along in their study of how otters affect the environment, thanks, oddly enough, to the animals' close brush with extinction. Biologists have years of data on the coastal kelp forests without otters. Now they can measure the impact of the otters' return. That impact is enormous.

Northern Pacific kelp forests are a habitat for all sorts of species.

"We might be out of business in five years," laments urchin diver Jim Clayholt, at left, who fears the sea otter's resurgence will cripple his livelihood. Relished by otters, sea urchins sell as delicacies in Japan and now surpass salmon as California's most valuable commercial fishery.

Most popular performers at one of America's most visited aquariums, the "juvenile delinquents"—as Monterey Bay Aquarium guides call this trio of rescued orphans—confer in a corner. Their favorite prank? "Dismantling

their exhibit," says a trainer. "If it can be screwed off, pulled off, pried off, or chewed off, they'll do it." Aquariums around the country have taken in rescued otters unable to survive in the wild.

One of them is the sea urchin, a big eater of kelp. The otters, it turns out, serve as kelp-forest "rangers," hunting the sea urchins. Without otters, urchin populations can explode and devour so much kelp that they create "urchin barrens." Since kelp affects waves and currents as well as providing habitat, otters are key players in coast ecosystems.

The ravenous appetite of the rebounding otter rangers has made them a political animal. Commercial abalone and sea urchin fishermen believe the otters will destroy their industry. Abalone sells for high prices, and urchin roe is prized in Japan. Ironically, it was the near extinction of the otters that created that industry in the first place, because with the otters gone, the shellfish populations exploded far above natural levels.

"Some people in the industry would just as soon wipe out the otters," says Zeke Grader, executive director of the Pacific Coast Federation of Fishermen's Associations.

Most fishermen would simply like to limit otters to their current 250-mile range, reserving the rest of the coast for fishing. Otters, they say, can be protected in this small range by forcing oil companies to move their tanker lanes much farther offshore, by prohibiting oil drilling in or adjacent to the otter range, and by controlling toxic runoff into the ocean from agriculture around Monterey.

"We feel that if this issue isn't resolved, in 15 or 20 years there will be no shellfish industry in California," says Grader.

Not everyone agrees. "Commercial interests always look for a culprit to blame when they themselves are the most guilty of overtaking!" declares Margaret Owings. She organized a group called Friends of the Sea Otter after attending a meeting of fishermen in 1968. "I was horrified," she says. "The fishermen were all standing up and shouting about killing sea otters. I saw that the otters needed a friend, so I just stopped everything and concentrated on them."

Under her leadership, Friends of the Sea Otter became a powerful voice in Sacramento. Once, when the legislature was considering a bill to allow shooting otters, she rushed a busload of placard wavers to the state capital. "Those legislators received thousands of letters from schoolchildren all across the country saying 'Stop Killing the Otters!' " Owings says. "They had to withdraw their bill!"

Despite such devoted fans, the California sea otter's future is shaky. Our abilities as conservators are still uncertain. Even the Monterey Bay Aquarium rescue program—where so much care and love is lavished on orphaned otter pups—is only a tentative success. Forty percent of the graduates do successfully return to the wild. But 60 percent do not.

Using its torso for a table, a sea otter banquets on Manila clams. Increasing in number by a feeble 5 percent a year, the California sea otter's comeback remains chancy. Complete recovery, biologists say, depends on the animal's being allowed to reoccupy

ONE MORNING I receive a telephone call: Casy is dead.

I am instantly depressed. Casy had been my favorite. I can still feel the strength in those mittenlike paws clinging to my arm. I had helped, in a small way, to get him over his cough. And I had smiled one day at his independence as he paddled far out on his own when Julie Hymer took him on a training swim. It was that independence that killed him.

Casy had befriended April, an older otter that is one of the program's successes. She has been self-supporting since her release, but she still regards the aquarium's tidal pool as her bedroom. Casy met her there and began swimming off with his new friend. Julie Hymer

more of its original range, a prospect that embitters fishermen but inspires otter allies like Margaret Owings. "The sea otter has been along our coast for three million years, since the Pliocene," she says. "We only arrived yesterday. They really belong."

decided to encourage his whim. Maybe April would teach her little admirer to forage. But April was not Casy's mother.

Something happened one night when Casy swam out with April into the bay. Maybe he nagged her for a crab and she snapped at him, sending Casy paddling into the darkness. April returned alone to the tidal pool. Searchers fanned out, but Casy had no implanted radio transmitter. Days later he washed up on the beach at Fort Ord, a few miles to the north, starved.

"A lot of us cried," said aquarium volunteer Bob Huettmann, who had helped rescue the pup.

Bob and I are standing on a dock behind the aquarium, keeping watch over another of the orphans, Danny. It is Danny's big day. He has just been released in a shallow cove next to the aquarium, and now he is resting on a float. We see him looking toward the horizon, working up courage to swim out.

I mull over how much humans now are trying to do for otters. It is new for us, this intense concern for other species. Perhaps we need the sea otters as much as they need us. Watching Danny poised to return to the wild, I wonder: As we humans try to help otters, could the otters be helping us become better humans? □

Living in the Shadow ISRAEL'S

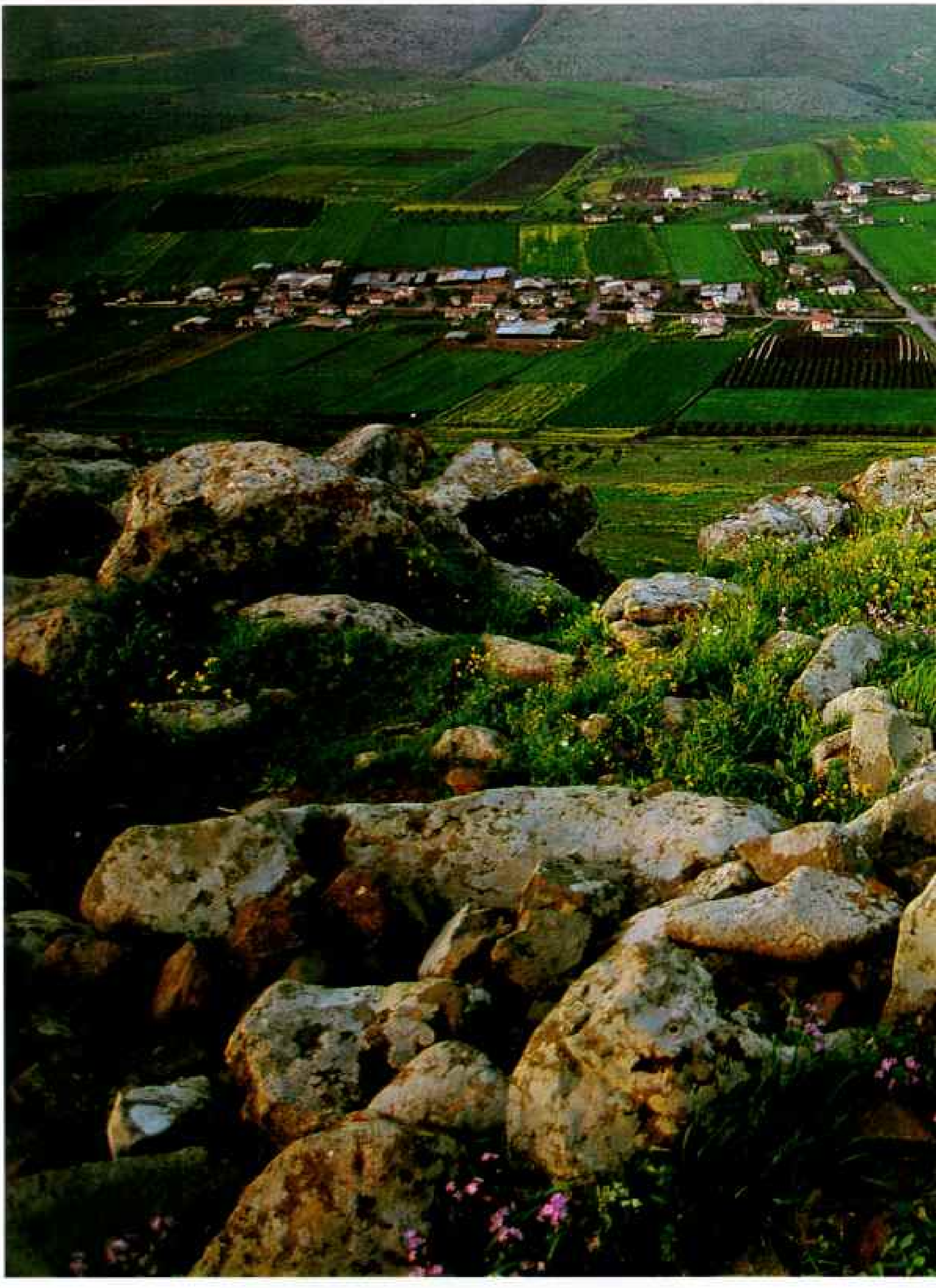
By DON BELT ASSISTANT EDITOR
Photographs by
ANNIE GRIFFITHS BELT

AFTERNOONS BROUGHT RAIN in early spring, when my wife, Annie, and I came to Galilee, the rugged hill country of northern Israel. Galilee is best known, perhaps, as the home of Jesus of Nazareth, and with its stony hillsides and gnarled old olive trees the region surely looks the part. Even the weather at first seemed biblical: Mighty, swift-moving thunderstorms would darken the skies and smite the earth. Then the gray marble clouds would part, and a single incandescent beam would pour through like a searchlight, probing the green hills and bone white stones like a miracle looking for a place to land.

A Druze elder collects his thoughts in Majdal Shams, an Arab village in the Golan Heights overlooking northern Israel's Galilee. Nearby are Israeli police, sent in by the hundreds to stop a pro-Syrian celebration. Such is the uneasy relationship of Arabs and Jews in Galilee as well, even as Israel and Arab nations reach out to make peace.

of Peace

GALILEE



Witness to history, these stones were washed in blood during the Crusades, when a Muslim army led by Saladin slaughtered thousands of Christian soldiers here at the Horns of Hattin. Modern Israelis,

such as Jewish farmers working the valley below, know that many civilizations have come and gone in Galilee over the past 6,000 years. Says a farmer: "We lose one war, and we too are history."

In the spring of 1994, miracles really *did* seem at hand in the Middle East. It had all begun a few months before, with a handshake between archenemies—Prime Minister Yitzhak Rabin of Israel and Yasser Arafat, chairman of the Palestine Liberation Organization (PLO). They had stunned the world by agreeing to end the decades-long conflict between Israel and the Arabs known as Palestinians, most of whom fled or were driven from their homes during Israel's 1948 War of Independence. Many were living in refugee camps in the West Bank and the Gaza Strip.*

Next up was Jordan, whose King Hussein was moving quietly to strengthen ties with Israel. To make peace with neighboring Syria, Israel was considering withdrawal from the Golan Heights, which it had annexed after capturing the territory in 1967.

Many Israelis were filled with hope at the prospect of peace; some, noting that Galilean Jews and Arabs have lived together quietly for decades, were even going so far as to call Galilee the "bridge to peace," a model for how the two groups can put aside old grievances and work toward a common future. This is what we came to see.

But what we found in Galilee suggests that mending fences with the Arabs outside Israel may turn out to be only the first, and most difficult, step toward lasting peace. The second: making peace with the 850,000 Arabs living *inside* Israel as citizens, whose discontent has been simmering for nearly 50 years.

"I just felt God all over me," reports Jerry Yother, at center, a nuclear technician and ordained minister from Chattanooga, Tennessee. Like 1.3 million Christian tourists each year, he came to Israel to walk in the footsteps of Jesus. Coming to Galilee—and renewing his baptism in the Jordan River—turned out to be a life-changing experience. "I can tell you exactly what I was thinking here," he says. "I'm hearing God say, this is my son Jerry, in whom I am well pleased."

Galilee is critically important to Israel in many ways—its Jordan River and Sea of Galilee supply more than a third of Israel's fresh water; its fertile valleys put food on the nation's table; its shrines and ancient cities serve as a storehouse of the Jewish spirit. Galilee also contains the heaviest concentration of Arabs in Israel, many of whom were displaced by the war of 1948 but remained within the new state instead of fleeing to neighboring lands. For these Arabs the prospect of a larger peace between Israel and its neighbors brings a new urgency to their long struggle with the state over the rights of citizenship.

The 450,000 Arabs in Galilee are a diverse group—most are Muslims, with minorities of Christians and Druze. Some 50,000 are Bedouin. But all are caught in this dilemma: They are outsiders, non-Jews in a nation that defines itself as the home for all Jews. And, in a country that has fought six wars against Arab nations and lost thousands of lives to Arab terrorists, they are still considered by many to be potential enemies.

The 447,000 Jews of Galilee are also a study in diversity. There are Ashkenazic Jews of European origin, Sephardic Jews from North Africa and the Middle East, and black Jews from Ethiopia. There are Jews from America, Jews from Iraq, Jews from the Caucasus, and many thousands of Jews from Russia. There are ultrareligious Jews, secular Jews who rarely set foot inside a synagogue, and Jews of a hundred variations in between. They mostly live in separate communities and don't agree on much except the most important thing of

This is the second GEOGRAPHIC story shot by contract photographer ANNIE GRIFFITHS BELT and authored by her husband, Don. The first, on Baja California, appeared in the December 1989 issue.

*See "Who Are the Palestinians?" by Tad Szulc in the June 1992 NATIONAL GEOGRAPHIC.

all: They are Jews in the homeland of the Jews, and they are here to stay.

The glue binding all these lives together into the human mosaic of Galilee is very thin. And, as we would discover, it doesn't take much to shake the pieces loose, along cracks left over from 1948, when the Jews and Arabs of Galilee went to war. "Ninety-nine percent of the time Arabs and Jews in Galilee are scrupulously correct in their behavior," warned Arnon Soffer, an Israeli geographer. "It's that other one percent that will give you a glimpse of the volcano we're sitting on."

NO ONE KNOWS THIS better than Palti Sella, a Galilean Jew of the older generation—the one that knew Palestinians before the war as neighbors and friends. When Palti was a boy, his younger brother contracted a severe eye infection. He needed an operation to save his sight, but Palti's parents were poor farmers who didn't have the two British pounds to pay the surgeon. In stepped one of their Arab neighbors, Ahmed Zuabi, who lent them the money. This was 1922, and Palti was just old enough to be trusted to deliver installments on the loan.

"One of my earliest memories was walking barefoot up the mountain to pay Zuabi the 20 shillings or whatever my father could afford to send," Palti recalls. "By the time we paid it off, I was practically a member of the family."

Today Palti is a tall man with a big soft laugh. He wears his 76 years proudly, his trousers loose, his gray hair short like a pelt. His burdens are carried with a slow dignity down the streets of Afula, the Jewish market town where he lives. And though his chronically sore feet have forced him into a pair of checkered flannel bedroom slippers, he was always glad to fold his big frame into the passenger

Captured by Israel in 1967, a Syrian gun emplacement in the Golan Heights (above) looks down on Jewish farms in northern Galilee, illustrating the military importance of this plateau.

About half of Galilee's 900,000 people are Arab, concentrated in a mountainous core that the UN assigned to an Arab state in its 1947 partition plan for Palestine, then ruled by British mandate. When the Jewish state, Israel, declared its independence in 1948, Arab nations attacked. Israel won the war, destroying 165 Palestinian villages in Galilee.

seat of my jeep and set out on some adventure.

"Where to, Mr. Don?" he'd rumble, turning slowly to face me with a merry look. "As usual, America drives," he'd say. "And Israel goes along for the ride."

One day Palti took Annie and me to Dahi, an Arab village up the mountain from Afula, to meet Mustafa Zuabi and his family, descendants of the man who saved his brother's eyesight. Mustafa, a stately, keen-eyed old gentleman in a white kaffiyeh, or traditional head covering, greeted Palti warmly at the door in Arabic and welcomed us into his home. Mustafa's four grown daughters—all in their 30s—whisked Annie off to the kitchen, where they were already preparing food for us. I joined the men in another room and listened as Palti and Mustafa, reclining on couches, tossed genial insults at each other across the cold tiles of the living-room floor.

"Abu Muhammad, I'm concerned for your health," Palti said to Mustafa in Arabic. "Are the girls feeding you properly?"

"I'm well, thank you. And your feet, Palti? Have you hired this man to drive you?" he asked, nodding in my direction.

"Abu Muhammad is wealthy in daughters," Palti said to me. "Next time you come, please bring five or six grooms with you. Even Jewish ones will do."

"If all Jews were like Palti, we would have no problem," Mustafa said, turning serious. "He makes bad jokes, but this you should know: Palti Sella *saved* us."

In the summer of 1948, Palti Sella was in a unique position to save them, thanks to the fluent Arabic and knowledge of Arab culture he'd picked up from the Zuabis. He was serving as a senior officer in the Haganah, the Jewish militia battling troops from five Arab countries that had attacked the new State of Israel. Initially outnumbered, the Haganah was better organized than its foes and soon gained the upper hand, conquering Palestinian villages one by one and usually expelling the residents or panicking them into flight.

Dahi's time came in June, during a Haganah sweep through lower Galilee. Prime targets were the seven Zuabi family villages around Afula. Hours before the attack was to begin, Palti intervened and persuaded the Haganah to spare them.

Ahmed Zuabi was so grateful to Palti that he made him his kin—among the highest honors an Arab can bestow—and ceremoniously added his name to the official sheepskin detailing the Zuabi family tree.

"Thirty-five years ago," said Mustafa, "I told my cousin Palti that peace would come to this land. Because if one Arab and one Jew can be friends, there's hope for all of us."

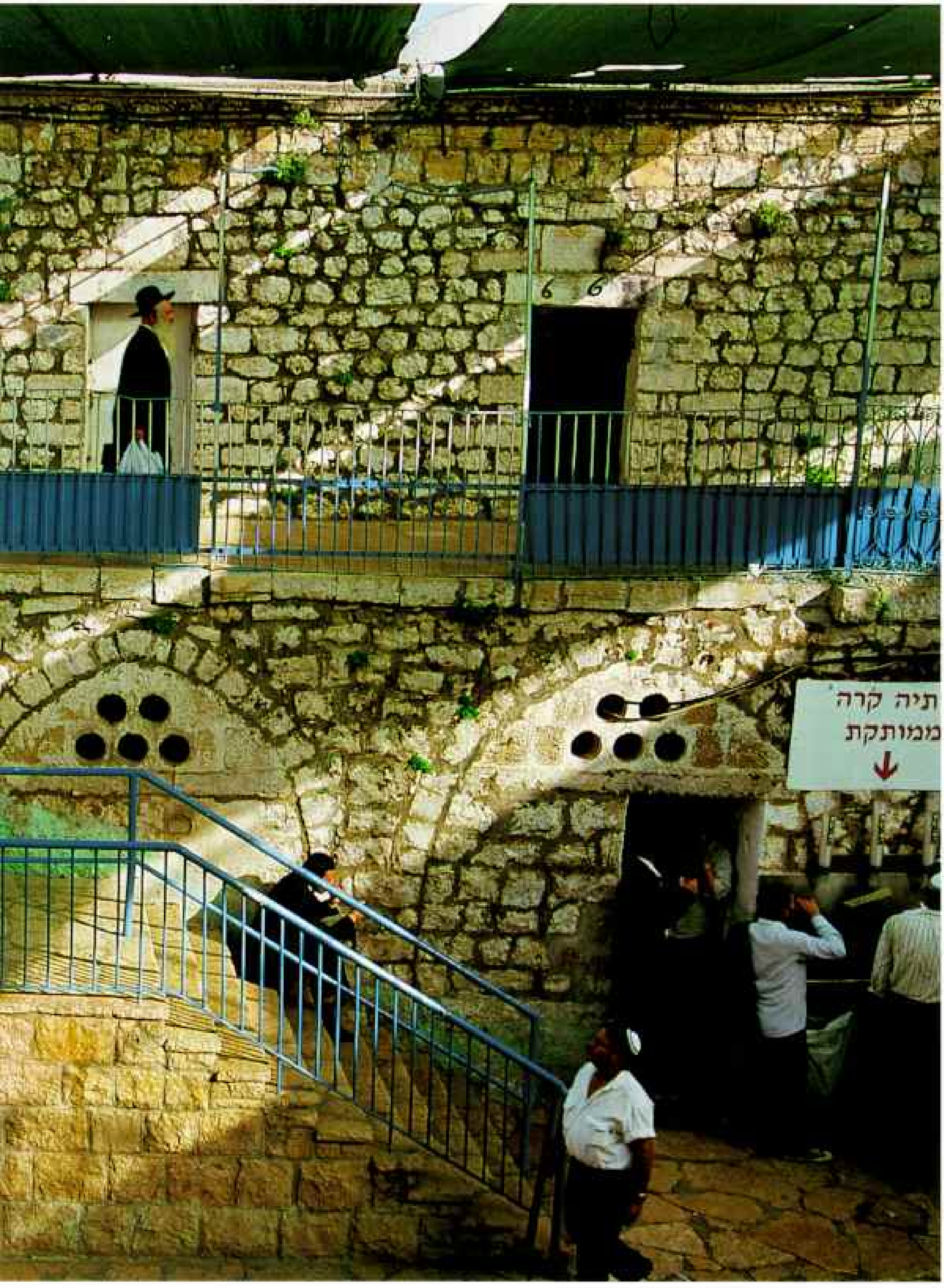
WE MADE A HOME for ourselves among the Jews, settling into an apartment at Maagan, a Jewish kibbutz, or communal farm, on the south shore of the Sea of Galilee. Annie and I had brought along our two small children, Lily and Charlie, and a kibbutz seemed like an ideal place to live while exploring Galilee.

Our neighbors were up before the sun; by seven the rowdy sidewalks were full of barefoot kibbutznik kids scrapping their way to school and adults on aging bicycles with fat tires. Engines roared to life. Men in old blue work clothes piled onto flatbed trucks and rumbled out into the fields, their hard hands and arms still smarting from yesterday's battle with the bananas and dates. Others filed into the dairy or gathered themselves for a day in the ostrich pen, collecting the eggs that fetch some $175,000 a year in export income from Europe and the United States.

From our doorstep it was 20 miles south to the Green Line separating Israel from the occupied West Bank, 27 miles north to the Lebanese border, and only two miles southeast to Jordan. Syria was just over the next hill, which happens to be the Golan Heights, Syrian territory until Israel captured it, along with the West Bank and Gaza Strip, in the Six Day War of 1967. The Golan's strategic position overlooking Galilee makes it a great vantage point from which to lob an occasional artillery shell at a neighbor or pick him off his tractor with a high-powered rifle—which is what the Syrian military regularly did until 1967 and why so many Jews in Galilee are against returning the Golan to Syria, a sworn enemy. It's also why all kibbutzim near any of these borders are part farm and part fortress.

Maagan's perimeter is protected by an eight-foot barbed-wire fence, antitank embankments, a series of bulletproof watchtowers painted gunmetal gray, and an armed guard who mans the front gate and checks all who come and go. Tucked between Maagan's residential buildings are 22 bomb shelters, and if you stand on shelter number 7 next to the

Jewish roots put down thousands of years ago still bear life, say visitors to Meron, where second-century rabbi Simeon bar Yohai, symbol of Judaism's staying power, is believed to be entombed (above). Driven



into hiding by the Romans, Rabbi Simeon developed a mystic philosophy. Passed from rabbi to student for a millennium, his teachings were codified in the Zohar, foundation of modern Jewish mysticism.

kindergarten, you can see Jordan, which the PLO used as a base of operations for attacks against Israel between 1967 and 1970.

