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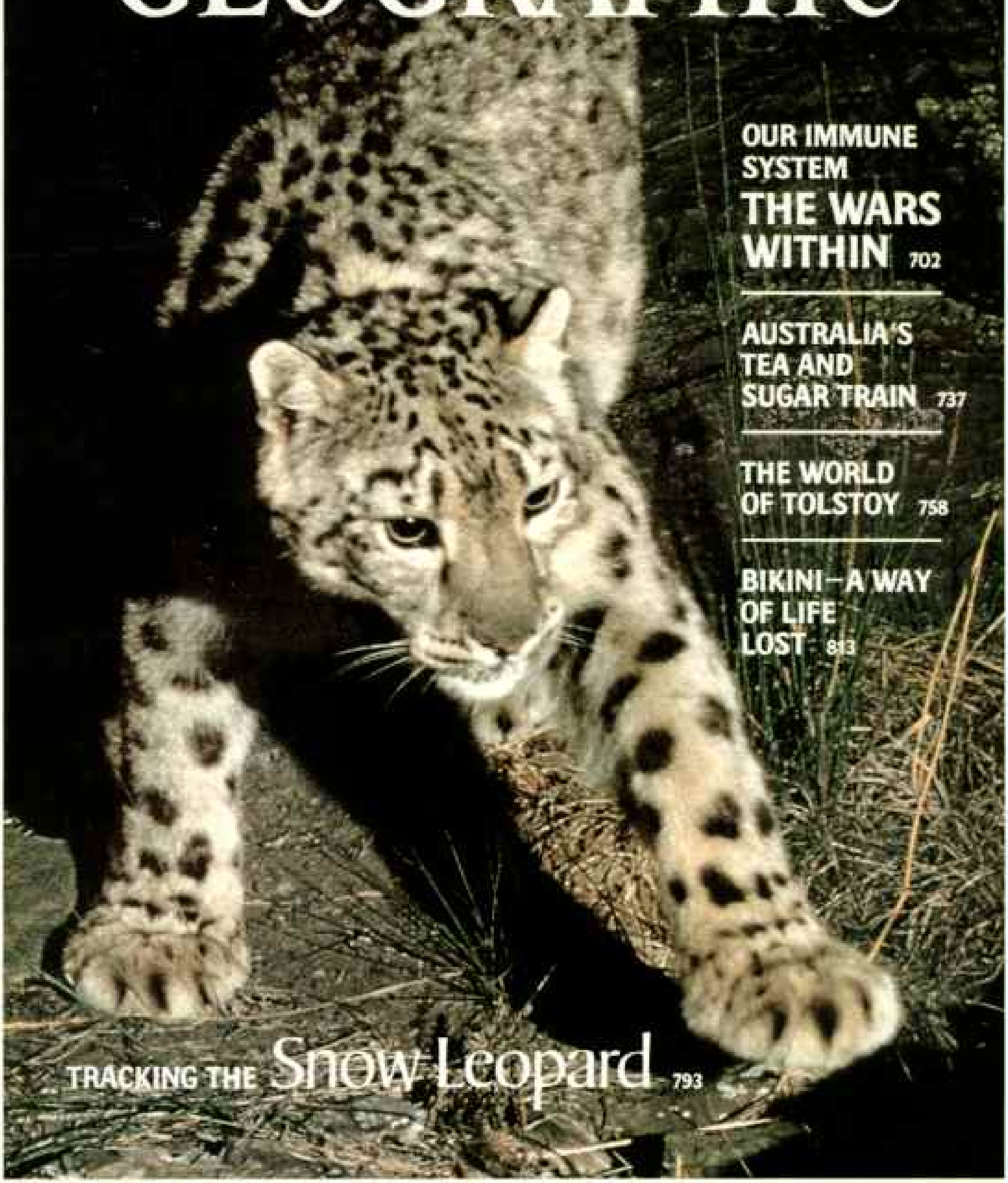

OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY WASHINGTON, D.C.