"It was bad with the Syrians, but those PLO days were the worst," remembers Estee Ben-Shoshan, who came to Israel in 1949, the year Maagan was constructed amid the rubble of a large Arab village, Samakh, destroyed in the 1948 war. "Our children grew up sleeping in bomb shelters," she said. "And my husband, Amnon, was shot in the back one night by the PLO as he was driving the road to Bet Shean. He recovered, but for two months he hung between life and death."

A delicate woman with graying red hair and the strong, lyrical spirit of a songbird that lived through a hurricane, Estee is an artist—a painter and sculptor—although her job on the kibbutz is making and mending children's clothes. It's a measure of Galilee's peace in recent years that Estee has been allowed by the kibbutz leadership to use number 18 bomb shelter as a warehouse for her paintings.

Like Israel itself, Kibbutz Maagan serves as a refuge for Jews who lived through the Holocaust. Many of the old folks here—Chava the seamstress, Iejo the gardener, Mondie the financial planner, Ruth in the laundry with her Auschwitz tattoo—survived the Nazi camps. Estee was 12 years old when the Germans swaggered into Hungary and ordered the government to round up Jews. She was one of the lucky ones sent not to a death camp but to a labor camp in Austria, where one of her jobs was collecting dead bodies in a factory bombed by the Allies. "I can't describe that terrible smell," she says softly, "and I will never be able to wash it away."

I asked a Galilean Jew once why these kibbutzniks stayed, even during the worst of the sniping and terrorism. "Because there's nowhere else to go," he said simply. "This is the cloud that hangs over every Jew in Israel."

ONE MONTH into our journey a heat wave accompanied by a strange cloud of dust settled over Galilee, which gave the entire region a muffled and dispirited feel. Our friends the kibbutzniks used the Arabic word *khamsin* (fifty) for this weather and reported that it had blown in from the deserts beyond Syria, where it was said to occur 50 days a year. The khamsin cloaked the landscape in an evil yellowish haze that made it impossible to see even the Golan Heights, or the water slides and tourist restaurants lining the lakefront road to Tiberias. As it turned out, this khamsin was nothing compared with the days ahead.

School let out early on the eve of Holocaust Remembrance Day—April 6, a Wednesday—in the quiet Galilee town of Afula. Just down the road and around the corner from Palti Sella's house, Jewish students from two nearby junior high schools chatted and laughed as they waited for a bus to take them home. Asher Attia pulled bus number 340 up to the curb and prepared to take on passengers. As he opened the door, a light-blue Opel swung in front of

Flames of faith soar from every hilltop during the Jewish holiday of Lag b'Omer. By tradition Hasidic Jews throng the tomb of Rabbi Simeon—who survived the Bar Kokhba revolt of A.D. 132-35, crushed by Rome—and light bonfires of celebration. The next day rabbis administer first haircuts to three-year-old boys (above).

the bus as if to park. Then its driver pushed a button on a metal box, connected by wire to a bomb strapped behind the rear seat.

By the next morning, when Annie and I arrived on the scene, all Israel—and much of the world—knew the gruesome details. Eight people died and more than 40 were wounded in the explosion, which the bomber intensified by placing two gas canisters and a bag of eight-penny nails in the car. The driver, who was also killed, was identified as a young Palestinian from the West Bank.

A terrorist group called Hamas, which considers all of former Palestine sacred Islamic territory, claimed responsibility for the attack and vowed that it was the first of many, to avenge an act of terrorism committed by a Jewish extremist just weeks before—the massacre of dozens of Arab worshipers in a Hebron mosque. Both acts were intended to sabotage the peace negotiations.

By 9 a.m. a full-throated mob had taken over Afula's main street and was already hoarse from chanting "*Mavet la Aravim!*—Death to the Arabs!"—led by right-wing agitators who had sped here during the night, media at their heels, to focus local rage against Prime Minister Rabin and the peace process. "You don't mean your neighbors, do you?" I asked a tall, dark-skinned man in the crowd. "All Arabs!" he snapped, his face contorted with rage. "Death to *all* Arabs!"

We went to see our friend Palti Sella. The bus driver killed in the attack was his neighbor, and Palti, who has seen so much death in his life, knew some of the schoolchildren who had been killed or injured. "This kind of killing is nothing but evil," Palti said, lifting his old hands in exasperation. "Where is *God?*"

We went for a drive and found ourselves on the road to Dahi, the village of the Zuabi family. We saw no police, only anxious Arabs who stopped what they were doing at the first sight of our jeep and studied us carefully as we passed. Only when they saw Palti inside did they relax.

We talked to the Zuabis in their living room. "Everyone here is afraid," said Fatina, the eldest of the four sisters. "It is a sad and terrible thing this man has done. Both Arabs and Jews have children. We know how much they are hurting right now."

The Zuabis depend on food stores in Afula, and I asked when they would again feel safe shopping there. "Not today, not tomorrow,"

In the afterglow of *aliyah*, or immigration to Israel, Eskadar Whaka, 40, sits for a haircut outside her home at Hatzrot Yasaf, a trailer park north of Akko where some 500 Jewish families from Ethiopia and the former Soviet Union are temporarily housed. Whaka and her five children came to Israel in 1991 during an emergency airlift of 14,000 Jews from Marxist Ethiopia. "I'm very happy to be here," she says, shrugging off the long wait for housing and jobs that rankles many new immigrants.

Fatina said. "Maybe not for a long time."

I saw things differently after that. My family was here with me. Knowing that terrorists had sworn to strike again, and that it might happen anywhere, at any time, had a clarifying effect on my senses. Suddenly the Arab hitchhiker carrying a paper bag, whom I would have picked up a week ago, didn't get a ride. The unattended briefcase at the next table whose owner disappeared became a cause for alarm. Buses and bus stops were avoided. I felt grateful for the kid soldiers with old eyes who are everywhere in Galilee, M16s and Uzis slung over their shoulders, thumbing rides. When my daughter's kibbutz kindergarten took a field trip, I was glad they were accompanied by an escort with a gun.

I was not alone. "Life in Israel is always stressful, but this is the worst," said Ayelet Weinstock, one of our kibbutz neighbors, a young social worker whom I liked a great deal

for her openness and warmth. Just that day, she said, she had picked up two Israeli soldiers who were hitchhiking to Zefat. After one of them got out, she noticed that the second, wearing sunglasses, looked like an Arab. Scenarios flashed through her mind: He might have stolen the uniform or mugged a soldier to get it. "By the time we got to Zefat, I could hardly breathe I was so nervous. It was the longest ride of my life. That's the thing about terrorism—it destroys your trust and your peace of mind."

It also destroys progress on that bridge to peace between Israeli Arabs and Jews. Many Galileans quietly express hope that one day it will be built. But terrorism tends to cleave Galilee exactly in two: You are an Arab or you are a Jew. Period. Nothing in between.

I, of course, *was* in between, and finally beginning to understand what life is like for people here. When fear is ever present, whom do you trust? Suddenly it made sense that the various subgroups in Galilee occupy separate villages, living not so much side by side as back to back. At times like this, I realized, those villages are safe havens, where people bunker down with those they trust. To our nervous neighbors on the kibbutz, my subsequent forays into Arab villages must have looked like ventures into enemy territory.

"YOU WANT TO DRINK COFFEE?" Abu Ghanem asked, his heavy brown eyes suddenly urgent with the hosting instinct, which is powerful in all Arabs and absolutely overwhelming in heavyset men over 50. We were standing in a bean field next to a highway north of Nazareth, miles from the nearest kitchen or restaurant. "Certainly, Abu Ghanem," I said. "But where?"

"One moment please, you will see," he said

Grief crashes down on the family of Asher Attia moments before his funeral in Afula. He and seven others died when a car bomb blew up in front of the bus Attia, 48, was driving. An Islamic terrorist group,

Hamas, initiated the attack from outside Galilee to sabotage the Middle East peace process. Says one Galilean, an Arab: "Because God is mostly silent, some think they can do anything they want in his name."

Toy guns are a dangerous game on Israel's border with Syria, disputed since Israel captured the Golan Heights.

Today an army patrol road and barbed wire separate Druze villagers from relatives in Syria, just across the valley. At the "shouting mountain" outside Majdal Shams, people visit by bullhorn.

On guard against terror, an Israeli soldier (below) accompanies a preschool outing near Galilee's border with Lebanon, where terrorist attacks are common.

with a wink and began foraging between waist-high bean plants on this, his own little piece of Israel—a quarter-acre plot he bought years ago from an old Arab who didn't own a car and was tired of hitchhiking back and forth to his land. Abu Ghanem comes here every afternoon to shake off the noise and confusion of downtown Nazareth, where he lives, and return to the soil where he grew up.

His roots are actually a few miles away—in Saffuriyya, an Arab village of 4,000 people that was conquered and destroyed by Jewish forces in 1948. Earlier Abu Ghanem had shown me the stones that were his boyhood home, now strewn among pine trees planted by the government after the war.

Bending over his bean plants, Abu Ghanem suddenly gave a shout and held up what he'd been searching for—a blue propane tank. "Now we're in business," he said, and beckoned me toward a pair of pomegranate trees at the edge of his field. Beneath the trees, he proudly offered me a seat—a gray plastic chair discarded from a bus stop—and plucked a dish drainer containing a white coffeepot and four ceramic cups from the branches overhead. He filled the pot with water from a plastic jug and lit the propane burner. From his truck he produced a bag of coffee and, with a flourish, measured out three generous spoonfuls and dumped them into the water, adding sugar when it started to boil. With a sly smile he filled two cups with the dark, rich liquid and presented one to me with both hands, as if it were a jewel.

"A touch of civilization," he said with great satisfaction. "Even here in the wilderness."

"Why not build yourself a little shed for all this?" I asked. He wagged his finger and explained that he is prevented from building so much as a storage shed on his property by one of the many statutes Israel enacted after

1948 to establish control of its new territory.

By itself, this law is a nuisance that limits a farmer's productivity, not to mention his hospitality. But combined with other regulations and unwritten codes effectively limiting everything from Abu Ghanem's education to his eligibility for jobs and benefits—in a nation whose every institution is expertly designed to ensure Jewish success—it adds up to a system that strips Israel's Arab citizens of dignity and power over their own lives.

"Fifty years after the war, Jews still see us as enemies," Abu Ghanem said. "It makes me angry and sad at the same time. I, whose father, whose grandfather, whose great-grandfather lived on this land, am the outsider. I feel like a foreigner in my own country."

As April reeled off one hot, dry day after another, the lush greens of Galilee faded to yellow and finally settled into a glossy biscuit brown, the color of summer. The shock waves of fear also subsided, although even a novice ear like mine could detect echoes now and then on the crowded streets of Tiberias—a discussion between two young women waiting for a bus over which part of the vehicle (front, middle, or back) was safest, a distant muffled blast that meant another abandoned briefcase had been destroyed by the police.

Though edged with fear, life went on. I even began taking my children to Tiberias again, which was always an experience. The town's 36,000 people are mainly Sephardic Jews, who bring to Israel the dark skin and exotic bazaar manners of North Africa and the Middle East. One morning my five-year-old daughter, Lily, and I went to town early and wandered through the city's old market, where both the produce and the soul of Galilee were on display.

Fishermen up all night on the Sea of Galilee were hawking their catch on sidewalks made

silver with stacked fish. Lily's eyes grew wide as we came upon a thick little woman in a floral scarf bartering angrily with a fisherman, occasionally smacking him with a fish to drive home her point. "What was that all about?" we asked after she had huffed off. "She says I owe her one more fish for that price," he laughed. "That's Israel—push, push, push."

Lily rode my shoulders as I waded into the crowd, flowing past tables full of luscious fruit—strawberries, dates, oranges, lemons, figs. A dapper old fellow in a mustache and black beret took a shine to Lily and flipped a banana in our direction. I caught it; swarthy faces turned to see, grinned, shouted their applause. I peeled the fruit and passed it into her dimpled hands.

Later we sat in a shady restaurant at water's edge and tossed chunks of pita bread to the hungry gulls that always seem to hover over anyone eating on the Sea of Galilee. In the blue distance, one of the wooden "apostle" boats, *Mark*, looked like something out of the first century as it moved toward Capernaum with a crowd of tourists. "Was Jesus Jewish?" my daughter asked, and I did my best to explain. Days like this didn't come often, but they were a welcome break from long stretches when all I ever seemed to hear were sad stories and the gnashing of teeth.

FROM A MILE AWAY, an Arab village in Galilee looks like a limestone formation, a jumble of cream-colored stones on a dusty hillside; entering it feels like being lured into a concrete-block fun house filled with brown-eyed kids and noise and laundry strung from porches and things gone haywire and whole sprawling piles of unfinished business. Streets are dusty and narrow, laid out with a logic that doubles back and then goes nowhere. Driving

Hometown of the holy: A procession of Arab Christian altar boys waits to join worshipers crowding the streets of Nazareth on Palm Sunday, a few blocks from the grotto where Mary and Joseph are believed to have made their home. A tiny hamlet in Christ's day, Nazareth is now home to 60,000 people, mostly Arab. Foreign tourists, whose visits sustain the local economy, find a community of native Christians in Galilee who trace their faith to the first century.

in Ibillin, a village of 8,200 people in western Galilee, was like this: I was forever climbing a hill and running out of road, or entertaining spectators on balconies by trying to follow a street that narrowed to an alley, then to a sidewalk, then ducked behind a wall. I tried half a dozen times to find Mufid Qassoum's house and never made it once, even with good directions. I usually had to pick up a little soccer player to guide me.

"Listen, every Jew in America or Russia or Ethiopia or Argentina has more rights in this country than we do," declared the 35-year-old teacher and community organizer, opening what was to be a series of long, intense dialogues over several weeks. "When he takes his seat on the plane, when he even makes up his mind to come here, he automatically goes to the head of the line for everything—education, housing, financing, jobs."

Jewish leaders are quick to point out that Israeli Arabs enjoy a higher standard of living than do Arabs in many other countries. But these facts remain: More than a third of Israeli Arab families live below the poverty line. A large percentage of Arab college graduates in Israel are underemployed. My part-time interpreter, Kamel, was one, despite a degree from a top American university and fluency in four languages. Standing at the end of the hiring line behind thousands of immigrants from Russia and Ethiopia, Arabs in Galilee do the jobs nobody else wants to do. They clean the hotel rooms, build the houses, pump the gas, and bring in the crops. Last I heard, my friend Kamel was working as a stock clerk.

Arab public schools are financed at half the level of Jewish schools. The gap is narrowing under the current government, but a quick tour of any Arab village school shows how far they have to go.

One of Ibillin's three elementary schools, for example, serves 600 pupils without heating or air-conditioning. Its "library" consists of three rickety metal bookcases in the back of a home economics classroom, stocked with titles such as *Dean's Annual for Boys* (1961), *The Joy of Knowledge* (1976), *Katie and the Computer* (1979), and a series of Egyptian paperback detective novels. The school has one television, one videocassette player, and nine computers, woefully outdated. Each student gets 45 minutes of computer time twice a month, every other year.

"By the time they graduate," said the sad-eyed teacher who led me around, "we want them to know at least what a computer is and how it works. Also, how to type."

"Sometimes it just feels like everything's against us," Mufid said at the end of one particularly long day. "My father is of the generation that never opened their mouths. I am educated, and I learned to open my mouth. My son may not be as patient as my father and me. He may learn to throw stones instead."

THE ARAB COMMUNITY in Galilee bears some responsibility for its dilemma. Israeli Arabs do vote—but unity usually escapes them, and political activity in the villages tends to be fractious squabbling among the leaders of various extended families over the little power that Israel actually does grant the village. Rising above these blood alliances, or banding together to demand more

from the state, is practically an alien concept.

Therefore it came as a shock to most Israeli Jews when the Arabs of Galilee put aside their bickering in 1976 and stood up to confront them. What wasn't a surprise was the issue that brought them to their feet: land.

Israel had been confiscating Arab land since 1948, when it began seizing the homes and land of Palestinians who fled the Jewish militia. The 1970s brought a new wave of land seizures, as Jewish planners, alarmed by regional demographics that showed a growing Arab advantage, especially in mountainous central Galilee, sought to "Judaize" the region by bringing in thousands of Jews to development towns such as Maalot and Karmiel.

But in 1976, after the state announced plans to seize even more land for development—some 5,000 acres of Arab-owned or -worked farmland between the large Arab villages of Sakhnin and Arrabe—something snapped. Arab leaders called for a general strike of protest. On March 30 police and soldiers clashed with Arab demonstrators in several villages, and by the end of the day six Arabs were dead, 70 injured, and 260 arrested.

Ever since, Palestinians have observed March 30 as Land Day, to commemorate all they have lost.

For the Arabs of Galilee, Land Day 1994 was charged with special meaning. For the first time in history Palestinian Arabs were getting land back from Israel—the Gaza Strip and Jericho in the West Bank, thanks to the peace negotiations—and the mood was one part defiance, two parts euphoria. Annie and I spent the day in Sakhnin and Arrabe, being swept through the streets by thousands of chanting demonstrators, many of them wearing the Palestinian colors—red, green, black, and white—or waving the once banned Palestinian flag. Israeli police have learned to stay out of these villages on Land Day, settling for barricades on the roadways between them, but the day's message could not be contained: Arabs inside Israel have a score to settle too.

Waving once outlawed colors, a crowd bearing the Palestinian flag surges through Arrabe on Land Day, marked each year to recall the 1976 protest in Galilee over Israel's practice of confiscating Arab land. In Sakhnin (above) mourners plant trees to honor the six Arabs killed during the demonstrations.

"We may be second-class citizens," says one mourner, "but we have a long memory."

A year of mourning ends as womenfolk of the Zuabi family visit the grave of their brother Hisham, killed in a car accident. Buried in the tomb beyond, tradition says, is a seventh-century Muslim holy man.

"Whether it's true or not doesn't matter," observes a historian. "Once a tradition is believed, it becomes real." Similar shrines – Muslim, Jewish, and Christian – stake claim to mountaintops throughout Galilee.

Emboldened by the new atmosphere of peace, they are openly embracing an identity they've kept hidden away for nearly 50 years.

This is what frightens geographer Arnon Soffer, who fervently supports Judaization, the deliberate effort to attract more Jewish settlers to Galilee and ensure that Arabs don't outnumber Jews. In 1991 this 30-year campaign finally gave Jews a slight majority in Galilee—an advantage lost the following year and almost sure to slip further away as traditionally large Arab families continue to grow. Sensing the mood in Arab villages, Soffer foresees "more and more friction between Arabs and Jews, more demands for Arab autonomy and self-determination."

To its credit, Rabin's government has committed itself to achieving full civic equality for all its citizens. But it will take time for good intentions to translate into roads and sewers and schools in Arab villages. Even that, in Soffer's opinion, will merely postpone the demand for autonomy. In the meantime, his recommendation still stands: Bring more Jews to Galilee.

The problem is jobs. Jewish Galilee is mostly farmers in valleys and professionals on hilltops, and only so many people are willing to commute long distances to Haifa over two-lane mountain roads.

Enter Stef Wertheimer, a 68-year-old industrialist and entrepreneur from Nahariyya who has created a high-tech heaven in the hills of upper Galilee. Tefen is a complex of 50 light-manufacturing firms (electronics, aeronautics, plastics, machine tools) clustered in a meticulously planned industrial park where abstract sculptures adorn the lawns and music fills the factory air. Wertheimer specializes in finding bright young entrepreneurs who thrive in this environment, seeding their handiwork with capital and advice, and helping them find overseas markets for their products. This is his vision for the future of Israel—a "new Zionism" to replace the farms and fortresses of the previous, worn-out version.

"It's time for Israelis—both Arabs and Jews—to stop looking backwards," he said. "Instead, I say let's get up early and make a product. Declare a truce, then begin to fight a new enemy—overseas competition and on-time delivery to Japan or Europe." Right now products made at Tefen earn 500 million dollars a year in export income, half of Galilee's total. Wertheimer figures to reach two billion dollars in ten years, generating jobs and opportunities for Jew and Arab alike.

Arabs and Jews lead mostly separate lives in Galilee. They pass on the streets of Tiberias or haggle in the town's old market (right)—but rarely do they connect. "It's sad, considering all we have in common," says an Arab Christian priest. "These two persecuted peoples—Arabs and Jews—should make for a better understanding." Says Tzachi Kolumbus, a Jewish teacher: "My dream? To take these crazy Jews and Arabs of Galilee and build a bridge to peace."

That hasn't happened yet, as even an optimist like Wertheimer will admit. Not one of Tefen's companies is owned, or run, by an Arab, and only 15 percent of its workers are Arab. "Tefen is great for them, but what about us?" asked a man in a nearby Arab village. "We need a Tefen too."

MY LAST WEEKS in Galilee were spent searching for the bridge to peace I'd come here hoping to find, although after the bus stop bombing, goodwill seemed to take a vacation. There were still signs of hope—an idealistic teacher here, a social worker there, a university program, a cross-cultural newsletter. I was especially touched by a group of two dozen high school students, Israeli Arabs and

Jews, who belonged to an organization called Youth Who Sing a Different Song.

Alarmed by the hatred stirred up after the bombing, they set up a roadside tent near Afula to collect names on a petition for peace. I joined them one afternoon and got a taste of the gestures and verbal abuse flung from passing cars. Over two days, they did manage to gather 87 signatures, which they sent to Prime Minister Rabin with a letter urging him to continue the peace process. But overall it was a disheartening experience. "They want to be bridges to peace," sighed their adult leader. "But reality is stronger than their hopes."

Everyone in Galilee has been a victim of that reality. Most have grievances that time has concealed. But the longer I stayed the more I could sense them—the underlying fractures in a country that since its founding has been, in the words of David Grossman, an Israeli author, "hard and twisted, like scar tissue on a bone that was broken and badly set." Will it take a miracle to heal?

Our route to Tel Aviv, and home, led one last time through Afula—down the tree-lined main street and past the bus stop, now familiar territory, where the car bomb had gone off.

There was practically no sign that here, less than a month before, eight innocent people had been murdered by a terrorist, or that dozens of others had been horribly injured. Six shiny new orange plastic seats were perched, all in a row, to replace those that had been blown to bits. Three of them, in fact, were occupied at the moment by Jewish students—visibly anxious teenagers in blue school uniforms, two girls and a boy with glasses, waiting for a bus with backpacks in their laps. Only an ugly black scorch mark on the road in front of them testified to what had happened here, and the rain had already begun to wash it away. □

SATELLITE REVELATIONS

New Views of the Holy Land

COMPUTER IMAGING BY RICHARD CLEAVE
AND TECHNION–ISRAEL INSTITUTE OF TECHNOLOGY

EYED FROM ABOVE, the Sea of Galilee gleams like a gem in the rough-cut setting of northern Israel's Galilee and the Golan Heights. This is no ordinary satellite image. Notice how the deep valley of the Yarmuk River, hills along the Jordan River, and volcanic cones on the Golan Heights all seem to emerge in three dimensions.

This computer-generated perspective and the ones that follow were created from high-resolution satellite images "draped" over a digital terrain model. Animation software makes it possible to "fly over" each scene, viewing it from any altitude and direction.

These techniques allow us to better grasp the history-rich geography of the Holy Land. In this oblique view one can visualize the path Jesus may have taken from Nazareth to the lake, 15 miles away.

The Valley of Jezreel lies to the southwest. Here on a route used by invading armies, the Book of Revelation places Armageddon, the final battle between good and evil.

Promised Land

AFTER FORTY YEARS in the wilderness Moses looked west across the Jordan River into a land "flowing with milk and honey." This image shows the terrain that beckoned. The panorama features the West Bank, the hilly region taken by Israel from Jordan in 1967. The West Bank is home to a million Palestinians and some 110,000 Jewish settlers.

The big picture

IT WAS A FLAWLESS January day in 1987 when Landsat 5 passed 440 miles above the Holy Land, recording data for a natural-color image. That image was enhanced with detail from a French SPOT satellite to become the image at right, the basis for this article's computer-generated perspectives.

By itself this vertical view provides an unparalleled look at the topography of the region. The cloud-free panorama extends from the snowy Anti-Lebanon mountains to the parched Negev desert. Even Mount Nebo, from which Moses sighted the Promised Land, is discernible.

Dividing the image is the winding thread of the Jordan River. It links the freshwater Sea of Galilee, 689 feet below sea level, with the saltwater Dead Sea—at 1,337 feet below sea level the lowest point on the earth's surface. The Jordan Valley is part of the rift system that extends from

southern Turkey all the way through East Africa.

Both sides of the river are mottled with irrigated fields. Israel and Jordan have drawn off so much water for agriculture that the Dead Sea is shrinking. Its vivid blue southern end, made up of mineral evaporation pans, survives with water pumped from the sea's deep northern basin.

Large urban centers appear as gray smudges: Beirut, Damascus, Amman, Tel Aviv-Yafo, and Jerusalem. The northern end of the Gaza Strip, a Palestinian self-rule enclave along with Jericho, can be seen on the sandy coast.

The coastal plain served as a land bridge between Asia and Africa. Along its length swept the armies of Ramses II and Alexander the Great, of Pompey, Saladin, Richard the Lion-Hearted, and Napoleon.

The hilly interior of this region, with its austere terrain and scant resources, became a world stage for the religions of Judaism, Christianity, and Islam. As one scholar has written, "this was a land that fostered faith."

Richard Cleave, head of Rohr Productions, Ltd., published *The Holy Land Satellite Atlas* in 1994.

Making the image

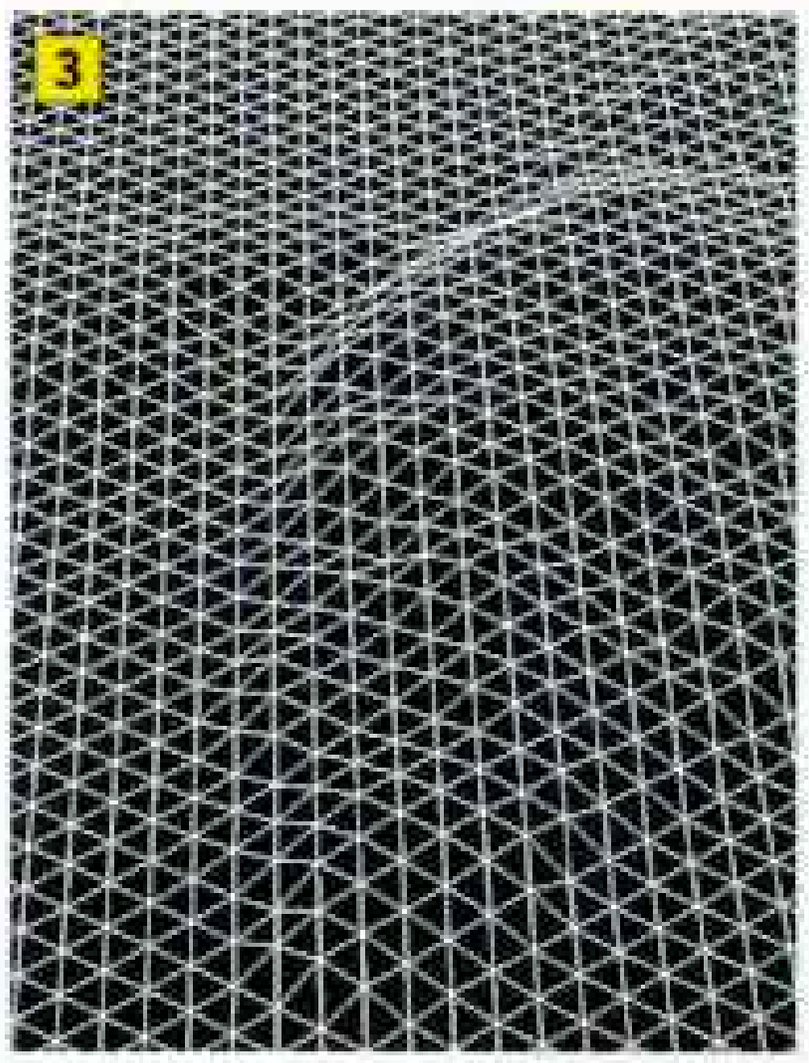
TO GENERATE from satellite data a dramatic oblique view that looks three-dimensional, project coordinator Richard Cleave led an international effort. He began with a high-resolution Landsat 5 image of the Holy Land in which each colored picture element, or pixel, covers a 30-by-30-meter square.

Technicians at Earth Satellite Corporation in Rockville, Maryland, then combined the Landsat color data with gray-scale data recorded by a French SPOT satellite. Among the most detailed satellite images available to the public, the SPOT scenes have ten-meter pixels. In the new image (1) resolution was increased dramatically.

Next John K. Hall of the Geological Survey of Israel prepared a digital terrain model from detailed topographic maps. The model consists of elevations distributed on a 25-meter grid. It can be used to illustrate topographic information in a variety of ways, from a color-coded contour map (2) to a mesh relief model (3).

Computers at Technion—Israel Institute of Technology in Haifa were used to merge the satellite data with the elevation data. This created the effect of draping the image over a relief map.

Software developed by Technion's Craig Gotsman and Gennady Agranov then let Cleave interact with the database, simulating flight over the landscape and viewing it from any angle or height like an aerial photographer. He could also exaggerate relief, a technique for emphasizing detail. In this way he selected the scenes for this article, such as the one of Haifa blanketing the slopes of Mount Carmel (4).



Jerusalem and the Judaean Hills

"A CITY THAT IS SET on a hill cannot be hid," says the Book of Matthew in the New Testament, and faith has built no city more visible or exalted than Jerusalem. The City of David now spreads over a web of limestone hills, home to more than 550,000 people. Israel claims the entire city as its capital. Jordan, which lost East Jerusalem during the 1967 war, does not recognize the claim, nor do most countries. Palestinian leaders, meanwhile, insist that predominantly Arab East Jerusalem become the capital of a future Palestinian state.

Jerusalem looks out over the Judaean hill country, a rugged upland that gave refuge to ancient Israelites. This image looks south across the calloused landscape, its ridges 2,000 to 3,000 feet high, from Jerusalem to Hebron, the only West Bank city where Jewish settlers live in the midst of a large Arab population.

Scattered across the hills are isolated Jewish settlements, built, despite Arab protests, to bolster Israel's claim to the contested land. Arab towns such as Bethlehem, birthplace of Jesus and King David, also dot the region.

David captured Jerusalem in about 1000 B.C. and made it the capital of his kingdom. Taking advantage of the defensive site, David built his citadel on a ridge flanked by deep valleys. The walled city fell to the Babylonians in the sixth century B.C. and to the Romans in 63 B.C., when the victors resorted to siege warfare.

Temple Mount, visible as a whitish rectangle in the foreground, is the most hallowed site in the Old City, sacred to Jews, Christians, and Muslims. Here David's son Solomon built a temple to house the Ark of the Covenant. The first of several sacred buildings to occupy this site, the temple was destroyed by the Babylonians. Here also is Dome of the Rock, the mosque built in the seventh century on the spot where Muslims believe Muhammad ascended to heaven.

Previous pages

SHALLOW BLUE WATERS of evaporation pans flash like a mirage in the gaunt environs of the southern end of the Dead Sea. From the east the Mawjib River, its canyons as deep as 1,700 feet, slices across the Moab Plateau in Jordan. On the opposite bank in Israel rises the Wilderness of Judaea, where David fled his enemies after killing Goliath. A shoreline cliff anchored the ancient fort of Masada. Historians locate the infamous biblical cities of Sodom and Gomorrah at this end of the Dead Sea. An earthquake may have razed them in "brimstone and fire."

The Golan Heights

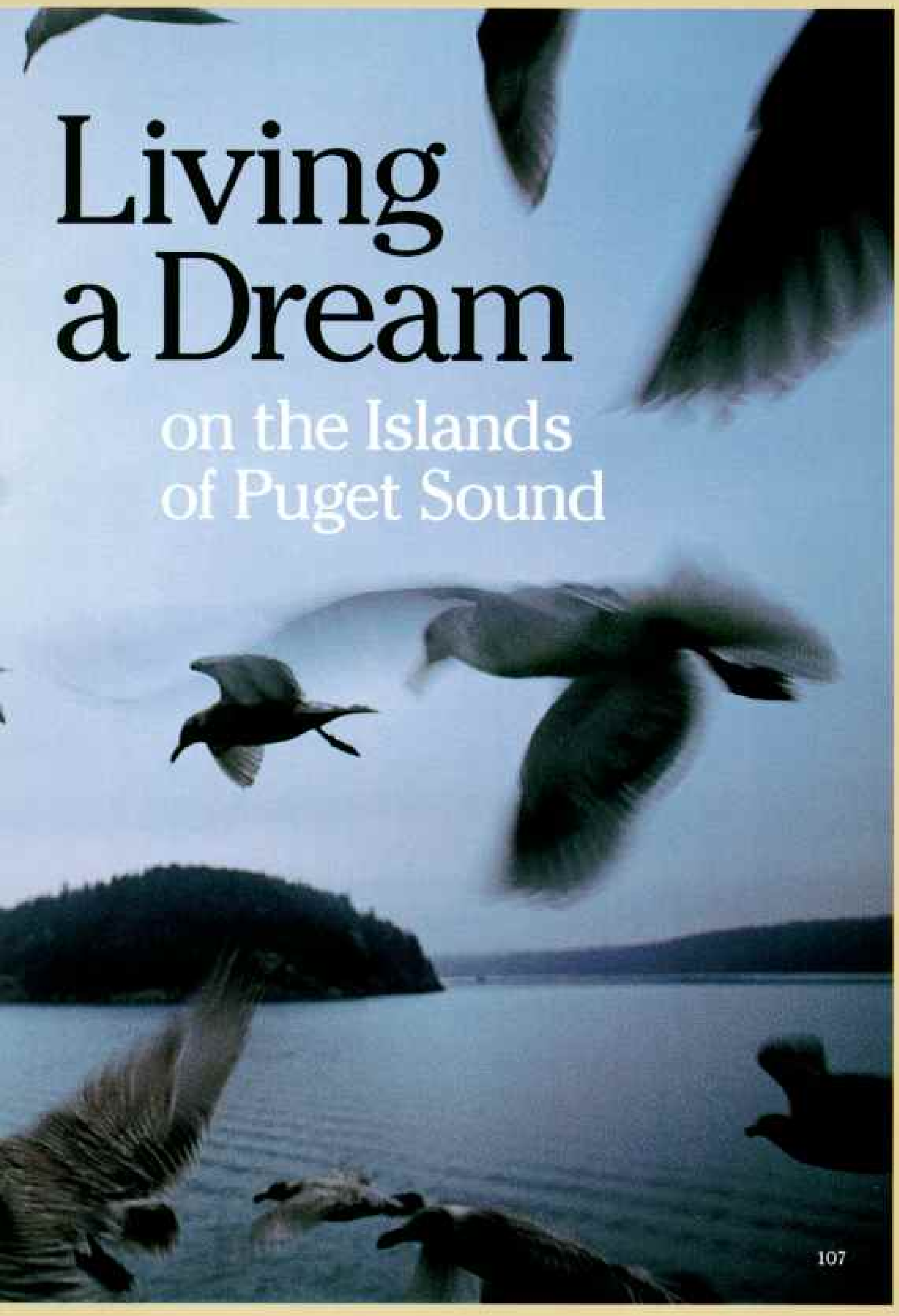
SNOWCAPPED Mount Hermon, 9,232 feet high, presides over a strategic corner of the Middle East. Only 60 miles separate the Syrian capital of Damascus and the Sea of Galilee. Between them rises the Golan Heights, with commanding views of northern Israel and southern Syria. Israel captured the plateau from Syria in the Six Day War of 1967, following years of shelling from the Golan Heights and after Syria tried to divert headwaters of the Jordan River from below Mount Hermon. Israel annexed the area in 1981.

Syria now demands the return of the Golan Heights as a precondition for any long-lasting peace agreement with Israel.

For reasons of tradition, security, and historical enmity, the nations of the Holy Land remain divided. With the help of these images, problems that seem incredibly confusing on the ground can seem clearer from above. In geography lie clues to a region's destiny. □

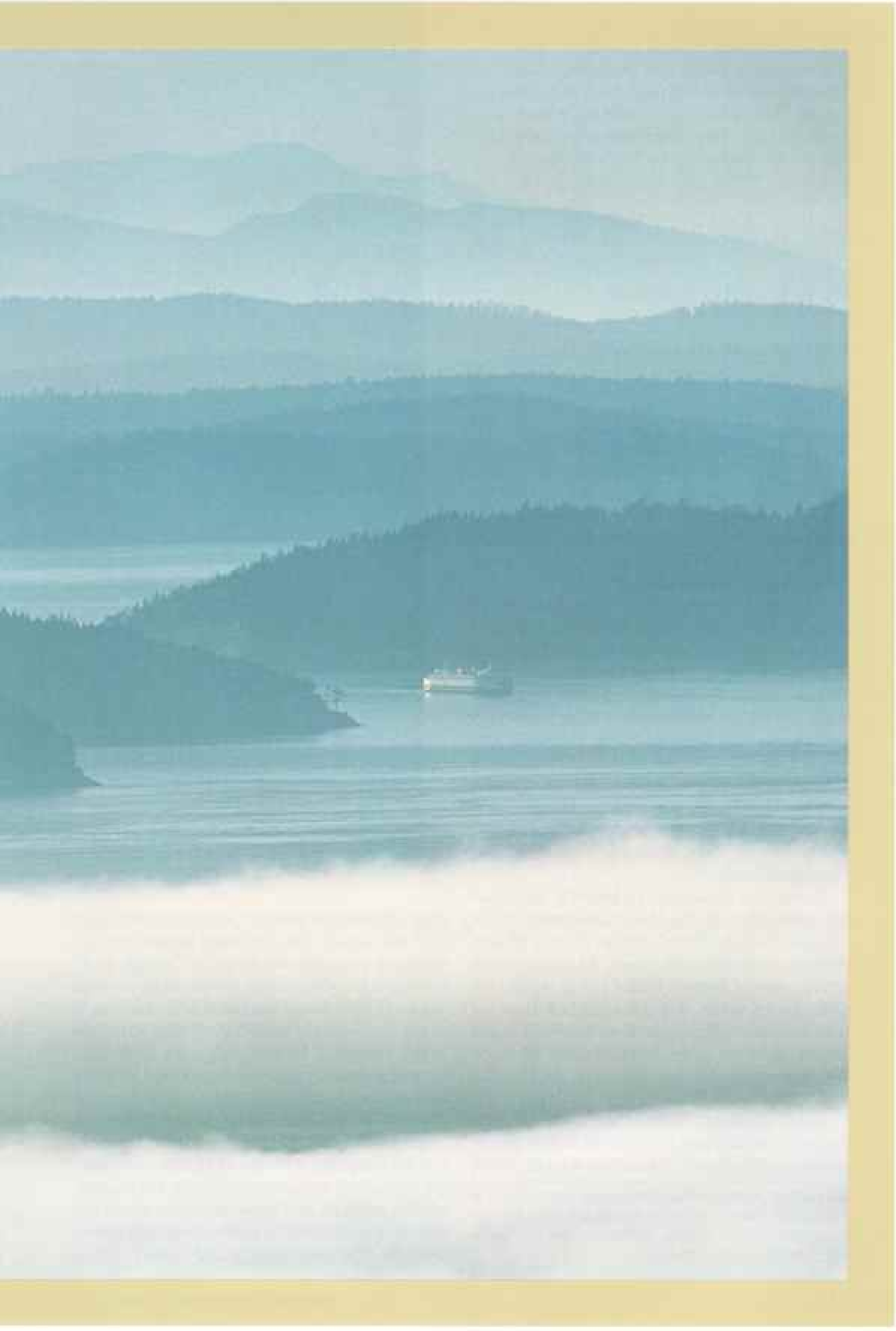
TEXT BY THOMAS O'NEILL
SENIOR EDITORIAL STAFF

Gulls dip and wheel near James Island, one of hundreds in the San Juan group—northern refuge for eagles, orcas, and the city weary.


Living
a Dream
on the Islands
of Puget Sound

Surging surf *and peeling madrona trees mark San Juan Island, made American by a German kaiser. The U. S. and Britain each claimed sovereignty for the decade following the "pig war" of 1859-1860, launched when an American farmer killed a British officer's pig—the war's only fatality. Kaiser Wilhelm I, asked to mediate, ruled for the U. S. in 1872. On Whidbey Island (right) hikers sample 17,000-acre Ebey's Landing National Historical Reserve, the first in the nation, set aside by Congress in 1978.*

Lifeline *to the islands, a ferry ducks through Thatcher Pass (right), heading east from the San Juans. The 25 state ferries carry 15 million passengers a year to the Puget Sound islands of Bainbridge and Vashon—easy commutes to Seattle—and to Whidbey and the San Juans. Eager to preserve woods where winter dusts deer ferns with frost (above), islanders have blocked all efforts to supplement the ferries with new bridges. Says Debra Madan, who has lived on Orcas Island for 24 years: "That body of water, between me and the rest of the crazy world, is a real relief."*



"Old wooden boats have magic in them," says Steve Knutson, testing the resurrected Ghost off Lopez Island with his son, Eilif, at the tiller, agrees. "You always have something to do on a boat," he says. "But I like it best when it's rough and windy weather. It's more of a challenge."

By BERNARD OHANIAN
NATIONAL GEOGRAPHIC EDITORIAL STAFF

Photographs by RICHARD OLSENIUS

AT QUITTING TIME America's luckiest commuters stream to the pier at the foot of Marion Street, a few blocks from the gleaming towers of downtown Seattle. Within minutes they begin boarding the four-tiered *Walla Walla* for a half-hour trip across the blue-gray waters of Puget Sound.

Topside, the ferry's main cabin looks like a floating diner with picture windows. Sitting in chairs or at restaurant-style booths, riders sip espresso or wine, work on laptop computers, or nap; others head to the top deck to power-walk the quarter-mile circuit (a sign reminds passengers—no skateboarding allowed). The cabin soon fills with the sounds of Pachelbel's Canon in D Major, played by 18-year-old Akemi Uchida of the Seattle Youth Symphony. Her violin case is open for donations; she makes, she says, a hundred dollars an hour on a good day.

Today is a good day. In fact it's spectacular—the kind of day these commuters have come to cherish. There's a clear view of Mount Rainier, covered with snow, 65 miles to the south, and of Mount Baker rising regally 95 miles to the north. And looming just ahead is wooded Bainbridge Island, a storybook home where children play unsupervised in open fields and deer browse within a block of the main street.

Here, in Puget Sound, the United States begins breaking into little pieces before disappearing entirely into Canadian waters. More than 200 named islands, and hundreds more without names, dot the sound proper and the northern passages abutting the Canada-U. S. border a hundred miles away. Only several dozen of the islands are inhabited, and many of the smaller ones stretch the definition of the word "island": Barely visible at high tide, they appear during low tide as small mounds of rock and earth with a tree or two jutting out like tufts of hair on a balding man's head.

Their rocky silhouettes are the aftermath of glacial sculpting that ended 11,000 years ago. Now, on crisp autumn afternoons, the islands' alders, poplars, and big-leaf maples stand out like fiery exclamation points amid evergreen Douglas firs and western red cedars. Fresh

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Freelance photographer RICHARD OLSENIUS, a Minnesota native, is drawn to cool subjects. He has covered stories on Alaska, Labrador, and the Arctic for NATIONAL GEOGRAPHIC.

water from mainland rivers mingles with Pacific salt tides that rush through the Strait of Juan de Fuca, creating rich environments for estuarine life. Over it all, the sky stretches above a prairie of water that meets the horizon in all directions.

"Look at a globe," says Drew Kampion, editor of the *Island Independent* newspaper, a biweekly. "See if you can find another place like this: a group of islands relatively close to a civilized hub, on an international boundary, with an abundance of natural resources and an eclectic wealth of creative people. It's like a piece of jewelry in which the stones set together and complement one another."

But some of the stones are losing their luster. Bainbridge, once all farms and forests, has taken on the look of an upscale leafy suburb; the island's Eagle Harbor is one of the most polluted in the nation. Farther north, on Whidbey Island, where farmland has been divided into house lots, commuters and Navy families have helped push the number of residents from fewer than 20,000 in 1960 to more than 55,000 today, making it the most populous island in Puget Sound.

Up by the Canadian border, beyond the reach of a daily commute to Seattle, the rustic San Juan Islands, still blanketed by forests and fields, also suffer growing pains. A huge banner that greets newcomers to the county seat reads: "Welcome to Friday Harbor. Please

help us conserve water." Yet vacationers waiting to return to the mainland on jam-packed ferries search the wall-size displays in real estate offices along the main street in Friday Harbor, perhaps hoping to join 12,000 full-time residents in the San Juans—more than a fourfold increase since 1960.

The growth seems certain to continue. County planners predict that the population of the San Juans, now the fastest growing area in the state, will increase by another 50 percent over the next 15 years.

"Tell your readers it rains all the time," Bill LaPorte yells over the roar of his powerboat as we skim across the channel between San Juan and Shaw Islands. "Tell 'em we have horrible crime. Tell 'em to visit all they want," he shouts, "but not to move here."

LaPorte knows the lure of these islands, knows from his own story that one visit can be enough to set a soul to dreaming of a new life. Years ago he lived in Detroit, where he worked at a slaughterhouse by day and ran a little wild at night. "People who come here are either looking for something or running away from something," he says, his weathered face and gravelly voice hinting that he was doing a bit of both when he arrived in the area in 1967.

Now he's an actor, playing bit parts in productions at the local playhouse. He lives on a 31-foot cruiser, with framed pictures of his three grown daughters over his bed. And he's mayor of Friday Harbor (population 1,800), winning on a platform to maintain what he calls its unique village character and promising constituents they could always drop by his boat to argue about zoning regulations or press for a moratorium on T-shirt shops.

Like many islanders, LaPorte—who is paid $300 a month as mayor—cobbles together a living from several part-time jobs. He sells signs, runs sight-seeing charters, and collects dry cleaning, which he hauls to the mainland twice a week. "You come here because you love the environment," he says. "Then you try to figure out how to survive."

You also try to leave yourself time to look for bald eagles, which nest here in one of the densest concentrations in the lower 48 states.