BECAUSE A SWEDISH photographer, Lennart Nilsson, practices camera magic, you and I enjoy in this issue a microscopic look into the magic of the body's immune system. Of course it's not magical. It's very real, and it has always been there doing its healing. We just haven't known much about it.

With new imaging technology married to large computers, doctors are now able to explore with amazing accuracy the inner workings of our bodies without a single scalpel cut. These noninvasive diagnostic tools, as they are called, are tagged with names as incomprehensible to the layman as a physician's handwriting on a prescription.

For example: DSA—digital-subtraction angiography—produces three-dimensional pictures of our blood vessels that can show prestroke indicators inside the brain. PET—positron-emission tomography—uses short-lived radioisotopes to reveal brain functions and possibly new ways to block cancer pain. MRI—magnetic-resonance imaging—helps distinguish cancerous from healthy tissue.

The Society's new book *The Incredible Machine* utilizes many of these imaging technologies to show and explain the human body.

Yet even for an informed patient, sick and in need of help, sterile hospitals with their high-tech machines can seem as remote and forbidding as Dr. Frankenstein's castle. But they are not creating monsters, they are destroying them. Monsters such as brain tumors—sometimes invisible even to the surgeon's eye—can be located, photographed in three-dimensional color, and removed from healthy brain tissue by laser with an accuracy of only ten microns—one-eighth the thickness of this page.

The United States leads the world in advanced medical technology. If the staggering costs of medical care, compounded by massive malpractice awards, don't force both patients and doctors overseas, medicine will become a leading industry and a prime source of foreign exchange. The U. S. Department of Commerce estimates that the export of medical equipment and supplies alone—not counting treatment of foreign nationals—will exceed 5.7 billion dollars in 1986, nearly double alcoholic beverages and tobacco products combined.

What is certain is that medical science has made a better and longer life for the least of us than was enjoyed by the greatest and the richest kings of old.

Wilbur E. Garrett

EDITOR

NATIONAL GEOGRAPHIC

June 1986

COVER: *A female snow leopard takes her own picture as she triggers a hidden camera.*

THE NATIONAL GEOGRAPHIC MAGAZINE
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THE NATIONAL GEOGRAPHIC SOCIETY
FOUNDED 1888