The Greater Sound

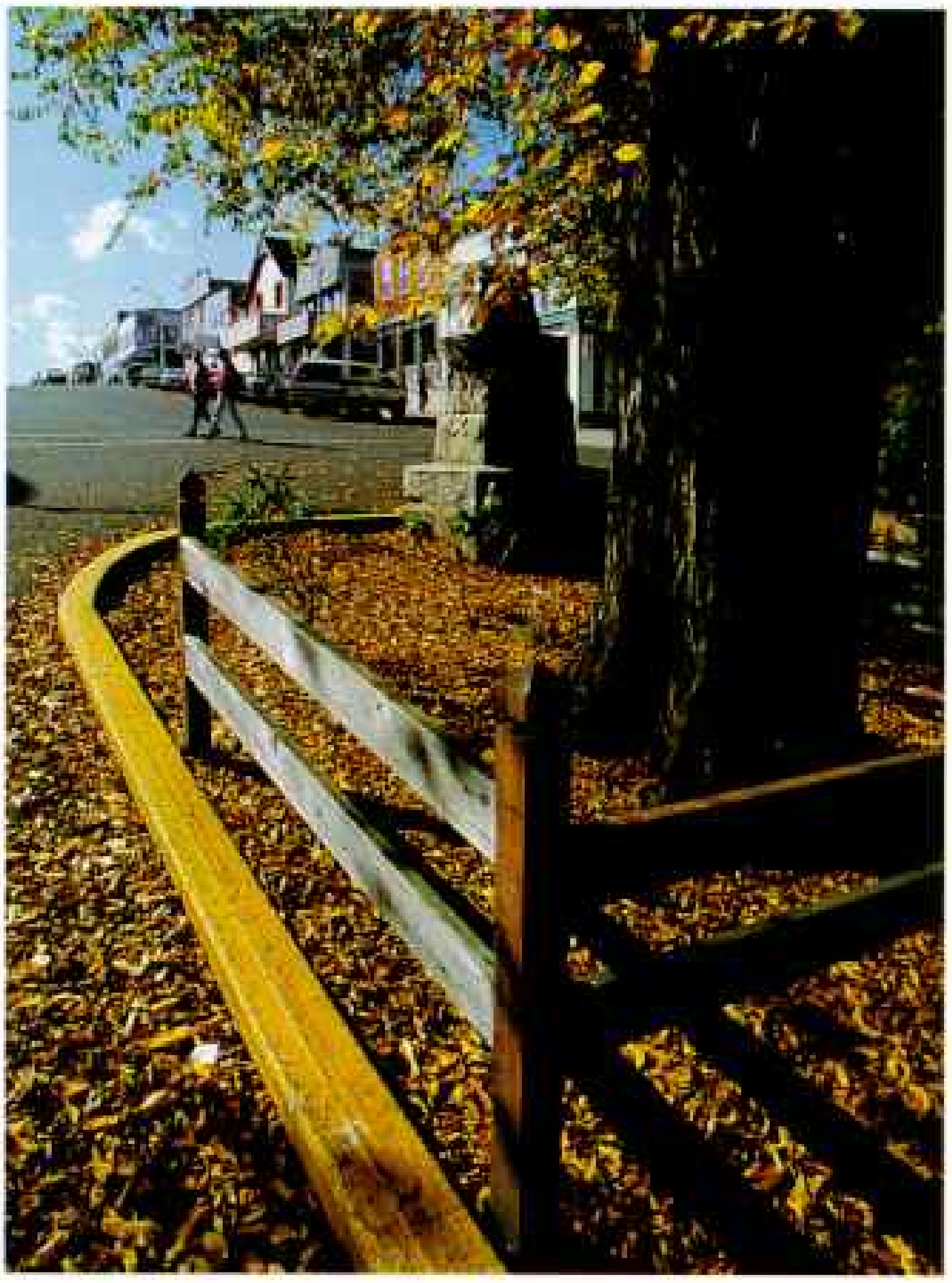
Deep, cold Puget Sound ends at Port Townsend, although most locals include the straits to the north as part of greater Puget Sound. Environmentalists want the waters around the San Juans and northern Whidbey set aside as a national marine sanctuary, with new restrictions on the transport of oil and hazardous materials.

So five minutes after I drop by unannounced one brilliant fall afternoon, we're out on the water, binoculars in hand.

We head north toward sparsely populated Stuart and Waldron Islands, then turn east toward Orcas Island, where Mount Constitution—at 2,407 feet the highest in the San Juans—rises under a thick coat of firs.

LaPorte slows the engine, and we pass the binoculars back and forth, scanning treetops for signs of an eagle nest. With none in sight he guides the boat toward tiny Jones Island, where we finally spot one of the majestic birds gliding high against the sunset sky. He cuts the engine, and we drift, watching. "Hoo-boy," he says softly, "I've died and gone to heaven."

With boatloads of summer visitors gone, leaves fall in golden peace in downtown Friday Harbor. Wary of attracting more tourists, residents entreated producers of the movie Free Willy 2 *to mask Friday Harbor's name while filming in the village.*



"EVERY PART of this country is sacred to my people," said Chief Seattle in 1854 about Puget Sound. "Every hillside, every valley, every plain and grove has been hallowed by some fond memory or some sad experience of my tribe."

Chief Seattle's Suquamish people and other tribes largely abandoned these islands under the terms of an 1855 treaty, and the Indian names were eclipsed. Spaniards, the first Europeans to see the San Juans, in the late 18th century, named San Juan and Lopez. Capt. George Vancouver led British explorers into Puget Sound proper in 1792, naming Whidbey and Vashon.

Today's explorers are tourists—officially uncounted, but at least three million a year—and new residents. They are the reason for Bill LaPorte's fear, shared by many others, that the islands are becoming too crowded. To an outsider accustomed to living in the heart of cities, it's baffling: Even with threefold and fourfold increases, how could these islands be overcrowded when the most densely populated, Bainbridge, has 17,500 people in an area the size of Manhattan?

Perhaps it's because most islanders have a bit of Norm and Toots Mills in them. Norm and Toots, both in their 80s, were born in the islands, and since 1962 they've lived two miles from Canada, on Stuart Island, with no ferry service and no phone lines. About a dozen families live on Stuart year-round; a few others come for weekends, arriving by small plane or, as I did, by private boat.

With its television, microwave oven, and other modern conveniences, the Millses' cedar house could be a middle-class home anywhere in the U. S., except that the view from the front door is a rocky blue-water cove on Haro Strait and the backyard is 37 acres of woods and pasture. Solar panels on the roof provide electricity, with a diesel generator as backup. Norm and Toots stay in touch with neighbors by cellular phone and CB radio, deciding whose turn it is to go to San Juan for supplies,

New buildings peek through a forest of masts at Bainbridge Island, where rising housing prices are forcing out much of the middle class. "It's too much of a financial sacrifice to live on the island," says police chief John Sutton. Like 14 of his 17 officers, the chief commutes from the mainland. On Whidbey Island, white is de rigueur at the annual Useless Bay Croquet Club Invitational (right). Many of the contestants are retired, but they're not playing to relax. "It's a vicious game," says Neil Rabitoy, a former history professor who plays or practices every day, weather permitting. "It takes me a long time to calm down after a match."

a 20-minute boat trip in benign weather.

Not that they need much from the store. Their orchard and garden keep them in fruits and vegetables—if Norm and his shotgun can keep out the raiding mink and raccoons—and a reef net provides them with salmon.

But self-sufficiency has its risks. "I worry about her," Norm whispers when Toots leaves the room. "The chopper had to come get her twice over the winter." Like most residents of the San Juans, the Millses pay a hundred dollars a year for air-ambulance insurance, which covers an unlimited number of trips to emergency rooms at several mainland hospitals. Still, it's at least an hour between dialing help and arriving at the hospital.

Stuart is no place for invalids. Few islands in Puget Sound and the northern straits are; rough around the edges, they make demands of those who choose them. Recent arrivals Richard and Sharon Hooper are part of a new wave, determined to use technology to smooth out the edges. They moved their recording business, World Disc Productions, from Monterey, California, to San Juan six years ago "once we realized we could live anywhere," says Sharon. "All we needed was our computers and fax machines and a post office."

Now the Hoopers employ 30 people in a modern two-story cedar-and-glass building on the outskirts of Friday Harbor. Their expenses are about 5 percent higher than they were in California, mostly from increased shipping and travel costs. "That's not much when you weigh it against the improvement in our quality of life," says Richard. "We have a house in the woods, and I'm still awed when I hear the cry of a red-tailed hawk."

Other small companies connected to the world by computer are following the Hoopers' lead: After all, if you can run your business from anywhere, why not pick paradise?

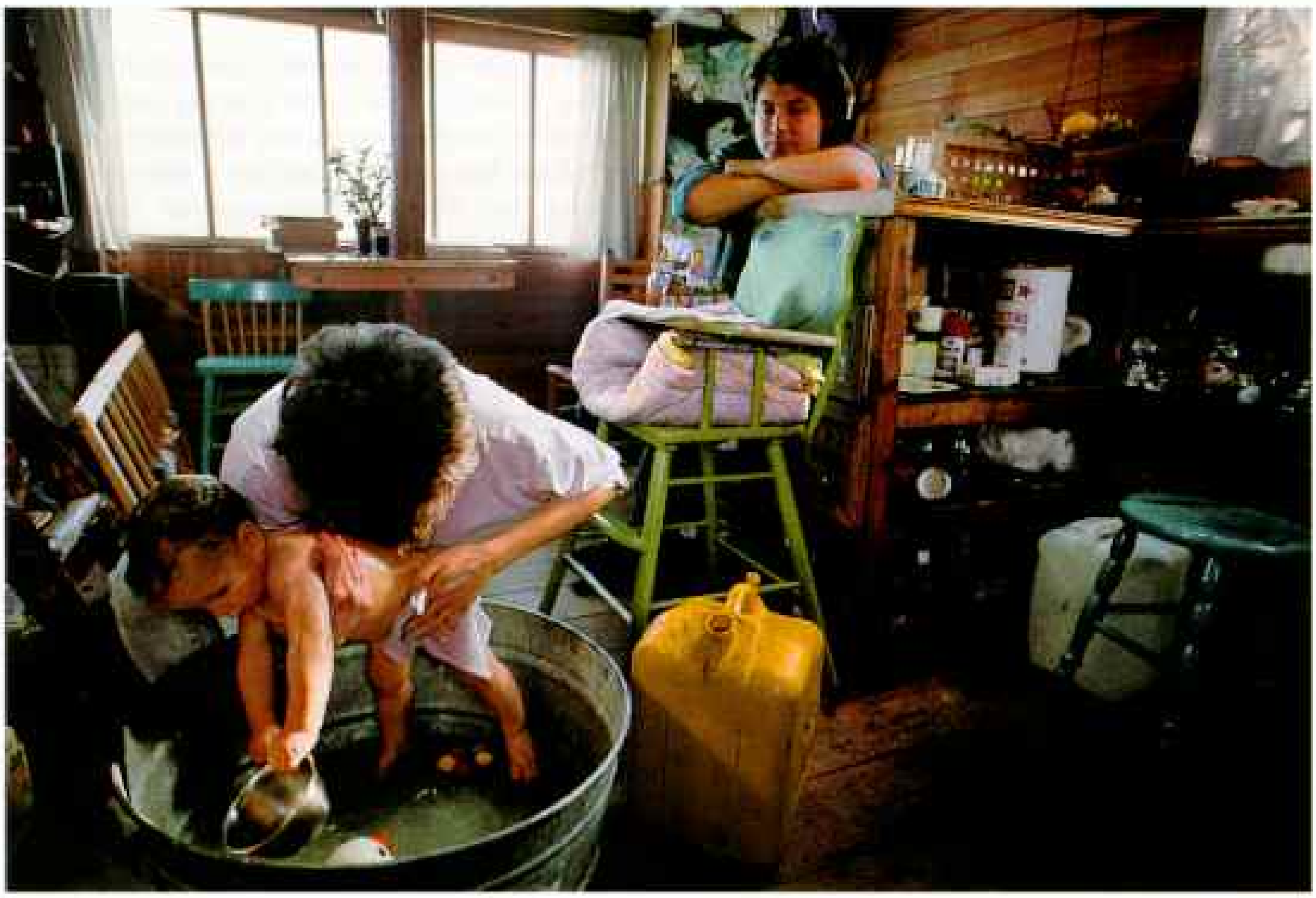
THAT'S A QUESTION that sticks in Stanley Bennett's craw. "The first place Californians ruined was southern Oregon," he says, his blue eyes full of dismay. "Twenty years later they moved here and helped ruin this place."

He and Wanda, his wife, retired 17 years ago to Whidbey Island—a 45-mile-long crooked string bean of land that is less crowded than Bainbridge and less raw than the San Juans. "It was really rural when we moved here," says Stanley. "But these newcomers are citifying the rural atmosphere." They're also citifying prices. With profits from real estate booms in California, Portland, and Seattle, new arrivals have bid up the price of housing from Bainbridge through the San Juans, more than doubling taxes for islanders who bought their property a decade ago.

The naval air station near Oak Harbor, 15 miles north of the Bennetts, is adding to the pressure to grow. Once slated for closing, NAS Whidbey Island is now bulging at the seams. There isn't enough base housing for everyone, and off-base housing on Whidbey is often too expensive for Navy allowances—so some Navy families live as far away as Mount Vernon, a mainland city 40 minutes by car over the island's only bridge.

More serious than the lack of affordable housing is the lack of water. On north Whidbey the city of Oak Harbor and the air base have enough drinking water only because the city pipes it in from the Skagit River on the mainland. Coupeville, a central Whidbey town that draws water from rain-fed aquifers, has halted new development because some wells, overtapped by the growing population, have run too low.

Throughout the islands, water shortages are an ironic by-product of the appeal of a life surrounded by water. The San Juans, and



Home is where the boat is for Bob Speers of Friday Harbor, whose fleet surrounds his dwelling. Live-aboards are more plentiful in Bainbridge Island's Eagle Harbor, where Mike and Anthea Martin are raising their son, Braven (bottom left), on the 400-square-foot Wicca. Mike and Anthea haul 50 gallons of water each week from the town marina, a ten-minute trip by rowboat. "Some of the landowners want to get rid of us," says Mike. "But if they do, I'm afraid this world is going to be all alike, nothing unique, no individuality."

most of Whidbey, lie in a rain shadow created by the Olympic Mountains and get only half Seattle's 38 inches of rain a year. That rain is precious: Aquifers, and the occasional rain-catch device jury-rigged onto a rooftop, are the primary sources of water. Last spring, after two years of drought, low water levels in Friday Harbor's reservoir forced the town to restrict new water hookups.

Many islanders blame developers for the increased competition for water, as well as for what they see as a general environmental decline. Some contractors try to meet environmental demands halfway, burying utility lines and cutting water use in their projects. This give-and-take grows out of what Bob Olson, then president of the Useless Bay Development Corporation in south Whidbey, calls the supermarket factor. "You can't stay mad at anyone around here for very long, because you'll probably run into them at the grocery store the next day." Thrown together on an island, unable to avoid one another, opponents stumble toward compromise.

BUT JUST HOW MUCH compromise can the islands take? That's the concern of animal behaviorist Bob Otis, who for six seasons has come to study killer whales, or orcas—the unofficial mascot of the San Juan Islands.

Three resident pods of orcas, each with its own dialect of sounds, cruise Haro Strait between San Juan and Vancouver Islands from April to September, looking to intercept salmon headed back to the Fraser River to spawn. As the orcas chase the salmon, boatloads of tourists chase the orcas.

Bob, a professor at Wisconsin's Ripon College, sets up a lab each summer in an old lighthouse in San Juan's Lime Kiln Point State Park—"the best place in the world to watch killer whales from land." The whale pods, named J, K, and L, pass as close as 20 feet to the lab. Variations in dorsal fins and a distinctive saddle-patch pattern of black-and-white markings allow the researchers to recognize each of the 93 orcas in the three pods, referring to them with numbers designated by the locally based Center for Whale Research.

Nationally the orca's popularity has exploded over the past two years as a result of the movie *Free Willy*—the story, filmed in part in the San Juans, of a captive orca returned to the wild. At the Whale Museum in Friday Harbor, visitors snap up orca earrings and coffee cups along with memberships in the Adopt-an-Orca program, which increased from 3,000 to 50,000 after it was touted in the *Free Willy* home video.

On the June day that I join Bob and assistant Vicki Zimmerman, a nearby resident calls to report that whales are moving in our direction. Most days just one pod passes by the point, but a few times every summer the three pods come together in a superpod—mingling, probably mating, and squeaking and squealing loudly enough to be heard onshore.

We head out to the rocks, where it soon becomes apparent that we're going to be lucky. "There's K-17!" says Bob, pointing to a whale 50 feet offshore. "And L-41. There's J-6. They're all here!" So are boats filled with whale-watchers, seemingly out of nowhere.

For more than an hour the whales—concentrated in front of us, as if our post on the

Espresso is served inside, *but a damp wind is Bridget Brillault's real wake-up call on the 6 a.m. ferry from Friday Harbor to Anacortes. Autumn fog follows summer's cloudless skies, grounding planes,*

shrouding houses, and forcing ferry captains to rely on radar. The mist scares off many who would call the San Juans home: Says a resident of Orcas Island, "This is when we see who'll make it through the year."

Vicenta Shepard and Elvira Dimario ease seed mussels into net socks at Penn Cove Mussels, Inc., off Whidbey Island, where some 200,000 bivalves are harvested on a typical day. In Bainbridge Island's Eagle Harbor (right) shellfish are off-limits. A fire hose mounted on a tugboat washes clean sediment overboard from a barge to cover toxics left in the harbor by a now closed creosote plant. When will shellfish here be safe to eat? "It could be 20 years," says cleanup director Elly Hale. "And it could be 150."

rocks were a reviewing stand—dance in an unchoreographed ballet. Some pop their heads straight up out of the water, then submerge, a move whale specialists call spyhopping; others breach, then hurl themselves on their sides with a huge splash.

After the orcas swim off, Vicki says she counted 25 boats—a lot for a weekday early in the tourist season but far short of the one-day record of 64 set July 3, 1993. "I haven't found any evidence that the boats harm the whales or alter their behavior," says Bob. "But if the number continues to grow at the current pace, by the year 2001 we'll have solid boats" —leaving the orcas no room to come up for air, to say nothing of breaching and spyhopping.

MANY of the whale-watching boats are converted fishing vessels, evidence that the economy of the islands has strayed from its traditional bases of fishing and farming. Salmon gillnetters, purse seiners, and reef netters could once make a living by fishing all summer—could even, in exceptional cases, pay a year's bills from one day's catch. Those times are gone, probably forever.

Some Pacific salmon runs have been reduced by 90 percent or more, largely because of overfishing, sediment buildup, and the destruction of habitat by dams and reservoirs. As a conservation measure the state virtually eliminated commercial harvests of chinook and coho last year and severely limited catches of sockeye, chum, and pink salmon. Fishermen had to call a hot line to learn exactly where and when they could harvest.

The new limitations have sliced into the income of people like Jim and Lisa Lawrence, who live on San Juan Island and fish off the island's west side. They depend on earnings from the summer's salmon catch to subsidize their work as artists: Jim carves wooden masks and makes silver jewelry, and Lisa's bright oil paintings are a mainstay in Friday Harbor's most prominent gallery. Now, says Lisa, they

fear that rising real estate prices and waning salmon runs could eventually mean the end of a lifestyle that has supported their principal work for two decades.

Something less tangible than art is lost with the decline of salmon: the spiritual connection islanders have with their land and its waters. "Fishing makes me feel part of the islands," says Jim, a strapping man with a graying ponytail who moved here from Seattle in the early 1970s. "Of course, I'm related to the rocks and the trees here by marrying Lisa. Her people have been in these islands for thousands of years."

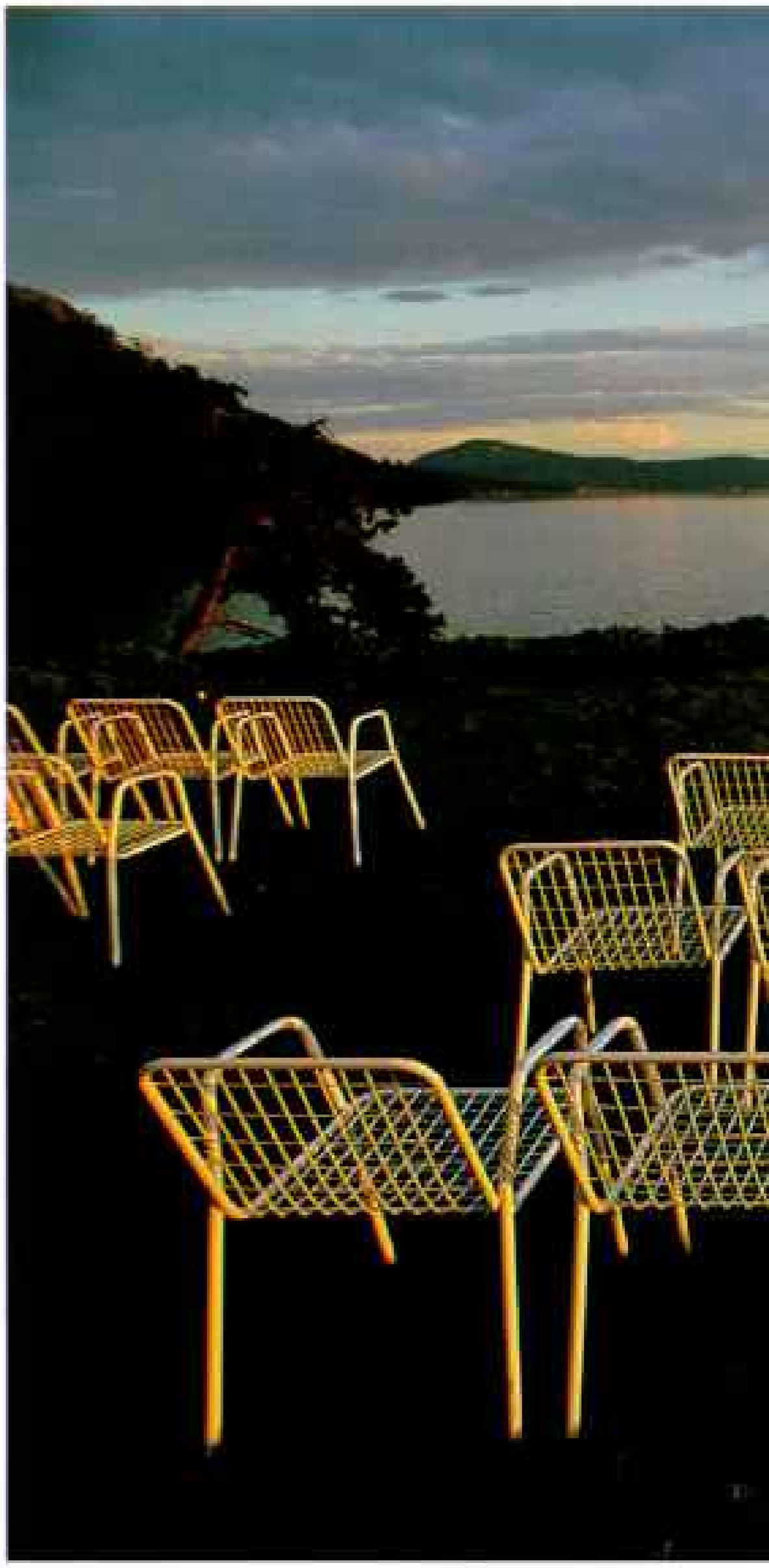
Lisa, a blue-eyed strawberry blonde, is part Swinomish Indian, so the Lawrences are among the beneficiaries of a 1974 federal district court ruling granting half the annual local salmon catch to Native Americans. The decision reaffirmed fishing rights guaranteed in the 1855 treaty in exchange for Indian lands.

But these days the largest salmon haul in the islands—3,000 tons a year—goes to a BMW-driving Norwegian businessman who grows his salmon in pens off Bainbridge and has been salmon fishing exactly once in his life. Adding insult to injury, his fish aren't even Pacific salmon. They're the Atlantic variety, which grow larger in captivity.

SALMON aren't the only form of marine life suffering in the sound. In some urban harbors bottom fishing for flounder, sole, and sand dabs is discouraged because of contaminants from factories, pulp mills, and sewage-treatment plants. Rotting pilings and abandoned cranes at the entrance to Eagle Harbor on Bainbridge were once the arms and legs of the Wyckoff creosote plant, which spent 80 years turning timber into railroad ties and telephone poles coated with the tarry substance. The plant closed in 1988 and is now a Superfund site; the Environmental Protection Agency has already spent two million dollars in an effort to blanket the creosote-soaked harbor floor with a protective layer of sediment. Warning signs are posted nearby in English, Spanish, Lao, Cambodian, Chinese, Korean, and Vietnamese: "Bottom fish, crabs, and shellfish may be unsafe to eat due to pollution."

Throughout the islands, tidelands once rich with shellfish beds are closed to harvesting, their waters sullied by runoff from streets and parking lots, agricultural wastes, leaking septic tanks, and sewage and oil from small boats.

The dwindling marine stocks mean that fewer and fewer islanders can support themselves entirely from the water. But others are trying, in the face of some opposition, to



Sunset sky caps an outdoor cathedral at Orcas Island's Rosario Point, frequent site of weddings and parties. Natural beauty has attracted scores of painters, sculptors, and writers to the islands. "Life here is soulful," says Michael Boyd, a tilemaker and co-founder of the Artworks Gallery. "You have a chance to get to know yourself."

harvest the sea in ways that match island traditions without depleting local resources.

"To make a living off the water you either fish it—and we've totally squandered that—you use it for transport, or you try to farm it, either salmon or shellfish," says Ian Jefferds, the wiry young president of Penn Cove Mussels, Inc. The Coupeville-based company, the largest mussel farm in the Northwest, grows mussels off the coast of central Whidbey on 25 rafts that look like diminutive aircraft carriers: flat-topped, low in the water, and lined up with military precision under a bluff to blunt winter winds that lash the mile-long cove.

"We fit the marine heritage that the islands are trying to maintain," Ian says above the squawk of seagulls outside his office, a small gray building at the end of a pier that once served as a farmer's dock. His company raises only mussels native to the cove, and regular tests show that these natural filters keep the water clean. Still, Ian has had angry words from homeowners on the surrounding bluffs who say the mussel rafts ruin their view.

The battle of aesthetics versus economics comes up again and again. Last spring the 16 Native American tribes in the Puget Sound area went to court to force a settlement similar to the 1974 salmon decision. Last December they won their case; a federal judge awarded them rights to 50 percent of the harvest of all local shellfish.

Shellfish farmers and many local landowners vowed to appeal. "There'll be fireworks if the Indians get rights to private tidal lands," says Ian Jefferds. Most of Washington's tidal flats (the area between the mean low-water and high-water lines) are privately owned, and beachfront homeowners fear that, as a Whidbey resident put it, "you'll find people digging in your front yard anytime of the day or night."

But Tony Forsman, executive director of the Suquamish tribe, says such concerns are overblown. "You can plan ahead—this beach on this date, that beach on that date," he says. "Tribal members won't be able to just pick up their clam forks and hit the beach whenever they need a few bucks."

When pressed on why he thinks the issue raises tempers, Forsman is quick to answer: "The idea that private property is sacred is nationwide, but it's especially strong out here."

PARADOXICALLY, the insistence of local property owners that they may do as they wish with their own land may be as much a force for conservation as for development.

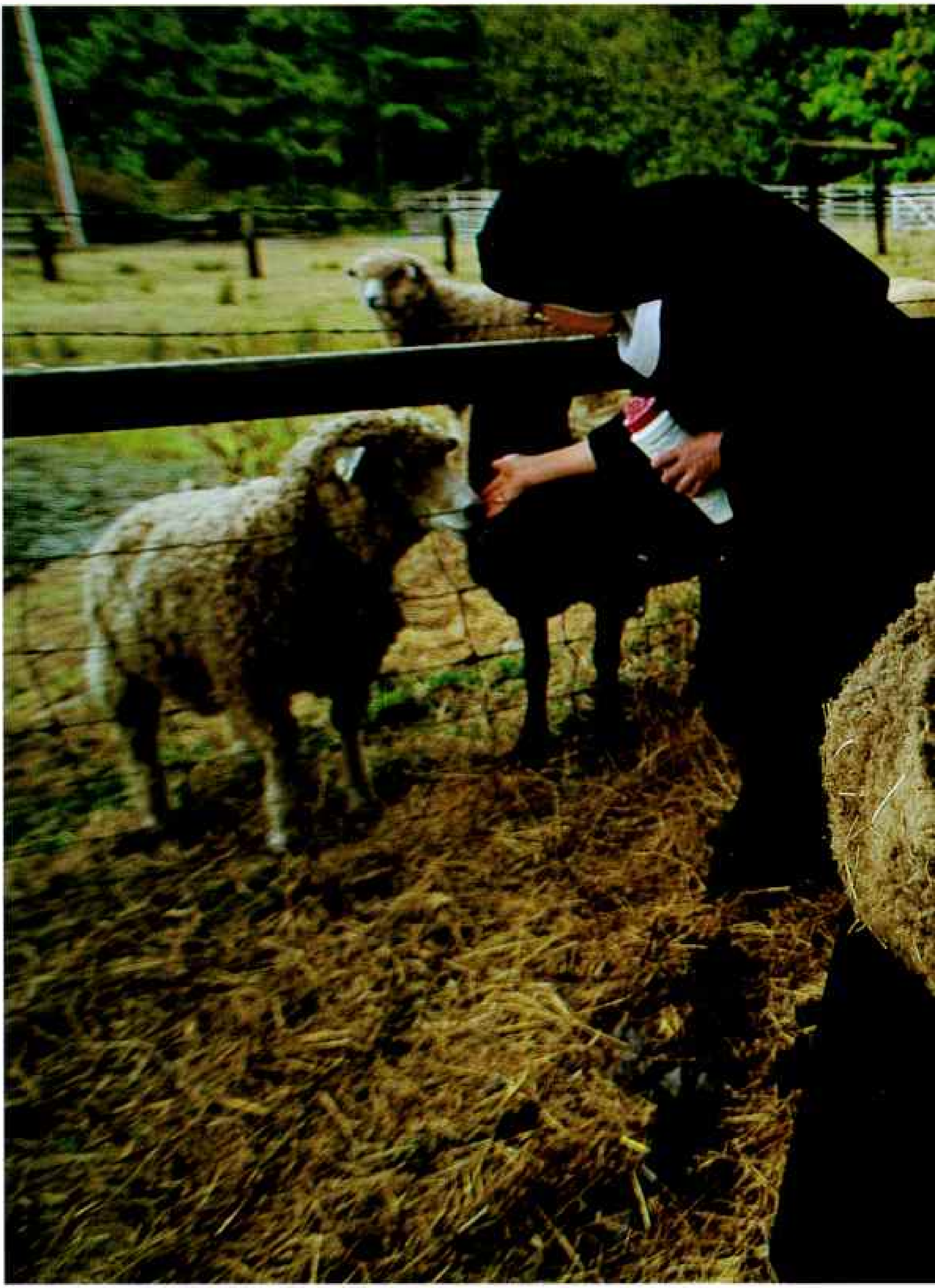
"These islands aren't really rural anymore," Bob Myhr says as we tour Lopez Island, flat and dry, in his 1977 Volkswagen

convertible. Farms and orchards began disappearing from the San Juans in the 1940s as Washington's Yakima Valley became more competitive. "What's valuable here now," he says, "is the *appearance* of rural."

Myhr runs the nonprofit San Juan Preservation Trust, working to preserve the islands' bucolic look by persuading landowners to forfeit their land's development rights—and earn a tax break in the process. Landowners place conservation easements on their property and name Myhr's group as trustee. Such easements, attached to the deed in perpetuity, ensure that no matter who buys the land, or when, it will never be covered with shopping malls or tract housing. The trust, founded in 1979, now administers easements covering more than 6,000 acres in the San Juans.

A similar, more ambitious project—the 17,000-acre Ebey's Landing National Historical Reserve—protects forest and farmland in the heart of Whidbey Island. Fifteen years ago local conservation groups, alarmed that the land might be sold to developers, persuaded the federal government to put aside money to buy conservation easements to the thousand-acre Ebey's Prairie, leaving the land itself in the hands of the farmers.

Today the prairie anchors the national historical reserve, the first of its kind in the nation. It includes two state parks and the entire town of Coupeville—stores, farms, houses,



Tending her flock, *Mother Hildegard George checks for parasites at Our Lady of the Rock Monastery on Shaw Island, home to 163 full-time residents. Mother Therese, giving an approving pat to another lamb in*

the background, oversees the farm, where seven nuns raise cattle, sheep, llamas, and a variety of fowl. "Working with these creatures," she says, "opens up different aspects of the mystery of God."

Sailboat and ferry glide across Puget Sound beneath Mount Rainier, symbol of the Northwest's good life. Islanders who have fled growth elsewhere fear it will follow them. Says Vashon Island architect Art Skolnik, a Chicago native, "If we can't make it work here, what's left? There's no place else to go."

schools, and a historic waterfront awash with brightly colored wood-frame buildings.

I take in the full sweep of the reserve from the top of a sand bluff, 300 feet above the surf at Ebey's Landing. Amid wild roses I look out on barns scattered among the neat furrows like children's blocks. Mountains rim the horizon on three sides. The lights of Seattle glow in the dusky sky to the south—glimmers of a busy mainland life that seems far, far away.

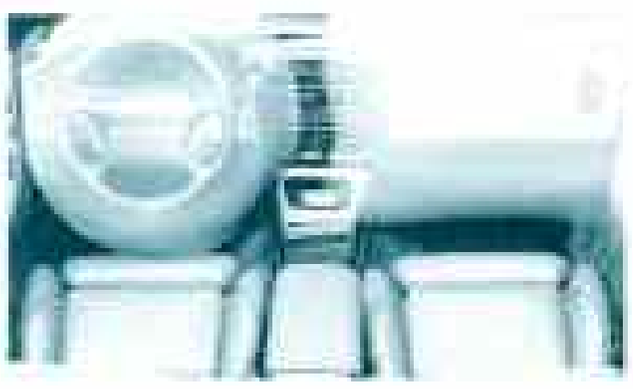
I HEADED BACK to the mainland the way I had come—through Bainbridge Island, scorned by residents of Whidbey and the San Juans as an example of development run amuck. Here the questions I heard throughout the islands are most urgent: Do people who have found paradise have the right to pull up the drawbridge? Can new arrivals, many of them wealthy, leave room for long-time residents? How do islanders live productively without destroying the very way of life they came here for?

On the west side of Bainbridge, away from crowded harbors, a few farms and chunks of forest remain, including an amphitheater of trees that surround the serene gardens on land tilled by Junkoh Harui's family since the early 1900s. The family had a prosperous nursery, extensive gardens, and a large grocery store until they were summarily evacuated during World War II, along with everyone else of Japanese descent on the islands.

When the family returned five years later, the greenhouses had collapsed, the sunken garden was overgrown, and most of the nursery plants had been stolen. One of the few plots remaining intact sprouted with dozens of small red-pine seedlings that Junkoh's father had hastily planted in the surrounding woods, where the young plants might have enough shade to survive.

"My parents had what is called *gaman*—inner strength, the strength to persevere," Junkoh says quietly, pausing on the wooden bridge leading into the forest, where the red pines now soar 60 feet. "It's a great legacy for us." It's a legacy for these islands as well, a gift of renewal and respect for the land and the sea and the dreams that are lived here. □

*Always wear your safety belt. †Based on an average of consumer-reported problems at three months ownership in a survey of Ford and competitive models designed and built in North America.



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All-new Control Trac 4-wheel drive provides instant traction control automatically.

It Already Offered The Whole Kit And Caboodle. So Now, We've Added The Whole Shebang.

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New SLA suspension and rack-and-pinion steering for a smoother ride and excellent handling.

Free 24-Hour Roadside Assistance for 3 years/36,000 miles. See dealer for details.

*Explorer has the highest quality of any American compact sport utility.***

Comfortable new interior has more room than any top-selling compact sport utility.

Introducing The New Ford Explorer.

100,000 miles of carefree driving before first recommended tune-up with standard V-6 engine.

Security and comfort come from new adjustable-height front belts.

Ford

THE BEST NEVER REST

> “This isn't just some business computer with a few **education** features bolted on. This is the **learning** tool of the future.

Our team built the very first Power Macintosh for education. Our objective: to give educators and students unprecedented power, for an affordable price.

Along the way, we also added a lot of education-specific features. For example, we added a tilt-and-swivel monitor, adjustable for kids of different heights. We added video-out, so teachers can hook their Mac up to a projection screen for more exciting presentations. And we added the option of video-in, which lets students capture video images and use them to put together really dynamic multimedia projects.

Not long ago I brought the prototype Power Mac home for my daughter. The neighborhood kids all came over to use it. They turned it on, started exploring. You could just see their eyes light up. You watch that, and you realize you're really doing something right. It's something that we can all be proud of.”

—H.L. Cheung

V.P. and head engineer of the Apple product group that designed the new Power Macintosh® 5200/75 LC.

• Quicktime makes high-resolution graphics, animation, stereo sound and CD-ROM drive are all included.

• The new all-in-one design features an expanded 15" color display, with a special tilt-and-swivel monitor.

• It's new PCI-compliant, PowerPC-chip offers radically enhanced performance, for more realistic graphics, video and animation.

• Even though it's a Mac,® it also runs DOS and Windows software up to 486 speed.

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For more information, call an Apple education representative at **800-800-APPL**, *or contact us over the Internet at* **http://www.info.apple.com/education**

At Apple, we design our computers specifically for the needs of education. We design them to be powerful enough to prepare high school students for the technology they'll encounter in the future. Yet we also design them to be easy enough for a first grader to use.

We design our computers to run all of the Macintosh® programs schools are already using, and we design them to run a whole new family of enhanced software that makes graphics, video and animation even more lifelike and exciting.

At Apple, we design our computers by listening. To students, to teachers, to administrators — and providing the kinds of solutions they can use.

It's this attention to the unique requirements of the learning environment that's made us the number one computer in schools today. And it's a commitment to education you'll find only with Apple.

We don't just want to make computers. We want to make a difference.

Apple

Ms. Gonzalez's Geography Class Has Gone To Pieces.

In an exercise, Marty Gonzalez places her sixth grade geography students in groups to decorate clay pots. Carefully the students paint animals, plants, and landscapes that portray geographic cultures. Afterwards, students proudly submit each of their creations which are put into individual brown bags. Then Ms. Gonzalez does the only natural thing left to do. She pounds each bag with a hammer, shattering the contents. Only to hand the bags over to different groups of students who face the task of rebuilding the pots and explaining the culture depicted on them.

In effect, the kids become archeologists. But this lesson does more than teach the children the rigors of being an archeologist. They learn how studying archeological artifacts is important in learning the history of a land and the people who lived there.

For her creative approach to teaching, State Farm is pleased to honor Ms. Gonzalez with the Good Neighbor Award and donate $5,000 in her name to Morris Elementary in Cypress, California.

STATE FARM INSURANCE

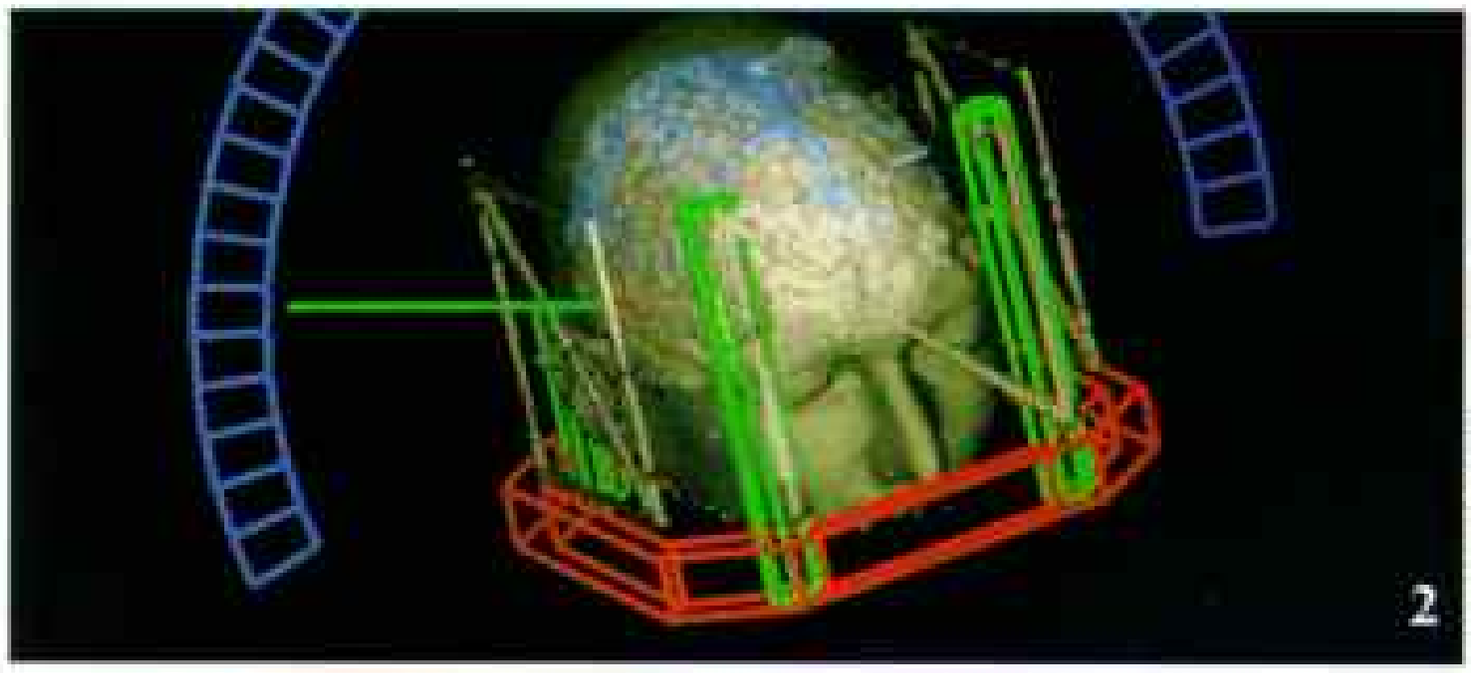
Good Neighbor Award

STATE FARM INSURANCE COMPANIES
Home Offices: Bloomington, Illinois

The Good Neighbor Award was developed in cooperation with the National Council for Geographic Education.

NATIONAL GEOGRAPHIC

JUNE 1995



The Cover

Dye-enhanced blood courses through vessels in a living human brain—as revealed in this angiogram at the University of Virginia Medical Center.

Photograph by Joe McNally.

Geographica

ANNIE GRIFFITHS BELT

A High and Mighty Cathedral Job

Going to great heights, mason foreman Joseph Alonso helps preserve a masterpiece: Washington National Cathedral in Washington, D. C. (NATIONAL GEOGRAPHIC, April 1980).

Begun in 1907 and not completed until 1990, the cathedral was constructed of Indiana limestone in the 14th-century English Gothic style—and in the painstaking, traditional way. Legions of sculptors, metalsmiths, masons, and stained-glass artists plied their crafts; artisans carved the gargoyles, grotesques, and finials, such as this one (left) atop the southeast pinnacle on the central tower, finished in 1964.

But nature delivers a pounding to the exterior, notably this tower, which at 676 feet above sea level tops all other buildings in the capital. "It's brutal up there," says Alonso. The tower is often buffeted by gale-force winds, battered by lightning, and drenched by thousands of gallons of water an hour during a driving rain. Water has seeped through gutters to damage interior ceilings. Mortar joining blocks of stone has deteriorated, and cracks have appeared in the stone itself. Pointing to an angel, Alonso says, "See how flecks of stone come off when you touch it?"

To halt and reverse the damage, workers dangle from the pinnacles to replace the mortar, often using silicone caulk that expands and contracts as temperatures change. They are also replacing cracked stones, doubling the tower's lightning-arresting capacity, and relining gutters to make the building watertight. "This isn't an office building that's going to be torn down in 30 years," Alonso says. "This is here for the ages."

Do Birds Renew Their Brains Each Year?

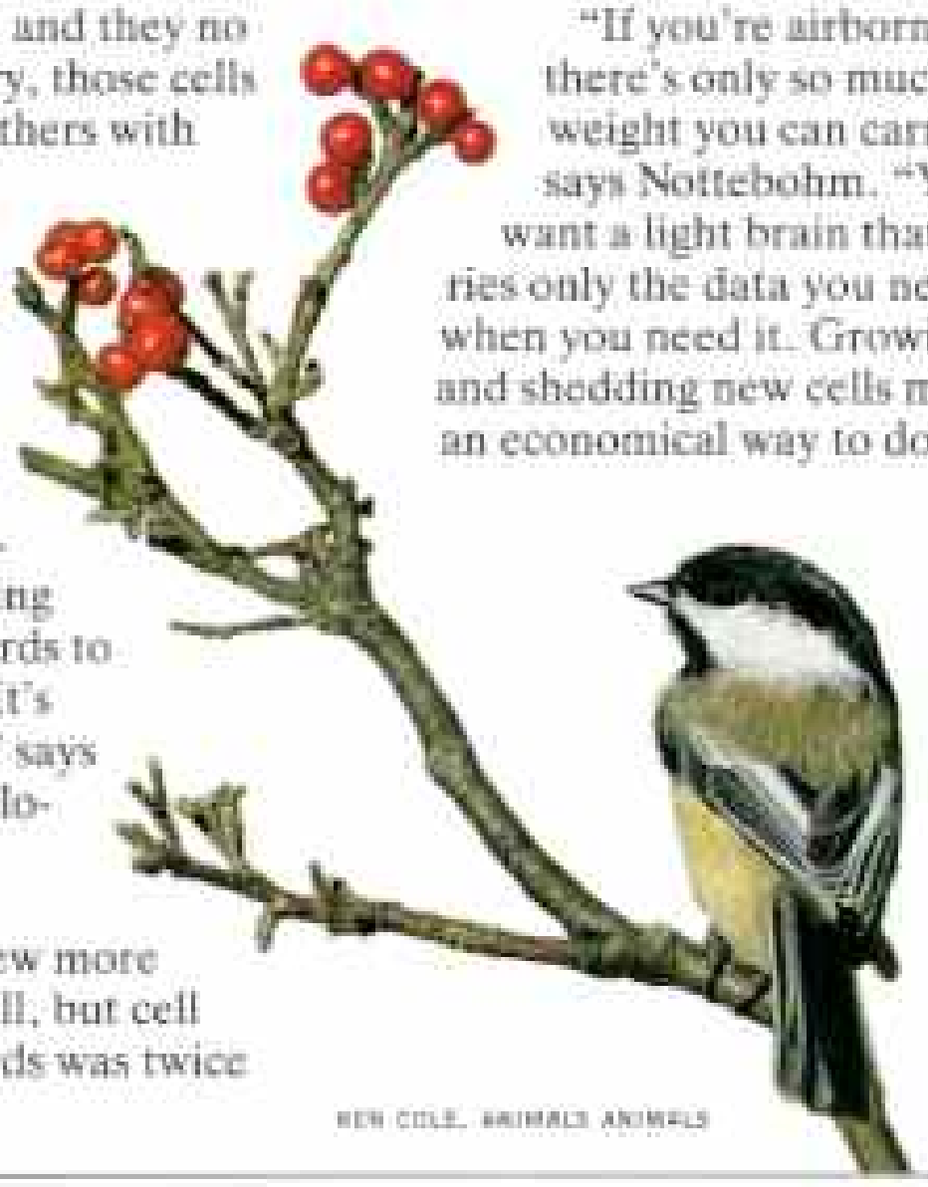
At summer's end black-capped chickadees stash hundreds of seeds and dead insects everywhere in the forest from the ground to the treetops. At the same time, as studies by Fernando Nottebohm and Anat Barnea of Rockefeller University show, the birds actually grow new brain cells. The regeneration occurs in the hippocampus, an area of the brain dealing with spatial memory, among other things. (See "Quiet Miracles of the Brain," pages 2-41.)