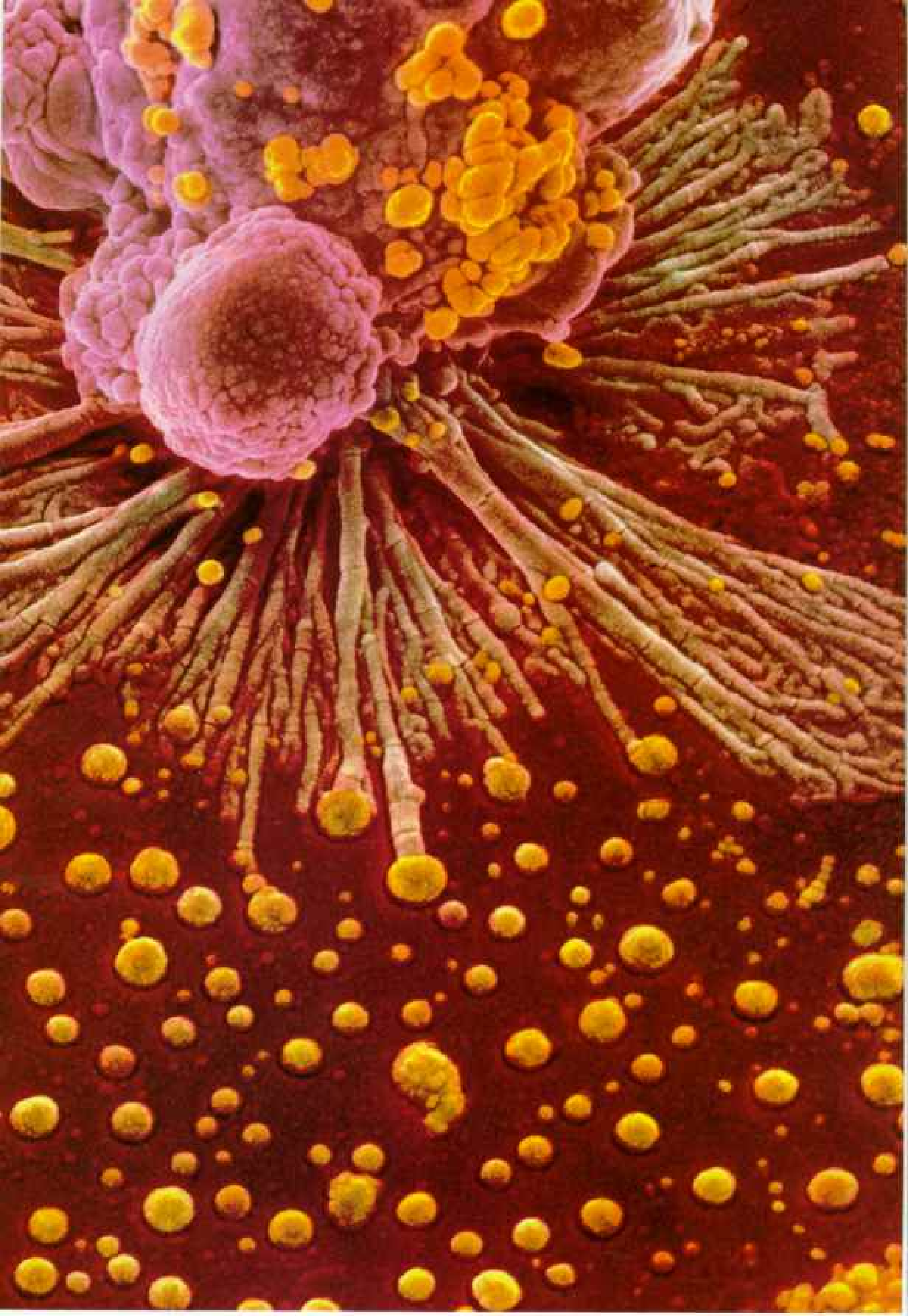
OUR
IMMUNE SYSTEM

THE WARS WITHIN

Besieged by a vast array
of invisible enemies,
the human body enlists
a remarkably complex corps
of internal bodyguards
to battle the invaders.
They can cleanse the lungs
of foreign particles,
rid the bloodstream
of infectious microorganisms,
and weed tissue of renegade
cancer cells.

By PETER JARET
Photographs by LENNART NILSSON

SCANNING ELECTRON MICROSCOPE



95 A MACROPHAGE, A HUMAN DEFENSE CELL, SEEKING TO ENGULF DROPLETS OF OIL. MAGNIFIED 19,000 TIMES © BOEHRINGER INGELHEIM INTERNATIONAL GMBH


FIGHTING
CANCER
NOW
THAT'S

A breathtaking succession of discoveries in the past 20 years in the young medical field of immunology has enabled doctors to assist and enhance our built-in defense arsenal.

In addition to physiological combatants, some doctors are looking at psychological factors. Combining fun and therapy, a young cancer patient at the M. D. Anderson Hospital in Houston, Texas, zaps cancer cells in the "Killer T Cell" video game. Thus visualizing his enemies and protectors may positively influence his immune system.

BILL BALLENBERG

EVERY MINUTE of every day wars rage within our bodies. The combatants are too tiny to see. Some, like the infamous virus that causes AIDS, or acquired immune deficiency syndrome, are so small that 230 million would fit on the period at the end of this sentence. Yet they employ tactics that can vanquish the much larger cells they swarm upon (right).

Usually we never even notice the battles in the incessant wars within us. We have evolved legions of defenders, specialized cells that silently rout the unseen enemy. Sometimes these warriors mistake harmless invaders, such as pollen, for deadly foes, and they mount an allergic reaction. Sometimes our defenders are caught unprepared, and we develop a cold, the flu, or worse. Occasionally some of our own cells begin the mutinous proliferation of cancer and manage to evade the surveillance of our body's defense forces. But for every successful penetration of our defenses, thousands of attempts are repelled. We sleep securely, trusting the invisible vigilantes of our immune system.