Coincidence? Nottebohm thinks not. His hypothesis, still being tested, is that chickadees grow cells that help them recall where they've cached their food. Then when the food has been retrieved and they no longer need this memory, those cells die, to be replaced by others with other purposes.

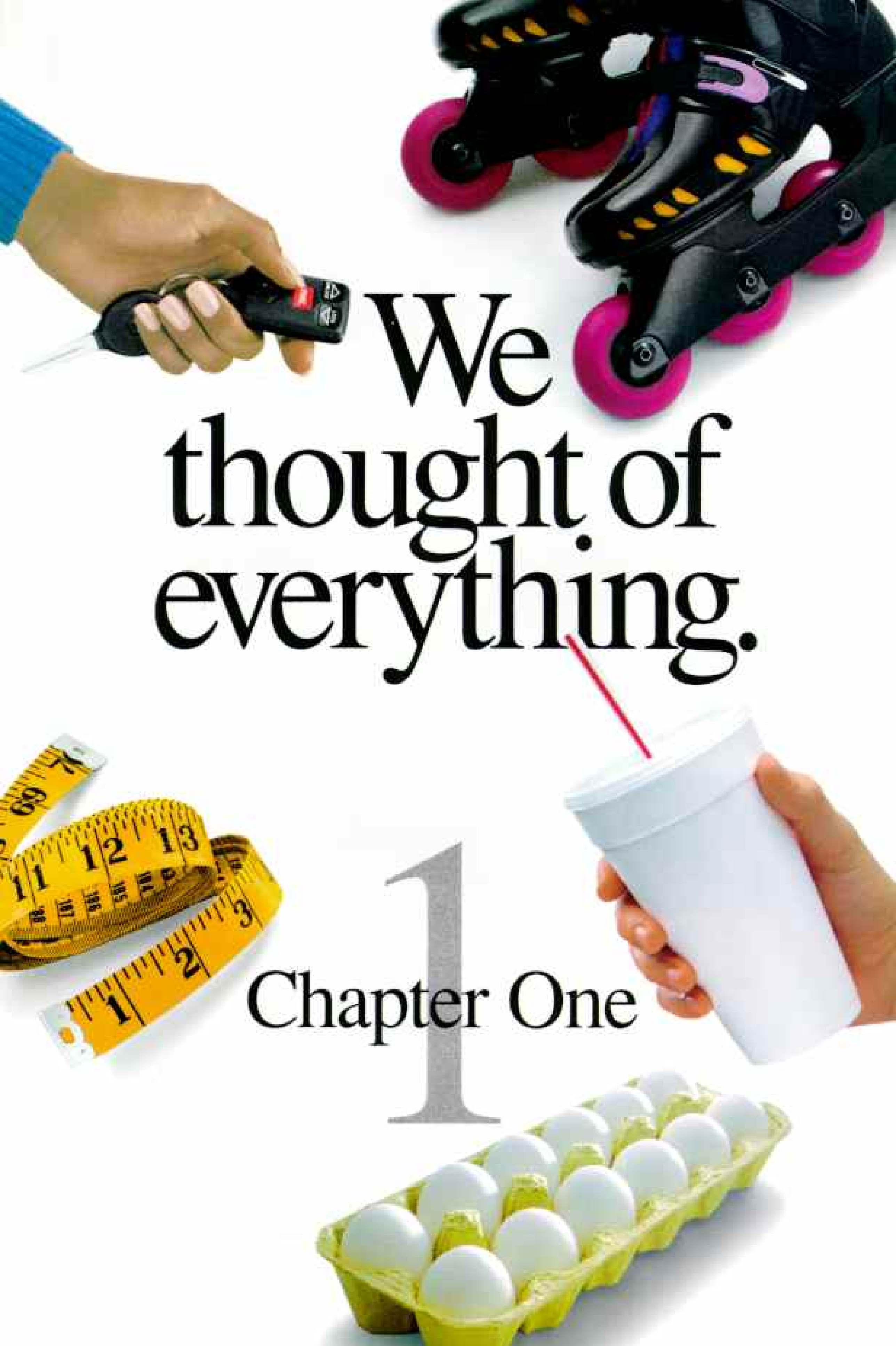
The researchers proved that cells grow in significantly greater numbers in the fall by injecting wild birds at different times of the year with a radioactive cell marker, freeing and later recapturing birds to examine brain tissue. "It's constant rejuvenation," says Nottebohm, a neurobiologist. "These birds are updating their brains."

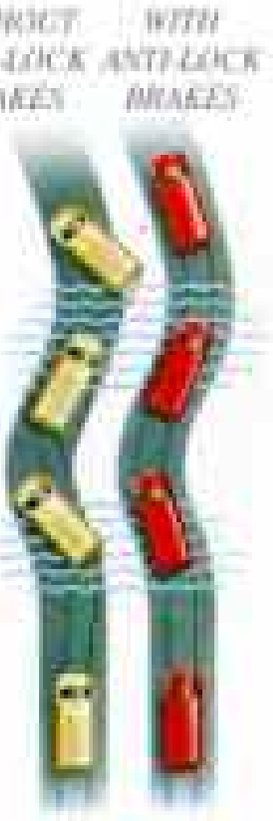
Captive birds also grew more new brain cells in the fall, but cell birth in free-ranging birds was twice as high.

"If you're airborne, there's only so much weight you can carry," says Nottebohm. "You want a light brain that carries only the data you need when you need it. Growing and shedding new cells may be an economical way to do it."



KEN COLE, ANIMALS ANIMALS


We
thought of
everything.
Chapter One



Anti-lock brakes help you brake and steer your way out of danger. And now we made them standard equipment on most models.

We moved the wheels farther apart, front and rear. Which gives the new Caravan even more stability.

Ultra-high strength steel door beams and front and rear crumple zones are part of the new Caravan's energy management system, which helps protect occupants from the force of an impact.

The new Caravan offers a personal alarm system that you can turn on or off by remote control.

There's room for 28 2x4s under the back seats. Plus we made the liftgate easier to lift and to close.

It's so easy to deploy the wheels on our rear benches, you can do it with one hand tied behind your back.

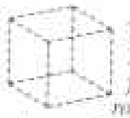
The wheels on our Easy Out Roller Seats™ pop down like landing gear.

The new Caravan thoughtfully comes with both a driver and a front passenger airbag, standard equipment.

We know safety is important to you. So to help protect you and your family, the new Caravan exceeds 1998 car safety standards.*

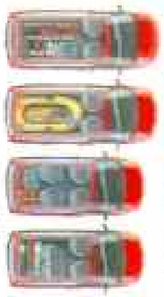
The new Caravan offers 12 cubbyholes, nooks, crannies and storage bins. So when you need to reach for a tissue, it's always close at hand.

We've made adjustments for everyone. The front passenger seat, for instance, adjusts 8".



There's 34 cubic feet more room inside the new Caravan. You'll enjoy discovering where we put it.

Our new single buckle system makes our available integrated child safety seats more convenient for parents.



It's a perfect foursome. And since the new Caravan comes in two sizes, it fits families of all sizes.

Here's a new option – heaters for the front and rear wipers that help melt away ice and snow.

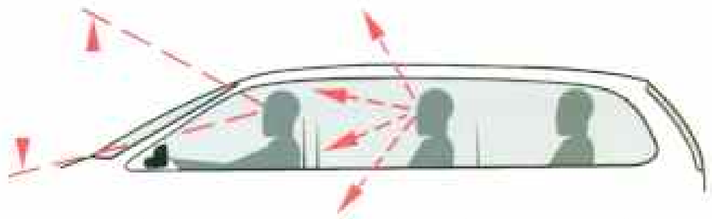
In our Deluxe Seating Package, the middle bench reclines 36° and the rear bench almost all the way back. And all seats are fine-tuned to minimize fatigue.

Just as original as the original.™

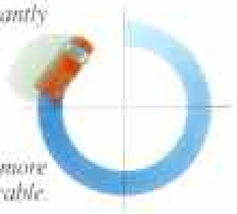
We offer a sliding door on the driver's side, as well.

As an option, you can fold the seats flat. And in our Grand Caravan, you can carry a 4x8 sheet of plywood with the liftgate closed.

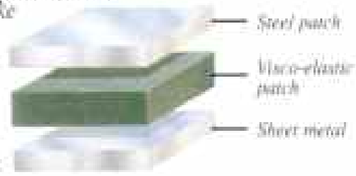
The new Caravan offers you up to 14 places to set a cup of coffee, a can of pop or a juice box. Even Big Gulps®.



It provides a dramatically improved overhead view and view of the road, up front. Plus a panoramic view out the side windows for everyone in back.



A significantly smaller turning circle makes the new Caravan more maneuverable.



We used sound-deadening techniques, like this patch constrained layer, to create the quietest Caravan ever.

The new Caravan offers separate air and heating temperature controls for both front passengers. The two of you will thank us.

For more options, select a pair of our Quad Command Seats. Because they fold flat, you get a set of tables in the bargain.

100000

Our available 3.3L and 3.8L V-6s are so advanced they can run 100,000 miles before a scheduled tune-up.

Grand Caravan LE

Introducing The New Dodge Caravan.

We think you'll agree, we thought of everything. But if you can think of anything else you'd like to know, call 1-800-4-A-DODGE. And we'll send you all kinds of information.

The New Dodge Caravan

Just as original as the original.™

Always wear your seat belt.
**Excludes sunscreen glass. Big Gulp® is a registered trademark of The Southland Corporation.*

Geographica

A Magazine, the KGB, and a Secret Message

In a building behind its Moscow headquarters, the KGB created a museum of spy craft. Under photos of such Soviet agents as the British turncoat Kim Philby and atomic bomb spy Klaus Fuchs are displayed tools of captured Western agents, such as tiny cameras and tablets that make invisible ink. Here also is a poison-tipped suicide needle said to have been carried by Francis Gary Powers, pilot of the U-2 spy plane downed in 1960.

And here too is a unique copy of the February 1983 NATIONAL GEOGRAPHIC.

Unknown to the Society, someone etched a micro-message into the black borders around several ads and features (below). Under high-power magnification, the message specifies where and how to leave a package and to make contact. "Wait ten minutes only," it reads (left). "Our representative will say. . . ."

Once the private domain of KGB operatives, the museum today belongs to the Russian FSK, or federal counter-intelligence service. It is open only to visitors who apply in writing.

DETAIL AT LEFT

On Assignment

CHARLES O'REAR

According to a museum curator, the doctored magazine was given to a Soviet intelligence officer, Col. Vladimir Mikhailovich Vasilyev, by two U. S. agents who recruited him in Budapest. Vasilyev delivered reports on weapons and military plans from 1983 until he was arrested by the KGB in 1986 and executed. Experts say he may have been fingered by CIA defector Edward Lee Howard or mole Aldrich Ames, arrested last year.

The KGB concluded that the micro-message was etched by a computer-guided laser beam in a secret lab that outfitted agents. Asked to comment, a CIA spokesman said only: "It is not surprising that the technology exists."

TODD BUCHANAN

Into the Cold Blue Yonder in a Class Plane

Vocational education teacher Jim Jackson (above, at right) squeezed into this shiny fiberglass craft in Kenosha, Wisconsin, last July and flew to the northern tip of Canada's Northwest Territories and back—7,850 miles in eight days. Meanwhile his students tracked the weather and intently followed his radio reports. For months they had pored over maps, studied the rugged terrain, plotted the course, chosen interim landing sites, and compiled technical data for the flight.

They had built the plane too.

Jackson teaches electronics, hydraulics, painting, metalwork, and navigation—"all within the parameters of a shop class"—at Mundelein High School northwest of Chicago. But while classes elsewhere build models, those who study with this licensed pilot and aviation mechanic construct actual airplanes. The two-seat craft that he and former student Tom Zentz flew at 200 miles an hour to the Arctic is a four-cylinder Lancair 360 with full instrumentation and retractable landing gear. "It's a beautiful piece of art" to Jackson, who was inducted into the National Teachers Hall of Fame in 1993. This year he is overseeing the crafting of his fourth plane—destined to aid glacier studies in Alaska. "It's endless what kids can do," he says.

Oldest Crayfish Emerge From Utah Canyon Walls

Crayfish, crawfish, crawdads: By various names the little crustaceans burrow into wet soil in much of the world. New fossil finds suggest that they are one of evolution's great survivors.

The previous record for crayfish fossils was 135 million years, in Germany. But fossils found near Utah's Canyonlands National Park are at least 220 million years old, from a time when this arid region was moist. Both the body structure and the burrows of these ancients resemble those of their modern descendants.

"This blows the doors off the theory that crayfish evolved from lobsters that migrated from the oceans up estuaries to rivers and lakes," says Steve Hasiotis, the University of Colorado graduate student who found the fossils. He believes the earliest lobsters appeared at about the same time as crayfish.

BORN TO PERFORM

JUST LIKE A PARKER

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The PARKER SONNET Laque Ambre is a genuine Chinese lacquer, hand-finished to give each pen a unique exterior, enriched by heavy gold electroplated trim. The fountain pen's performance is enhanced by a precisely engineered ink flow system designed to give a smooth and uninterrupted flow to your writing. A pen that comes from a long line of famous performers. Like all PARKER writing instruments, it now comes with a Full Lifetime Warranty.

Fountain pen shown. The PARKER SONNET collection includes a wide range of other finishes. Fountain Pens, Roller Balls, Ball Pens and Pencils available. For the store nearest you, call 1-800-BEST PEN.

Geographica

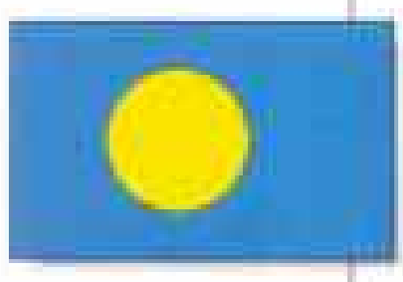
DAVID DOUBILET

Pacific Islands of Palau Are Independent at Last

"My country will be one of the smallest members of this august body, but we are large in things that count," Kuniwo Nakamura told the United Nations last December, two months after Palau became independent. The president of the world's newest nation cited a cultural heritage derived from Malay, Melanesian, and Polynesian ancestors; a commitment to human rights; a democratic government; the talents of 16,000 citizens; and rich marine resources, including 1,400 fish species and 600 corals.

Palau's 200 islands add up to an area about two and a half times the size of Washington, D. C. They played a major role in World War II. Occupied by Japan in 1914, the islands were fortified as a major naval stronghold until the Japanese were ousted in the bloody 1944 battle of Peleliu. For 47 years the islands were a UN trusteeship administered by the U. S.

The Republic of Palau has some subsistence agriculture and fishing, but most residents work for the government in the capital, Koror. Palauans are optimistic that their islands' well-earned reputation as a diving paradise will attract tourists from Asia, the U. S., and Europe and help the young nation become self-sufficient. "We pledge to preserve our marine environment as a living treasure not just for ourselves but for the entire planet," President Nakamura said.



Under terms of a compact, the U. S. will provide a total of 517 million dollars in aid over 15 years in return for the right during the next 50 years to establish military bases if needed and to operate nuclear warships in Palau's territorial waters.

Antarctic Fish Swim With Antifreeze

The fish that thrive off the Antarctic coast in frigid 28°F water survive the same way a car does in a North Dakota winter: with antifreeze. But a little fish antifreeze could keep your motor purring for a long time. It's 300 times as effective per molecule as the ethylene glycol in a car radiator.

In the Antarctic there are almost a hundred species of fish called notothenioids, ranging from six-inch zooplankton feeders to six-foot toothfish. They swim at all depths, from the 3,200-foot-deep bottom to the surface. Notothenioids produce their antifreeze, a glycoprotein, in the liver. They secrete it into the bloodstream, where it fills spaces around cells, says Arthur DeVries of the University of Illinois, who studies fish "freezing avoidance." Although seawater with ice crystals gets into the fish's blood, the antifreeze stops the ice from growing, and eventually it is filtered out.

—Boris Weintraub

RICHARD THOMPSON

National Geographic, June 1995

It suggests both Fortune

Calfnap-grained leather-trimmed seats. Cavernous space thanks to its innovative cab-forward design. A premium 120-watt Chrysler/Infinity Spatial Imaging™ Sound System with no fewer than 11 speakers. And, of course, driver and front passenger air bags.† Why, with all that, you'd think we

500 and Indianapolis 500.

made this car exclusively for the corporate elite. Enter a 214 horsepower, 24-valve, 3.5 liter V6 engine. Road-touring suspension and low-speed traction control. Plus a wide track for superior handling. And you'd be apt to think racing elite. Chrysler LHS. Whatever circles you drive in, you'll be comfortable in both. For more information, call 1-800-4-A-CHRYSLER.

Chrysler LHS

form follows function

ASHLEY STEPHENSON

Chief Horticulturist of England's Royal Palace Gardens, retired.

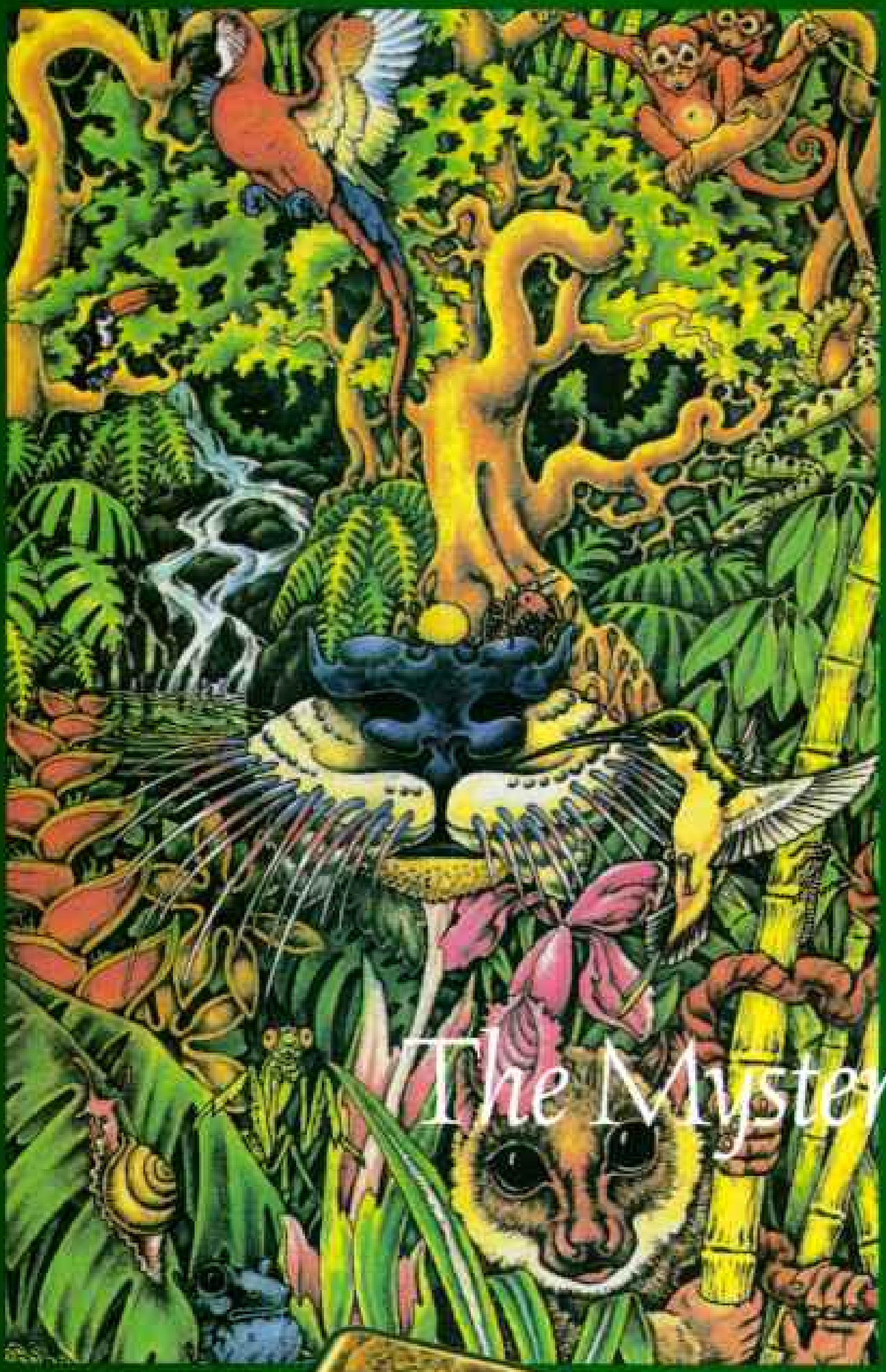
I realized the dream of every English gardener
when I was put in charge of the Royal Palace gardens.

My mission was to further enhance their beauty. That was when
I first used Miracle-Gro. The results it achieved were outstanding.

I'm still using Miracle-Gro, although today,
the only garden I'm enhancing is my own.

Ashley Stephenson

MIRACLE-GRO



MYSTERIES OF THE Forest

Find 14 hidden creatures in Mysteries of the Forest™, Zippo's 1995 Limited Edition collectible set. The stunning original artwork of the four-lighter set contains the camouflaged image of a jaguar. In the left eye of this image are the eyes of the jaguar portrayed on the companion lighter, Jaguar and Cub at Turtle Falls™, available separately.

Zippo's new Technigraphic™ imprinting ensures that the artwork will endure. These are the most exciting collectible lighters ever. They are available only during 1995.

The Mystery Is Here

1995 Limited Edition

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The Mystery is at your Zippo retailer, or call Barrett-Smythe Ltd. at 800-335-5994 to order.

Lifetime Guarantee • Made in USA

Forum

Amazon

Writer Jere Van Dyk has been able to unite objective and subjective views and convey to the reader what life on the Amazon is like (February 1995). I can see it, I can hear it, I can smell it, and, most of all, I can feel it.

URSULA BIALLAS-LANGE
Darmstadt, Germany

The story was more about the author's trip and what he did than about the Amazon as a river road and how the people who live there deal with it.

DANIKA N. FEODOROFF
Phoenix, Arizona

As a Bryn Mawr College student in the late 1970s, I conducted anthropological research in a small mestizo village surrounded by Indians on the Ucayali River. So much of your article rang true. Most articles on the Amazon focus on the tropical rain forest, not on the river, the very essence of life there. I only wish you had covered more of the river from Manaus to the source. If readers think your journey was exotic, they would be stunned to learn that life beyond is little different from the time Francisco de Orellana first explored the area.

LYLA STEENBERGEN
Easton, Connecticut

The meeting and mixing of waters is an impressive sight (pages 8-9), something you will never forget once you have experienced it. Please note, however, that the town of Tefé is not located on the river but on Lake Tefé, which is about seven miles wide where the picture on pages 2-3 was taken.

STEPHEN HEIEN
Arnold, Missouri

Regarding the 14 Tikuna Indians killed in Brazil in 1988 (page 27), there are currently 14 Amnesty International groups worldwide working on this case. Our goal via letter writing, petition signing, and publicity is to maintain pressure on authorities to keep the case alive and bring to trial those charged with the crime—with the hope of breaking the cycle of impunity in such killings. The case has been taken over from local state courts by federal courts, but a trial date set for December 12, 1994, was postponed.

CONSTANCE R. CLARK
Norton, Massachusetts

Harpy Eagle

While the story and picture of the apiomado falcon in Earth Almanac brought us a lot of favorable

Komodo Dragon (*Varanus komodoensis*) **Size:** Total length, 1–3 m **Weight:** Large specimens, 20–100 kg **Habitat:** Tropical savannas, stream-side thickets and coastal regions of the Lesser Sunda Islands, Indonesia **Surviving number:** Estimated at 6,000 Photographed by José Azel

WILDLIFE AS CANON SEES IT

A Komodo dragon pounds across the beach, its swift powerful strides reverberating on the sand. Called *ora* on the islands, the world's largest lizard is both an awesome predator and a scavenger. Specialized teeth and strong jaws enable a large ora to take on prey as big as a water buffalo. Found only on a few islands, these spectacular reptiles are especially vulnerable to changes in their geographically limited range. 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.

comments from your readers, the February issue included another species we are working with: the harpy eagle. As I write in March, we have just had one egg hatch in our laboratory and are watching over another, which—with a little luck—will hatch next month. We believe that there have been fewer than ten harpy eagles in the world hatched in captivity. I will keep you posted.

JEFF CILEK
The Peregrine Fund
Boise, Idaho

Bonampak Murals

It was impressive to discover many of the unknown details of the Bonampak murals. Please accept the appreciation of all those Mexicans who feel proud of our ancient cultures.

ABELARDO MORENO CASTILLO
Mexico City, Mexico

The painting on pages 62-4 shows an infant heir presented to important figures who are all turning away. I think that instead of ignoring the child, they are turning away in respect. Perhaps the Maya considered their ruler too holy or powerful to look upon. As a sophomore in high school, I thank you for providing the opportunity to broaden my world and my mind.

ALEXANDRA CHECKA
Arlington, Texas

While Giles Healey was the first outsider to see the murals, he was not the "Bonampak discoverer." John G. Bourne and H. Carl Frey discovered the site in February 1946. Bourne did extensive measured drawings of many of the buildings. He did not notice the one containing the murals, however, probably because of the heavy underbrush. Four months later Healey visited the site and discovered the murals.

BARBARA VAN CLEVE
Santa Fe, New Mexico

As a publisher of books on the Maya, I lament that you never tell us about the artistic significance of these masterworks, which can be favorably compared with the art of the pre-Renaissance and, six centuries later, the work of the late Mexican painter Rufino Tamayo.

LUIS GUTIERREZ
Mexico City, Mexico

Venice

Erla Zwingle's article on Venice was as beguiling as the city itself, and the pullout map supplement of Italy was superb. Italophiles everywhere—indeed all students of history—owe you a debt of gratitude.

BILL DAL CERRO
Italic Studies Institute
Chicago, Illinois

I liked the description of the town and its problems, especially the depiction of the real estate

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situation. I had friends who were forced to abandon Venice because they could not afford to rent or buy even a small unit because of the outrageous costs.

I have in my travels met a few people who disliked this city, mostly because of its smell during the summer or its winter atmosphere, which they found depressing. But I never met a person that had not been marked by the place. If a tourist goes to Venice, he will experience something powerful and unique that he will remember forever.

PAOLO BAGNOD
Saint Christophe, Italy

Like many young adults I toured Europe. Being a religious Jew, I visited the synagogues and Jewish quarters. It is interesting to note that Venice is thought to have had the first Jewish quarter known as a ghetto. It was established in 1516.

NECHAMA DINA ZIRKIND
Montreal, Quebec

I was disappointed to find no mention of Venice's artistic patrimony. I have visited on several occasions and have always noticed a great number of tourists visiting the churches, museums, and old palaces, admiring the great works of art they exhibit.

FRANCISCO LETO
Miami, Florida

Map of Italy

A supplement such as "Italy/Historical Italy" in the February issue provides an interesting way of exploring historical and current geography. But I was appalled to see ocean soundings in fathoms. I appreciate the rich historical nature of finding depths in fathoms on an 1895 map, but not one from 1995. I think it is ridiculous to ask my students to multiply soundings by 1.8288 to convert them to meters, and I urge you to use feet or, better yet, meters for both elevations and soundings.

CATHRYN L. RHODES
Davis, California

The northern province of Italy labeled Trentino-Alto Adige includes South Tirol, which was forcibly Italianized. It was from 1363 until 1918 part of Austria. Occupied by the Italian Army after the Allied victory in World War I, it was made part of Italy. German-speaking South Tiroleans still represent the majority there. After World War II German and Rhaeto-Romance-speaking South Tiroleans were granted a degree of autonomy and the reintroduction of original place-names.

ROMAN SCHRITTWIESER
Innsbruck, Austria

You depict a monument that you label the tomb of Victor Emmanuel II. The monument is dedicated to him but is not his tomb. All Italian kings—except Umberto II, who is buried in Portugal—lie in the Pantheon in Rome.

CHRISTINA MONTALTO
Milan, Italy

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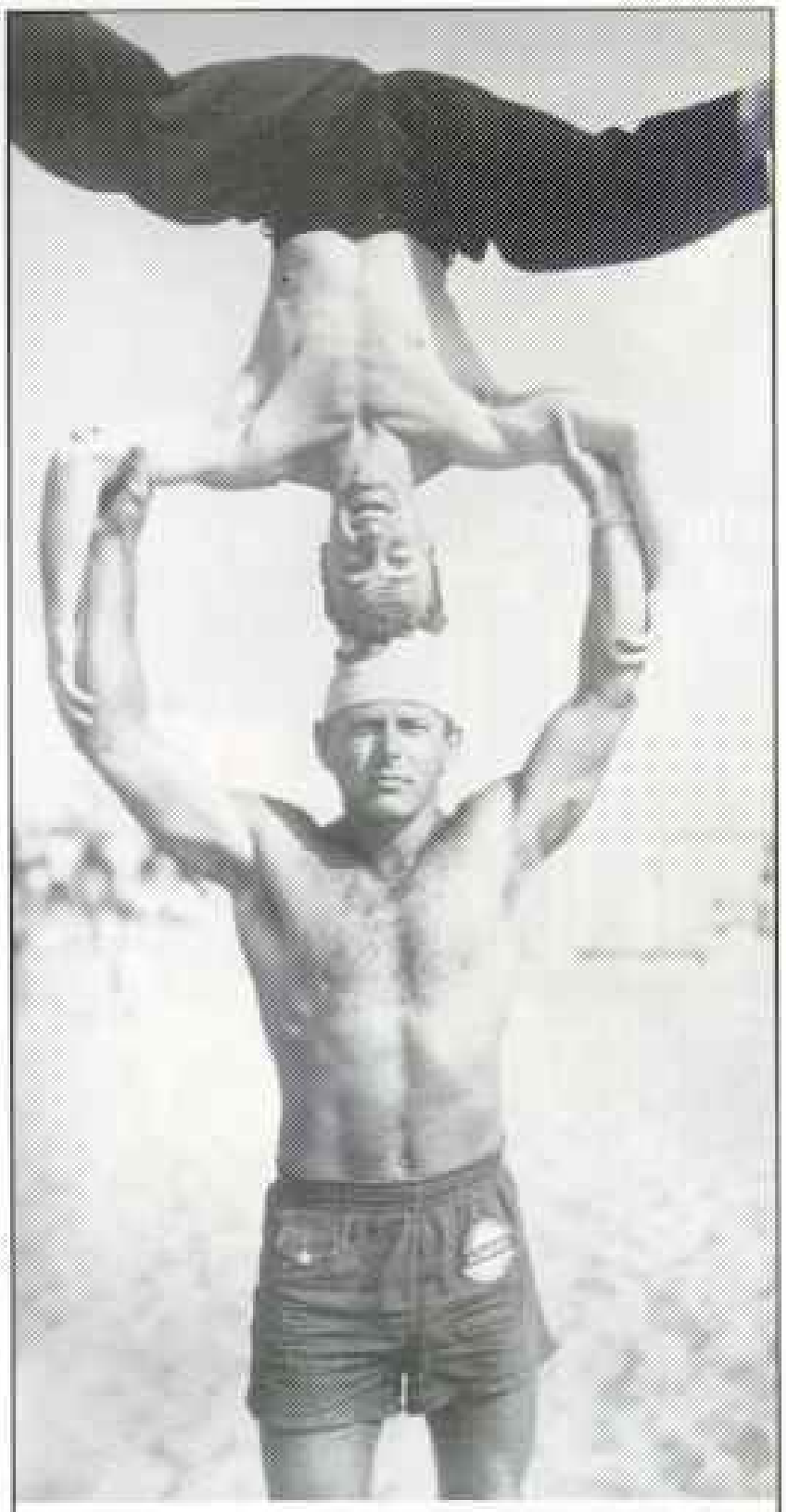

Headstand, Muscle Beach, Santa Monica, California, 1954
LARRY SILVER

Grand Teton National Park

While visiting the park this past summer, I noticed that it was fully outfitted with late-model police cars and weaponry and expensive uniforms. The park appears far less generous with visitor services and facilities. My visit to the Moose Visitor Center revealed an overworked volunteer, several home-made exhibits, and no adult-level programs. Road conditions were only a preview of the rough travel that lay ahead in Yellowstone. When I pay taxes and the ten-dollar entry fee, I believe it is reasonable to expect a balance between visitor services and law enforcement. The resource must be protected, but there is no need for *Hawaii Five-O*.

J. BENJAMIN RICKETTS
Arlington, Virginia

Having spent half of my 15-year career as a fisheries biologist working on the upper Snake River system, I was dismayed to find blame placed on introduced brown trout for the demise of native cutthroat trout elsewhere. Surprisingly, the two coexist quite nicely in the Snake system. It is irrigation diversions, regulated stream flows, dams, poor livestock management, and hybridization with the introduced rainbow that are primary factors in the loss of cutthroat populations in the upper Snake system.

CHARLES E. CORSI
Rathdrum, Idaho

To ranch families who state they must or did sell their land to avoid being wiped out by inheritance taxes, I would recommend consulting a competent estate-planning attorney. A married couple can eliminate taxes on the first 1.2 million dollars of an estate. With a little planning none of the families described would probably have to pay any estate tax. Despite the statement that land must be assessed at its highest value, qualified families can also have the land valued for special use, such as agriculture.

RONALD W. RUTZ
Fort Collins, Colorado

Earth Almanac

I would add to the item titled "A Forest Where Frogs Rain" that the *coquí* is named because that is the sound it makes throughout the night: *ko-KEE, ko-KEE*. It is a very pleasant sound. If you want to hear it and cannot go to Puerto Rico, just call anyone you know there after 7:30 p.m. and listen to the background sounds. It makes all islanders nostalgic when we call home.

RAMON E. BAEZ
Virginia Beach, Virginia

Letters for FORUM should be sent to National Geographic Magazine, Box 37448, Washington, D. C. 20013-7448, or by fax to 202-828-5460, or via the America Online computer network to ngsforum@aol.com. Include full name, address, and daytime telephone. Letters selected may be edited for clarity and space.

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1803E5

Brief Summary of
Prescribing Information as of April 1993

CARDIZEM® CD

(diltiazem HCl)

Capsules

CONTRAINDICATIONS

CARDIZEM is contraindicated in (1) patients with sick sinus syndrome except in the presence of a functioning ventricular pacemaker, (2) patients with second- or third-degree AV block except in the presence of a functioning ventricular pacemaker, (3) patients with hypotension (less than 90 mm Hg systolic), (4) patients who have demonstrated hypersensitivity to the drug, and (5) patients with acute myocardial infarction and pulmonary congestion documented by x-ray on admission.

WARNINGS

1. **Cardiac Conduction**. CARDIZEM prolongs AV node refractory periods without significantly prolonging sinus node recovery time, except in patients with sick sinus syndrome. This effect may rarely result in abnormally slow heart rates (particularly in patients with sick sinus syndrome) or second- or third-degree AV block (13 of 3290 patients or 0.40%). Concomitant use of diltiazem with beta-blockers or digitalis may result in additive effects on cardiac conduction. A patient with Prinzmetal's angina developed periods of asystole (2 to 5 seconds) after a single dose of 60 mg of diltiazem.
2. **Congestive Heart Failure**. Although diltiazem has a negative inotropic effect in isolated animal tissue preparations, hemodynamic studies in humans with normal ventricular function have not shown a reduction in cardiac index nor consistent negative effects on contractility (dp/dt). An acute study of oral diltiazem in patients with impaired ventricular function (ejection fraction 24% ± 8%) showed improvement in indices of ventricular function without significant decrease in contractile function (dp/dt). Worsening of congestive heart failure has been reported in patients with preexisting impairment of ventricular function. Experience with the use of CARDIZEM (diltiazem hydrochloride) in combination with beta-blockers in patients with impaired ventricular function is limited. Caution should be exercised when using this combination.
3. **Hypotension**. Decreases in blood pressure associated with CARDIZEM therapy may occasionally result in symptomatic hypotension.
4. **Acute Hepatic Injury**. Mild elevations of transaminases with and without concomitant elevation in alkaline phosphatase and bilirubin have been observed in clinical studies. Such elevations were usually transient and frequently resolved even with continued diltiazem treatment. In rare instances, significant elevations in enzymes such as alkaline phosphatase, LDH, SGOT, SGPT, and other phenomena consistent with acute hepatic injury have been noted. These reactions tended to occur early after therapy initiation (1 to 8 weeks) and have been reversible upon discontinuation of drug therapy. The relationship to CARDIZEM is uncertain in some cases, but probable in some. (See PRECAUTIONS.)

PRECAUTIONS

General

CARDIZEM (diltiazem hydrochloride) is extensively metabolized by the liver and excreted by the kidneys and in bile. As with any drug given over prolonged periods, laboratory parameters of renal and hepatic function should be monitored at regular intervals. The drug should be used with caution in patients with impaired renal or hepatic function. In subacute and chronic dog and rat studies designed to produce toxicity, high doses of diltiazem were associated with hepatic damage. In special subacute hepatic studies, oral doses of 120 mg/kg and higher in rats were associated with histological changes in the liver which were reversible when the drug was discontinued. In dogs, doses of 20 mg/kg were also associated with hepatic changes; however, these changes were reversible with continued dosing.

Dermatological events (see ADVERSE REACTIONS section) may be transient and may disappear despite continued use of CARDIZEM. However, skin eruptions progressing to erythema multiforme and/or exfoliative dermatitis have also been infrequently reported. Should a dermatologic reaction persist, the drug should be discontinued.

Drug Interactions

Due to the potential for additive effects, caution and careful titration are warranted in patients receiving CARDIZEM concomitantly with other agents known to affect cardiac contractility and/or conduction. (See WARNINGS.) Pharmacologic studies indicate that there may be additive effects in prolonging AV conduction when using beta-blockers or digitalis concomitantly with CARDIZEM. (See WARNINGS.)

As with all drugs, care should be exercised when treating patients with multiple medications. CARDIZEM undergoes biotransformation by cytochrome P-450 mixed function oxidase. Coadministration of CARDIZEM with other agents which follow the same route of biotransformation may result in the competitive inhibition of metabolism. Especially in patients with renal and/or hepatic impairment, dosages of similarly metabolized drugs, particularly those of low therapeutic ratio, may require adjustment when starting or stopping concomitantly administered diltiazem to maintain optimum therapeutic blood levels.

Beta-blockers. Controlled and uncontrolled domestic studies suggest that concomitant use of CARDIZEM and beta-blockers is usually well tolerated, but available data are not sufficient to predict the effects of concomitant treatment in patients with left ventricular dysfunction or cardiac conduction abnormalities.

Administration of CARDIZEM (diltiazem hydrochloride) concomitantly with propranolol in five normal volunteers resulted in increased propranolol levels in all subjects and bioavailability of propranolol was increased approximately 32%. In vitro, propranolol appears to be displaced from its binding sites by diltiazem. If combination therapy is initiated or withdrawn in conjunction with propranolol, an adjustment in the propranolol dose may be warranted. (See WARNINGS.)

Cimetidine. A study in six healthy volunteers has shown a significant increase in peak diltiazem plasma levels (58%) and area-under-the-curve (53%) after a 1-week course of cimetidine at 1200 mg per day and a single dose of diltiazem 60 mg. Ranitidine produced smaller, nonsignificant increases. The effect may be mediated by cimetidine's known inhibition of hepatic cytochrome P-450, the enzyme system responsible for the first-pass metabolism of diltiazem. Patients currently receiving diltiazem therapy should be carefully monitored for a change in pharmacological effect when initiating and discontinuing therapy with cimetidine. An adjustment in the diltiazem dose may be warranted.

Digitalis. Administration of CARDIZEM with digoxin in 24 healthy male subjects increased steady-state digoxin concentrations approximately 20%. Another investigator found no increase in digoxin levels in 12 patients with coronary artery disease. Since there have been conflicting results regarding the effect of digoxin levels, it is recommended that digoxin levels be monitored when initiating, adjusting, and discontinuing CARDIZEM therapy to avoid possible over- or under-digitalization. (See WARNINGS.)

Anesthetics. The depression of cardiac contractility, conductivity, and automaticity as well as the vascular dilation associated with anesthetics may be potentiated by calcium channel blockers. When used concomitantly, anesthetics and calcium blockers should be titrated carefully.

Cyclosporine. A pharmacokinetic interaction between diltiazem and cyclosporine has been observed during studies involving renal and cardiac transplant patients. In renal and cardiac transplant recipients, a reduction of cyclosporine dose ranging from 15% to 48% was necessary to maintain cyclosporine trough concentrations similar to those seen prior to the addition of diltiazem. If these agents are to be administered concurrently, cyclosporine concentrations should be monitored, especially when diltiazem therapy is initiated, adjusted, or discontinued.

The effect of cyclosporine on diltiazem plasma concentrations has not been evaluated.

Carbamazepine. Concomitant administration of diltiazem with carbamazepine has been reported to result in elevated serum levels of carbamazepine (40% to 72% increase), resulting in toxicity in some cases. Patients receiving these drugs concurrently should be monitored for a potential drug interaction.

Carcinogenesis, Mutagenesis, Impairment of Fertility

A 24-month study in rats at oral dosage levels of up to 100 mg/kg/day and a 21-month study in mice at oral dosage levels of up to 30 mg/kg/day showed no evidence of carcinogenicity. There was also no mutagenic response in vitro or in vivo in mammalian cell assays or in vitro in bacteria. No evidence of impaired fertility was observed in a study performed in male and female rats at oral dosages of up to 100 mg/kg/day.

Pregnancy

Category C. Reproduction studies have been conducted in mice, rats, and rabbits. Administration of doses ranging from five to ten times greater (on a mg/kg basis) than the daily recommended therapeutic dose has resulted in embryo and fetal lethality. These doses, in some studies, have been reported to cause skeletal abnormalities. In the perinatal/postnatal studies, there was an increased incidence of stillbirths at doses of 20 times the human dose or greater.

There are no well-controlled studies in pregnant women; therefore, use CARDIZEM in pregnant women only if the potential benefit justifies the potential risk to the fetus.

Nursing Mothers

Diltiazem is excreted in human milk. One report suggests that concentrations in breast milk may approximate serum levels. If use of CARDIZEM is deemed essential, an alternative method of infant feeding should be instituted.

Pediatric Use

Safety and effectiveness in children have not been established.

ADVERSE REACTIONS

Serious adverse reactions have been rare in studies carried out to date, but it should be recognized that patients with impaired ventricular function and cardiac conduction abnormalities have usually been excluded from these studies.

The following table presents the most common adverse reactions reported in placebo-controlled angina and hypertension trials in patients receiving CARDIZEM CD up to 360 mg with rates in placebo patients shown for comparison.

CARDIZEM CD Capsule Placebo-Controlled Angina and Hypertension Trials Combined

Adverse Reactions	Cardizem CD (n=607)	Placebo (n=301)
Headache	5.4%	5.0%
Dizziness	3.0%	3.0%
Bradycardia	3.3%	1.3%
AV Block First Degree	3.3%	0.0%
Edema	2.8%	1.3%
ECG Abnormality	1.8%	2.3%
Asthenia	1.8%	1.7%

In clinical trials of CARDIZEM CD capsules, CARDIZEM tablets, and CARDIZEM SR capsules involving over 3300 patients, the most common events (ie, greater than 1%) were edema (4.6%), headache (4.5%), dizziness (3.5%), asthenia (2.8%), first-degree AV block (2.4%), bradycardia (1.7%), flushing (1.4%), nausea (1.4%), and rash (1.2%).

In addition, the following events were reported infrequently (less than 1%) in angina or hypertension trials:

Cardiovascular: Angina, arrhythmia, AV block (second- or third-degree), bundle branch block, congestive heart failure, ECG abnormalities, hypotension, palpitations, syncope, tachycardia, ventricular extrasystoles.

Nervous System: Abnormal dreams, amnesia, depression, gait abnormality, hallucinations, insomnia, nervousness, paresthesia, personality change, somnolence, tinnitus, tremor.

Gastrointestinal: Anorexia, constipation, diarrhea, dry mouth, dysgeusia, dyspepsia, mild elevations of SGOT, SGPT, LDH, and alkaline phosphatase (see hepatic warnings), thirst, vomiting, weight increase.

Dermatological: Petechiae, photosensitivity, pruritus, urticaria.

Other: Amblyopia, CPK increase, dysphoria, epistaxis, eye irritation, hyperglycemia, hyperuricemia, impotence, muscle cramps, nasal congestion, nocturia, osteoarticular pain, polyuria, sexual difficulties.

The following postmarketing events have been reported infrequently in patients receiving CARDIZEM: alopecia, erythema multiforme, exfoliative dermatitis, extrapyramidal symptoms, gingival hyperplasia, hemolytic anemia, increased bleeding time, leukopenia, purpura, retinopathy, and thrombocytopenia. In addition, events such as myocardial infarction have been observed which are not readily distinguishable from the natural history of the disease in these patients. A number of well-documented cases of generalized rash, characterized as leukocytoclastic vasculitis, have been reported. However, a definitive cause and effect relationship between these events and CARDIZEM therapy is yet to be established.