NATIONAL GEOGRAPHIC PHOTOGRAPHER JAMES L. STANFIELD

Exercise "can only help," *says Dan Turner of San Francisco. Treated for acquired immune deficiency syndrome (AIDS) for nearly five years, he is one of the disease's longest survivors. While the value of exercise for AIDS patients is unknown, some studies suggest that physical exertion increases the effectiveness of immune cells. A major component of the immune system, a helper T cell (**facing page**) is seen under attack by the AIDS virus (blue).*

For decades immunology—the study of the immune system—was a backwater of medicine. In reality we did not have the instruments to explore the battlefields within us. In the past 20 years, however, powerful microscopes and improved laboratory techniques have helped detail the strategies of both defenders and foes. By 1980 it had become clear that immunology held great promise for treating diseases as diverse as cancer and arthritis.

Then suddenly there was AIDS—a new, virulent scourge that relentlessly disarms the immune system. Into our peaceful sleep has crept a nightmare, putting the quest to understand the body's defenses on a crisis footing.

We may never know for certain how it began. The source was probably the green monkey of central Africa, which for centuries harbored a harmless virus in its bloodstream. Then, perhaps no more than 15 years ago, nature apparently altered the genetic code of the virus through the kind of random mutations it uses to evolve all species. Just as the influenza virus had once done, this new virus crossed the boundary from animal to man.

Halfway around the world in San Francisco, where I work

Peter Jaret is coauthor, with Steven B. Mizel, of *In Self-Defense* (Harcourt Brace Jovanovich, 1985), an in-depth look at recent advances in immunology. **Lennart Nilsson**'s photographs have been published in books in 20 countries. His work with pathologist Jan Lindberg appears in *The Body Victorious* (Delacorte, U. S./Bonnier, Sweden) and in a new National Geographic book, *The Incredible Machine*. Nilsson's previous works include *A Child Is Born* and *Behold Man*.

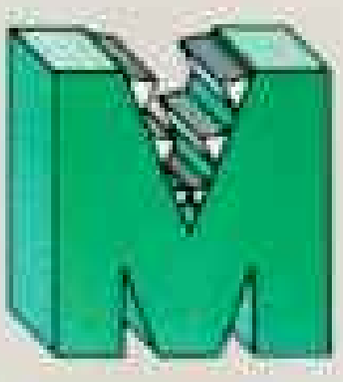
30.000 x © BOEHRINGER INGELHEIM INTERNATIONAL GMBH

CELL WARS

About one trillion strong, our white blood cells constitute a highly specialized army of defenders, the most important of which are depicted here in a typical battle against a formidable enemy.

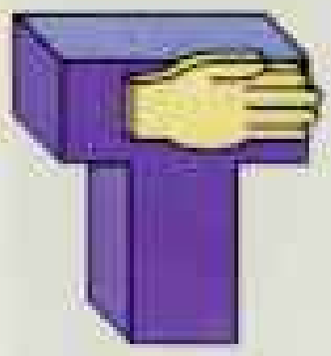
VIRUS

Needing help to spring to life, a virus is little more than a package of genetic information that must commandeer the machinery of a host cell to permit its own replication.



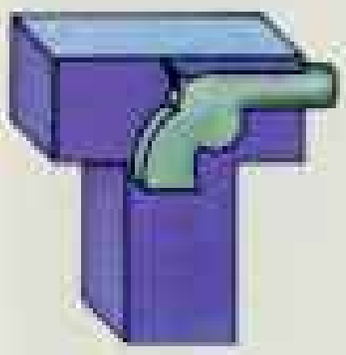
MACROPHAGE

Housekeeper and frontline defender, this cell engulfs and digests debris that washes into the bloodstream. Encountering a foreign organism, it summons helper T cells to the scene.



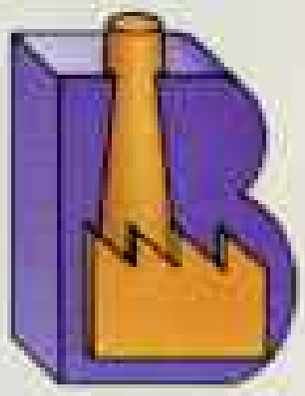
HELPER T CELL

As a commander in chief of the immune system, it identifies the enemy and rushes to the spleen and lymph nodes, where it stimulates the production of other cells to fight the infection.



KILLER T CELL

Recruited and activated by helper T cells, it specializes in killing cells of the body that have been invaded by foreign organisms, as well as cells that have turned cancerous.

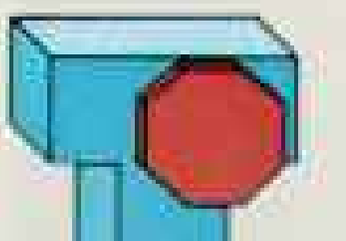


B CELL

Biologic arms factory, it resides in the spleen or the lymph nodes, where it is induced to replicate by helper T cells and then to produce potent chemical weapons called antibodies.

ANTIBODY

Engineered to target a specific invader, this Y-shaped protein molecule is rushed to the infection site, where it either neutralizes the enemy or tags it for attack by other cells or chemicals.



SUPPRESSOR T CELL

A third type of T cell, it is able to slow down or stop the activities of B cells and other T cells, playing a vital role in calling off the attack after an infection has been conquered.

MEMORY CELL

Generated during an initial infection, this defense cell may circulate in the blood or lymph for years, enabling the body to respond more quickly to subsequent infections.

1 THE BATTLE BEGINS

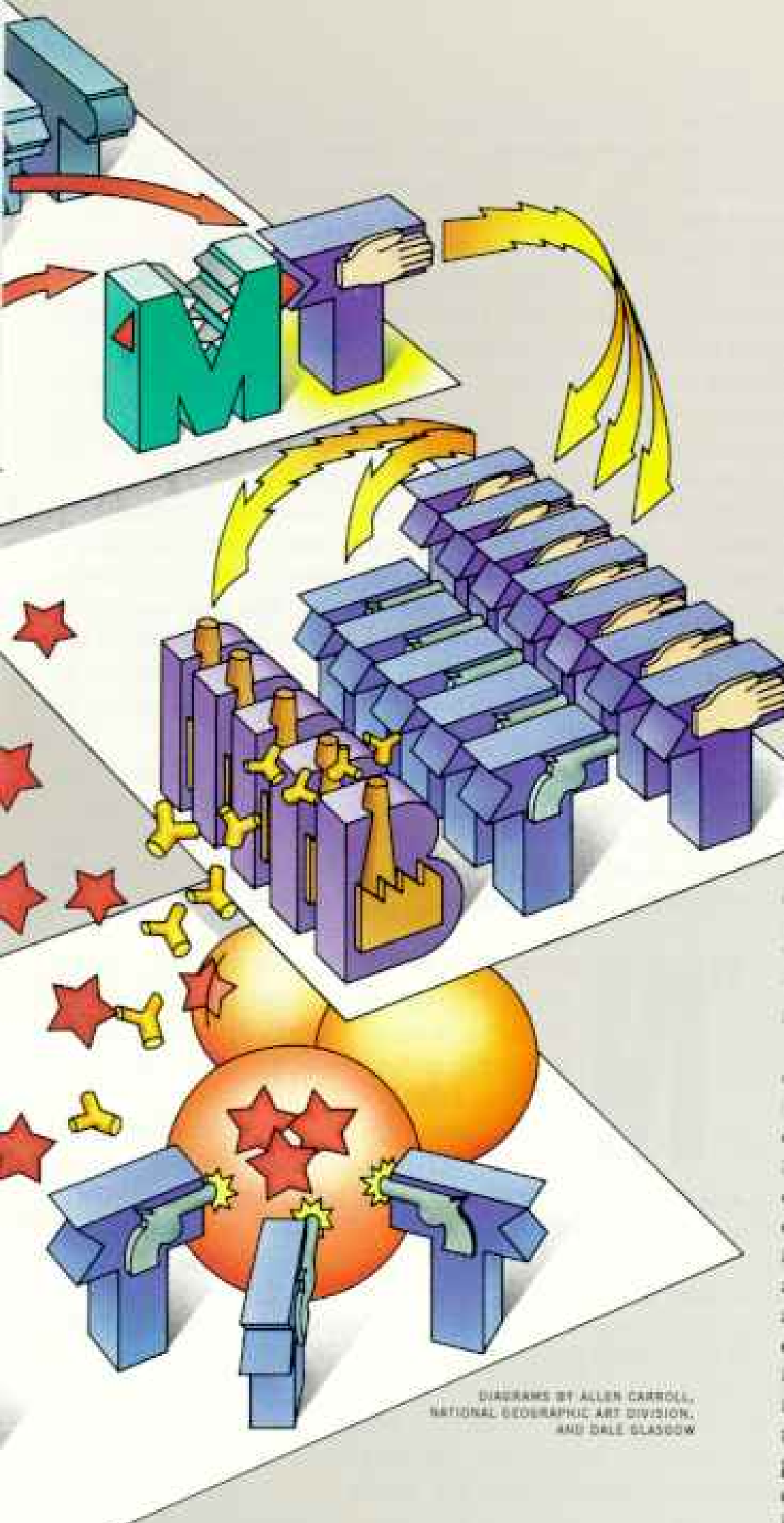
As viruses begin to invade the body, a few are consumed by macrophages, which seize their antigens and display them on their own surfaces. Among millions of helper T cells circulating in the bloodstream, a select few are programmed to "read" that antigen. Binding to the macrophage, the T cell becomes activated.