Prescribing Information as of April 1993

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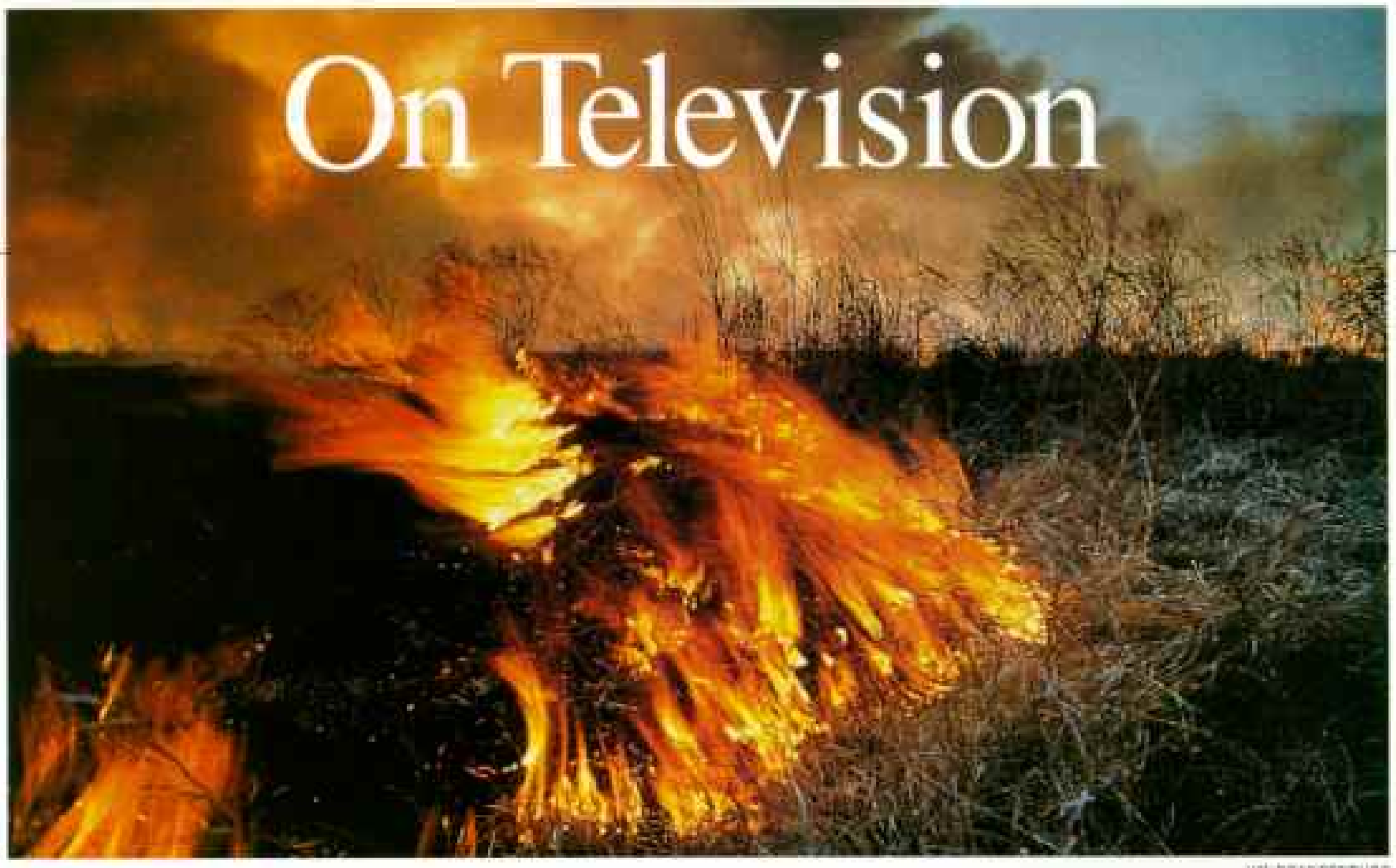

JIM BRANDENBURG

Rebuilding the Range Where the Buffalo Roam

Thundering through 6,000 acres, a managed fire (above) mimics a primal force that helped shape the Great Plains. Called red buffalo by Plains Indians, fires helped prevent growth of forests. Fire's partner—enormous herds of buffalo—tilled prairie soil with their hoofs and fertilized it with dung. Together, fire and buffalo built the most extensive grasslands on earth, once covering a ninth of the continent.

"Fire and Thunder," on EXPLORER, shows that in the past 150 years the tallgrass prairie—the easternmost portion of the Great Plains—has been all but erased. Now, in the Flint Hills of Oklahoma on land too rocky to plow, the nonprofit Nature Conservancy is transforming 37,000 acres of ranchland into the largest expanse of tallgrass prairie yet set aside. The Conservancy has also returned 300 buffalo, free to graze and roam.

More than 150 kinds of grasses, some growing to ten feet, make up the heart of the tallgrass ecosystem. Says Harvey Payne, director of the restoration, "We're trying to replicate what happened before the breakup of 142 million acres of tallgrass prairie."

"Fire and Thunder" airs Sunday, June 4, at 9 p.m. ET on TBS Superstation.

The Rough Courtship of Nurse Sharks

Nurse sharks intent on mating are oblivious to Nick Caloyianis, coproducer of the EXPLORER film "A Savage Kind of Love." It is the first film to detail the sexual behavior of sharks in the wild.

The male seizes the female by her pectoral fin, propels her into deeper water, flips her, and inserts one of his two claspers (right)—nearly impossible if she resists.

Fewer than one in ten attempts is successful, conclude Harold "Wes" Pratt and Jeff Carrier, marine biologists who are studying nurse sharks off the Florida Keys.

"A Savage Kind of Love" airs June 25 at 9 p.m. ET on TBS Superstation.

HAROLD "WES" PRATT

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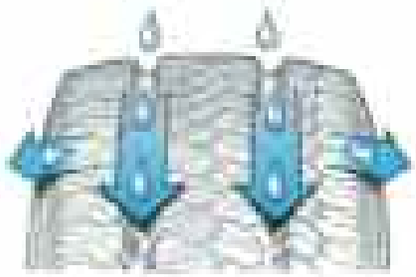

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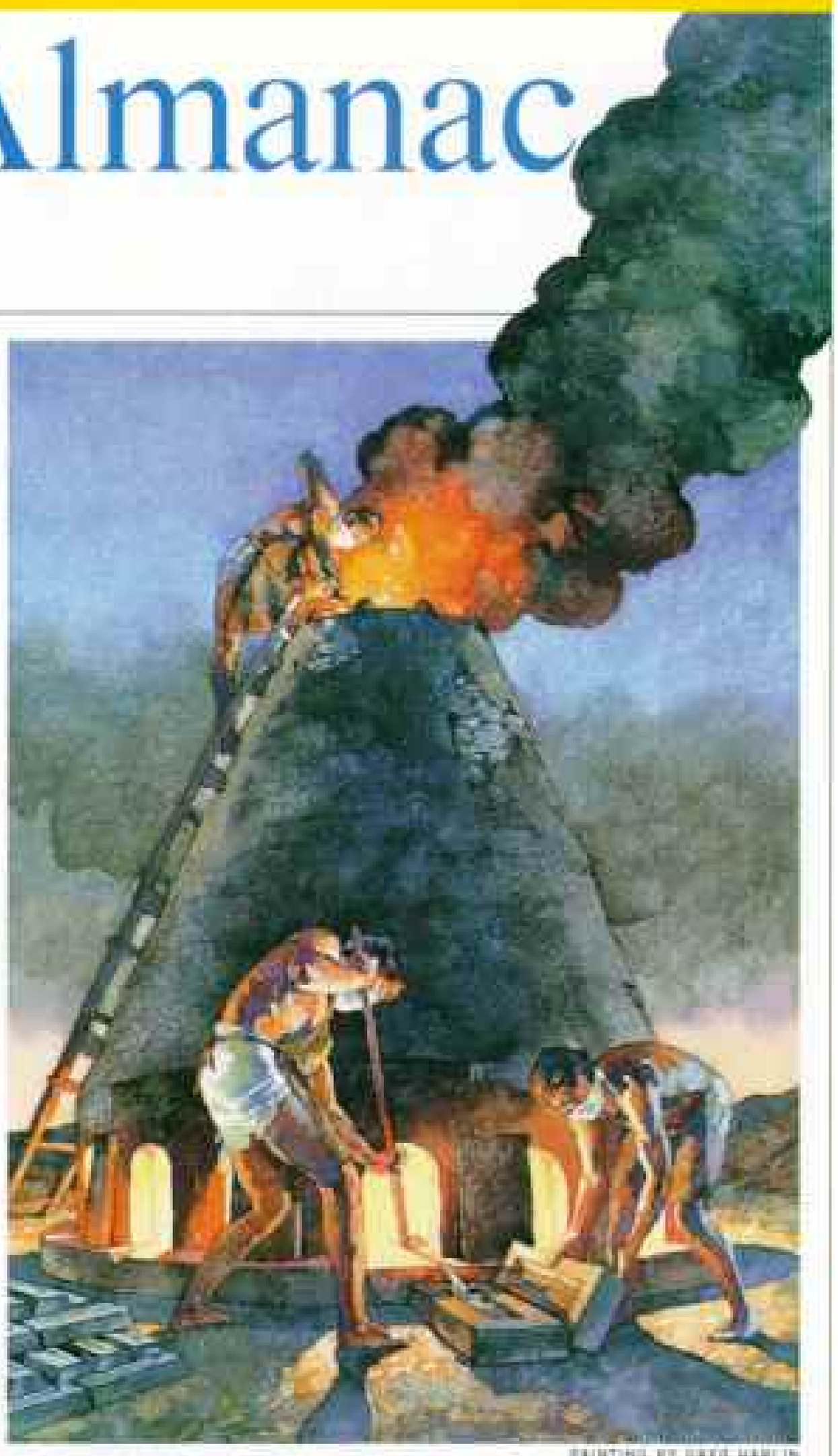
Earth Almanac

Lead Pollution Fouled Ancient Skies

Air pollution is an old, old curse. In their quest for lead and silver—metals crucial to their civilizations—Greeks and Romans poisoned their air and themselves with belching smelters. How do we know? In Greenland's ice French geologists have found high levels of lead that rose into the atmosphere from fires in ancient Europe and fell in Arctic snow. Between 500 B.C. and A.D. 300 enough lead precipitated onto Greenland to equal 15 percent of the lead deposited there by the burning of leaded gasoline from 1930 to 1990.

In their heyday the smelters produced almost 90,000 tons of lead ingots a year. They were kept especially busy in Spain, Britain, and southern France. Here one worker adds chunks of a lead-bearing ore called galena to the smelter's top, while others pour molten lead into molds. Further purification by remelting the lead recovered silver, also often present in galena ore.

The refiners cover their faces, as advised by Pliny the Elder in A.D. 77: "otherwise the noxious and deadly vapor of the lead furnace is inhaled." Both Greeks and Romans used silver for coins, but Romans smelted galena ore mainly for lead, used to make cisterns, roofing, pipes, and paint. They even flavored food with boiled-down grape juice that got much of its sweetness from leaden cooking pots. "They ingested enormous quantities of lead in their food and drink," says archaeologist John P. Oleson of Canada's University of Victoria.



PAINTING BY GREG HARLIN

Elegant Survivors of the Plume Trade: Spoonbills

Sounding off with a hoarse croak, a roseate spoonbill at the mouth of Louisiana's Atchafalaya River displays its trademark, a bill handily flattened to scoop crustaceans, fish, and insects from the water.

Spoonbills barely survived the "age of extermination" around 1900—an avian holocaust. Feathers flew as hunters devastated more than 60 species to adorn fashionable women. The millinery trade employed 83,000 people—one out of every thousand Americans. Plumes were once worth $80 an ounce—nearly three times their weight in gold.

The long, ethereal finery of herons, especially egrets, was preferred to festoon elaborate hats. Spoonbills were also sought, but their gorgeous pinks faded after the birds died, hunters discovered. Still, they chopped off the wings and sold them as ladies' fans. By the early 1900s the birds no longer nested anywhere in Texas, and only about two dozen pairs held out in southern Florida.

Conservationists began to halt the slaughter in 1910, and spoonbills started a long, slow recovery. The birds' numbers have fluctuated widely because of varying rainfall and loss of wetland habitat to development. Florida Bay now hosts 900 breeding pairs. Spoonbills from Mexico recolonized the Gulf Coast during the 1920s, and today about 2,400 pairs nest in Texas and Louisiana.

JOHN EASTCOTT AND YVA MOMATIUK, ANIMALS ANIMALS

National Geographic, June 1995

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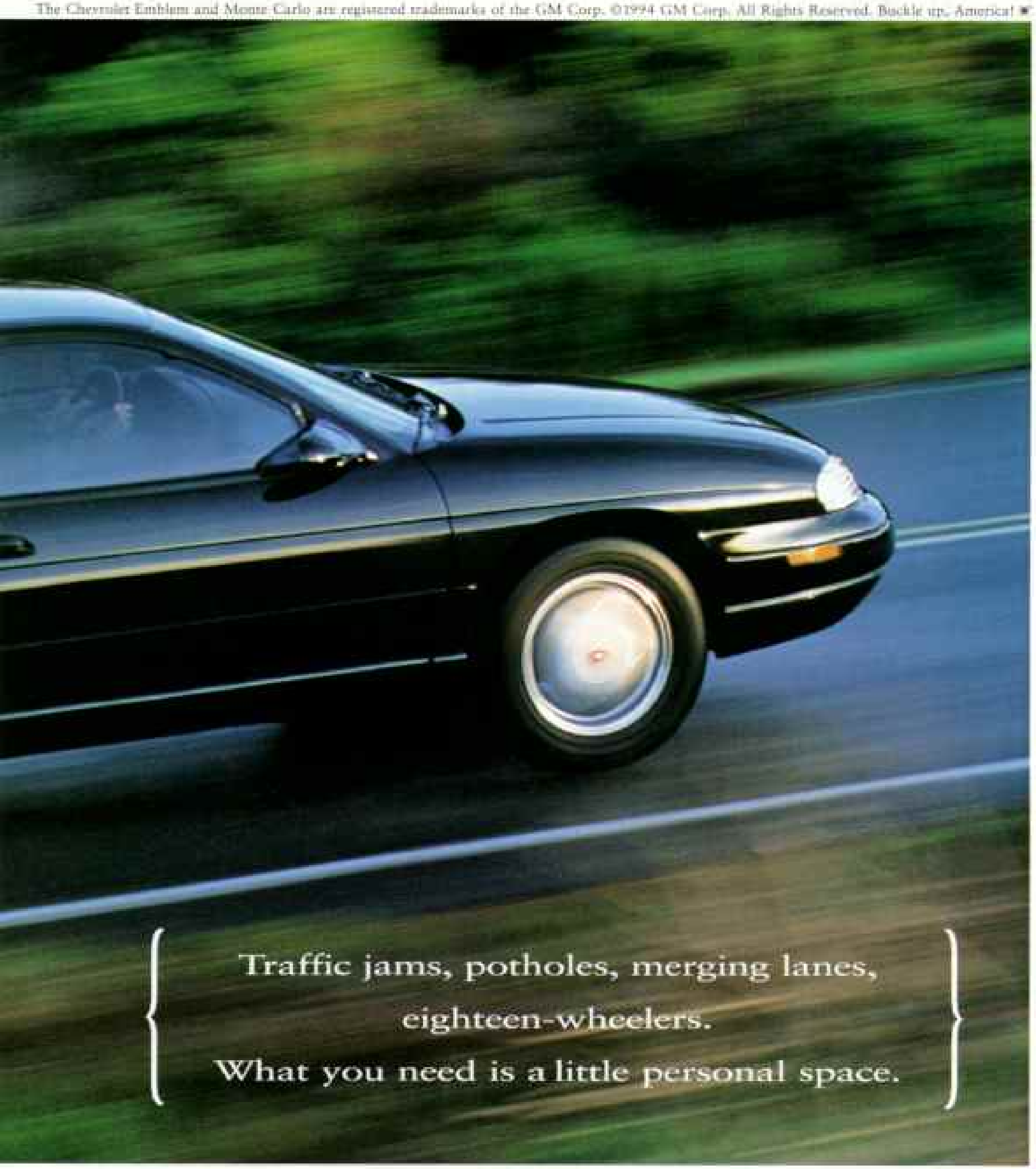

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JOHN CORR, NAS

Infections May Strand Taiwan's Pet Orangutans

Designer pets of the rich, orangutans seem to be everywhere in Taiwan, including a Taipei market called Snake Alley. Inspired by a local television show that featured an orang as a pet, Taiwanese smuggled about a thousand orangs at $4,000 apiece from Indonesia during the 1980s. Because Taiwan does not subscribe to the Convention on International Trade in Endangered Species, the practice went unchecked until 1989, when Taiwan outlawed it.

Now grown up and unmanageable, many orangs are being abandoned. About two dozen have been repatriated to Indonesia by the Orangutan Foundation, although much of their habitat has been cut down. But during resettlement two orangs were found to be carrying hepatitis and tuberculosis antibodies. "There's no chance of returning infected orangutans to the wild," says the foundation's Ashley Leiman. For now, castoffs will be banished to a barely adequate shelter in southern Taiwan to be checked for disease—insult upon injury for these soulful primates that now number no more than 30,000 worldwide.

Port Orford Cedars, Rare and Ailing

Only a little pocket of southwestern Oregon and northwestern California is home to the 200-foot-tall Port Orford cedar. Its creamy wood is almost religiously prized in Japan for temples and sushi counters. Buyers in Japan often examine a log and purchase only a single board; the rest of the log may take years to sell.

Now many cedars are dying from a fungal root disease. The fungus spores spread by streams and in mud picked up by cars and logging trucks. Forest Service officials have closed some roads and taken other control measures—but not enough, claim environmentalists, who have filed suit to beef up protection.

Bobcats Hold Their Turf

Surveying Montana's Bob Marshall Wilderness, this bobcat kitten stands a better chance of reaching adulthood than other large predators. Bobcat hunting is legal in most states but has dwindled because of a drop in fur prices since the late 1980s. Even when demand was higher, bobcats were never in danger as a species. These feisty, adaptable 25-pound cats roam from Canada to Mexico, with between 700,000 and 1.5 million in the U. S.—probably more than in colonial days.

"Bobcats profited from fragmentation of habitat as the country developed," says Dick Mitchell, a U. S. Fish and Wildlife Service zoologist. Small game flourished amid spreading farmland, and bobcats feasted. While cougars, bears, and wolves must scour large territories for food, some bobcats can make a living within just one square mile.

—JOHN L. ELLIOT

ART WOLFE, TONY STONE IMAGES

National Geographic, June 1995

How inviting is your home?

It's the obvious but overlooked things that often cause home burglaries. You go on vacation but forget to tell neighbors. And so mail and newspapers pile up. Or you leave your house totally dark. Or the fence out back is so high, it blocks the view of neighbors. Or maybe you forget to lock up. Forty percent of home invasions happen because people simply don't lock their doors and windows. The list goes on and on. To help make your home burglar-proof, see your Allstate Agent.

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On Assignment

Lending a lens, contract photographer ANNIE GRIFFITHS BELT (right) let Druze women in the Israeli-occupied Golan Heights use her camera for a telescope as they searched for relatives over the Syrian border. Families such as these—riven geographically by the Six Day War—are rarely permitted get-togethers, so they hail loved ones across the 550-yard divide.

"They refer to this place as 'shouting mountain,'" says Annie, "because as they call out, their Syrian family members stand on the other side, shouting back."

Annie and her husband, Assistant Editor DON BELT, kept their own family together during fieldwork in Galilee, living with their two young children on a local kibbutz. "Our neighbors turned out to be wonderful contacts," says Don, "and kibbutz life was great for the kids."

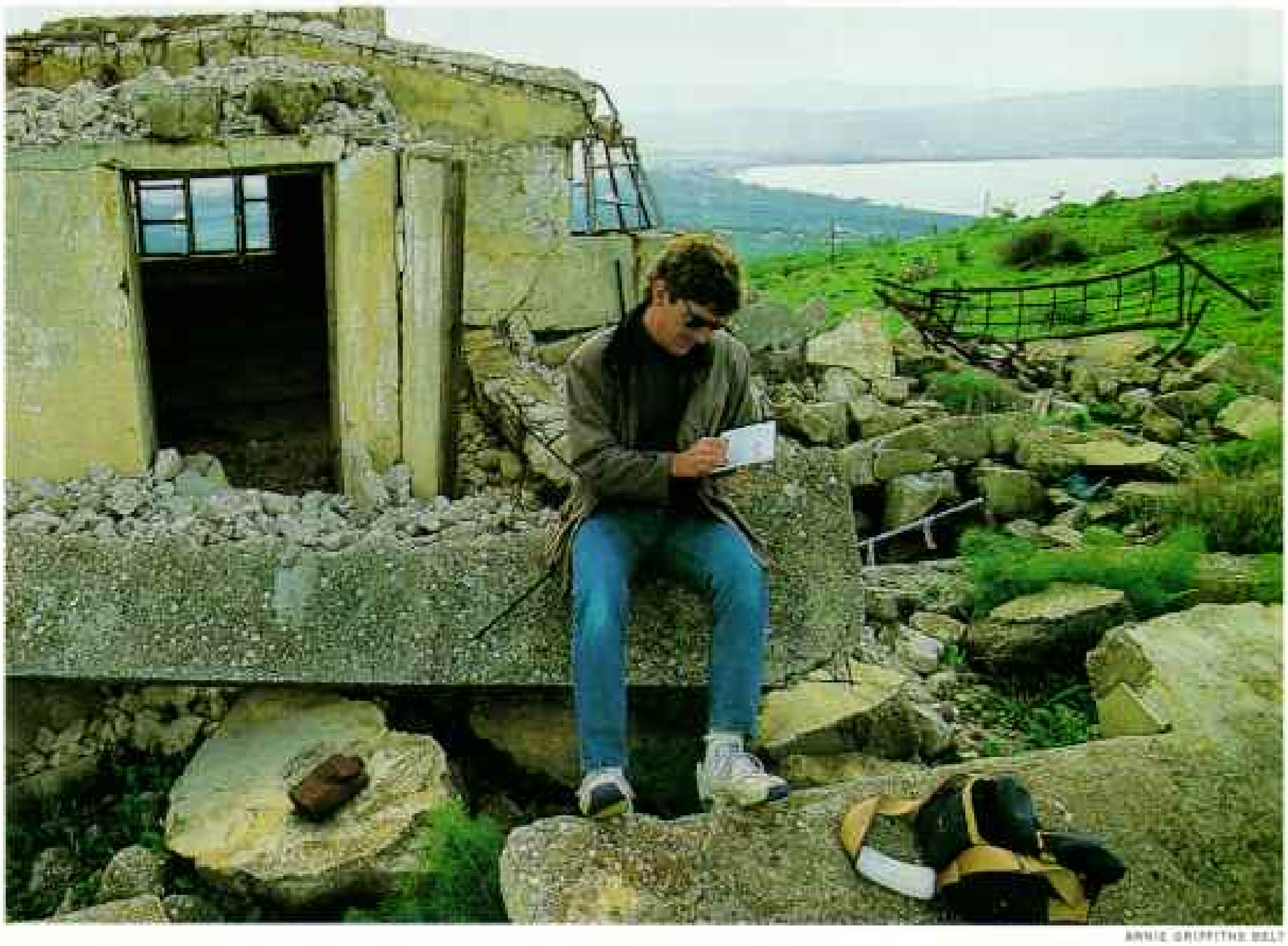
JANICE MOLINARI

The family's experiences will be featured in an EXPLORER segment that will air July 16 on TBS Superstation.

In the southern Golan Heights (below) Don visited a Syrian bunker, destroyed in the 1967 war, that looks down on the family's kibbutz.

"Farmers used to work their fields here just a stone's throw from the Syrian guns," he says. "When you see how tightly surrounded Israel is, you can understand its sense of vulnerability."

The Belts met when Don was assigned to write captions for Annie's photographs of North Dakota in the March 1987 issue. The next year the couple were married, leaving three days later to cover Baja California for the magazine. According to Annie, "If you really want to know a guy, spend eight weeks in the desert with him, in a jeep."



ANNIE GRIFFITHS BELT

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