2 THE FORCES MULTIPLY

Once activated, helper T cells begin to multiply. They then stimulate the multiplication of those few killer T cells and B cells that are sensitive to the invading viruses. As the number of B cells increases, helper T cells signal them to start producing antibodies.

3 CONQUERING THE INFECTION

Meanwhile, some of the viruses have entered cells of the body — the only place they are able to replicate. Killer T cells will sacrifice these cells by chemically puncturing their membranes, letting the contents spill out, thus disrupting the viral replication cycle. Antibodies then neutralize the viruses by binding directly to their surfaces, preventing them from attacking other cells. Additionally, they precipitate chemical reactions that actually destroy infected cells.



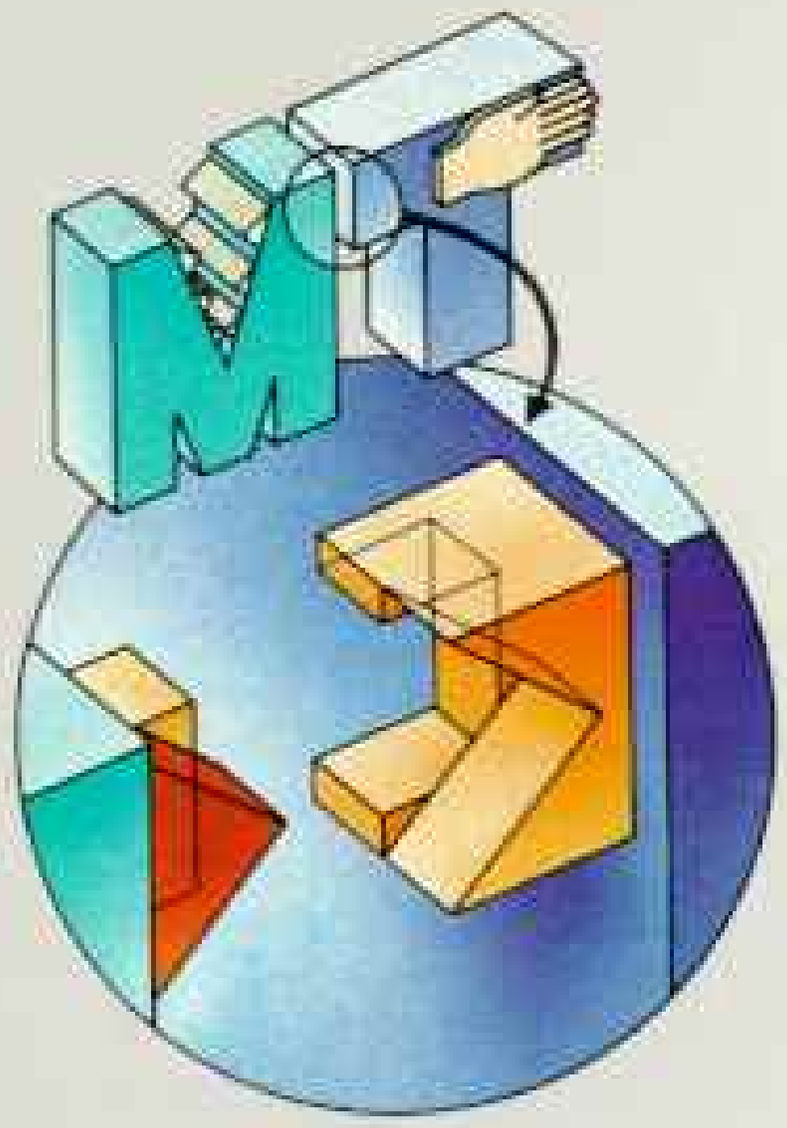
DIAGRAMS BY ALLEN CARROLL, NATIONAL GEOGRAPHIC ART DIVISION, AND DALE GLASGOW

4 CALLING A TRUCE

As the infection is contained, suppressor T cells halt the entire range of immune responses, preventing them from spiraling out of control. Memory T and B cells are left in the blood and lymphatic system, ready to move quickly should the same virus once again invade the body.

A miracle of evolution, the human immune system is not controlled by any central organ, such as the brain. Rather it has developed to function as a kind of biologic democracy, wherein the individual members achieve their ends through an information network of awesome scope. Accounting for one percent of the body's 100 trillion cells, these defender white blood cells arise in the bone marrow. They fall into three groups: the phagocytes, or "cell eaters," of which the stalwart macrophage is one, and two kinds of lymphocytes, called T and B cells. All share one common objective: to identify and destroy all substances, living and inert, that are not part of the human body, that are "not self." These include human cancer cells, which have turned from self to nonself, friend to foe.

There are four critical phases to each immune response: recognition of the enemy, amplification of defenses, attack, and slowdown. Each immune response is a unique local sequence of events, shaped by the nature of the enemies. Chemical toxins and a multitude of inert environmental substances, such as asbestos and smoke particles, are normally attacked only by phagocytes. Organic invaders enlist the full range of immune responses. Besides viruses, these include single-celled bacteria, protozoa, and fungi, as well as a host of multicelled worms called helminths. Many of these enemies have evolved devious methods to escape detection. The viruses that cause influenza and the common cold, for example, constantly mutate, changing their fingerprints. The AIDS virus, most insidious of all, employs a range of strategies, including hiding out in healthy cells. What makes it fatal is its ability to invade and kill helper T cells, thereby short-circuiting the entire immune response.



The vital union *that activates a helper T cell takes place only when the T cell recognizes both a "self" marker (rectangle) and a "nonself" antigen (triangle) on a macrophage.*

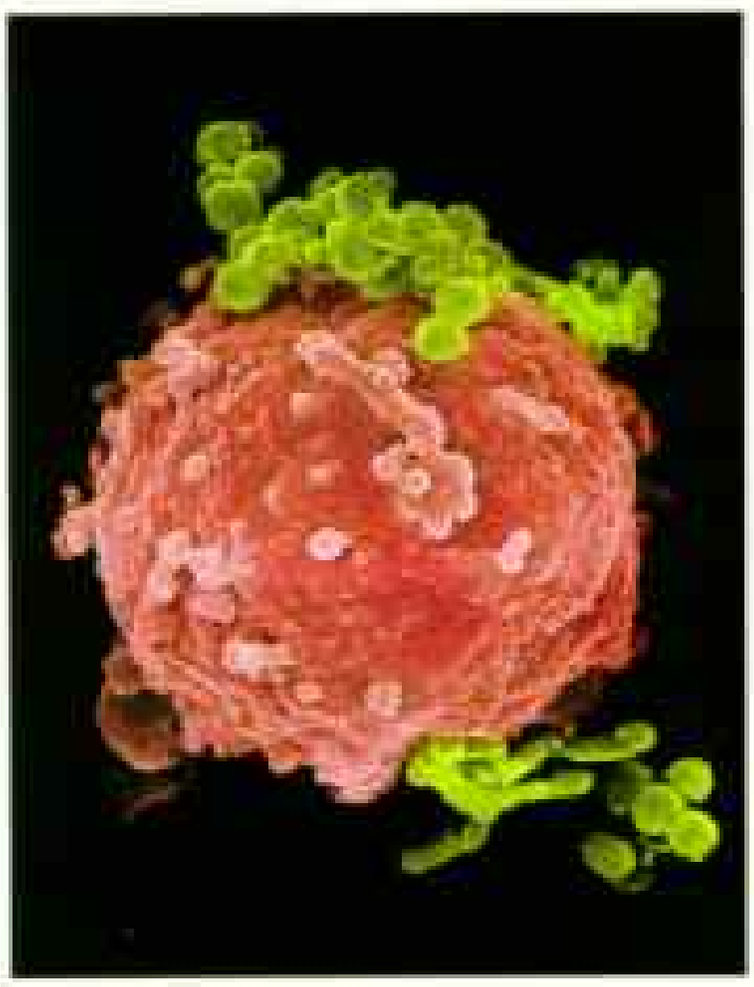
as a medical writer, the first reports began to appear in 1981—of a pattern of bizarre infections and cancer striking young, otherwise healthy men. Most of them were homosexual. Almost all were dying. There was no cure.

The headlines portrayed this new disease, quickly dubbed AIDS, almost as science fiction—some unreal Andromeda strain loosed on the world. Then a friend of mine was discovered to have AIDS, and the disease took on a human face.

Jimmy was 32 when he first noticed the dark purple spots on his arms—a rare cancer called Kaposi's sarcoma. Otherwise he seemed strong, healthy, full of life. There was no sign that the warriors within him were being decimated.

Relentlessly the cancer spread. Fungal infections took hold in his mouth and throat. Severe pneumonia choked his lungs, leaving him weak and wasted. In time the cancer blocked vessels that normally permit fluids to drain. His legs and arms swelled grotesquely. In his last weeks Jimmy moved with the frailty of an old man. At times he was too short of breath to speak. Thirty-five when finally overwhelmed by infections, he had lived much longer than most AIDS patients.

As I watched my friend succumb, I realized that the difference between Jimmy and me—a functioning immune system—was literally the difference between life and death. And, as I set out to learn more about the body's defenses, I was astounded to discover how besieged they are.



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Latecomers *in immune-system evolution, B cells, like this specimen covered with bacteria, produce armies of antibodies whose sole purpose is to attack a single kind of pathogen.*

"NATURE ABOUNDS with little round things," observed biologist Lewis Thomas. Bacteria, protozoa, fungi, and viruses. Not all round, not all friendly, they stalk us in countless forms.

Some bacteria, such as the familiar streptococci and staphylococci, continuously swarm in legions over our skin and membranes, seeking access that can cause sore throats or boils.

Or consider the bacterium *Clostridium botulinum*, the cause of botulism. This single cell can release a toxin so potent that four hundred-thousandths of an ounce would be enough to kill a million laboratory guinea pigs.

Or *Plasmodium malariae*. A single-celled parasite transmitted by a mosquito, *P. malariae* destroys red blood cells and causes the chills, high fever, and weakness that afflict 150 million malaria victims around the world.

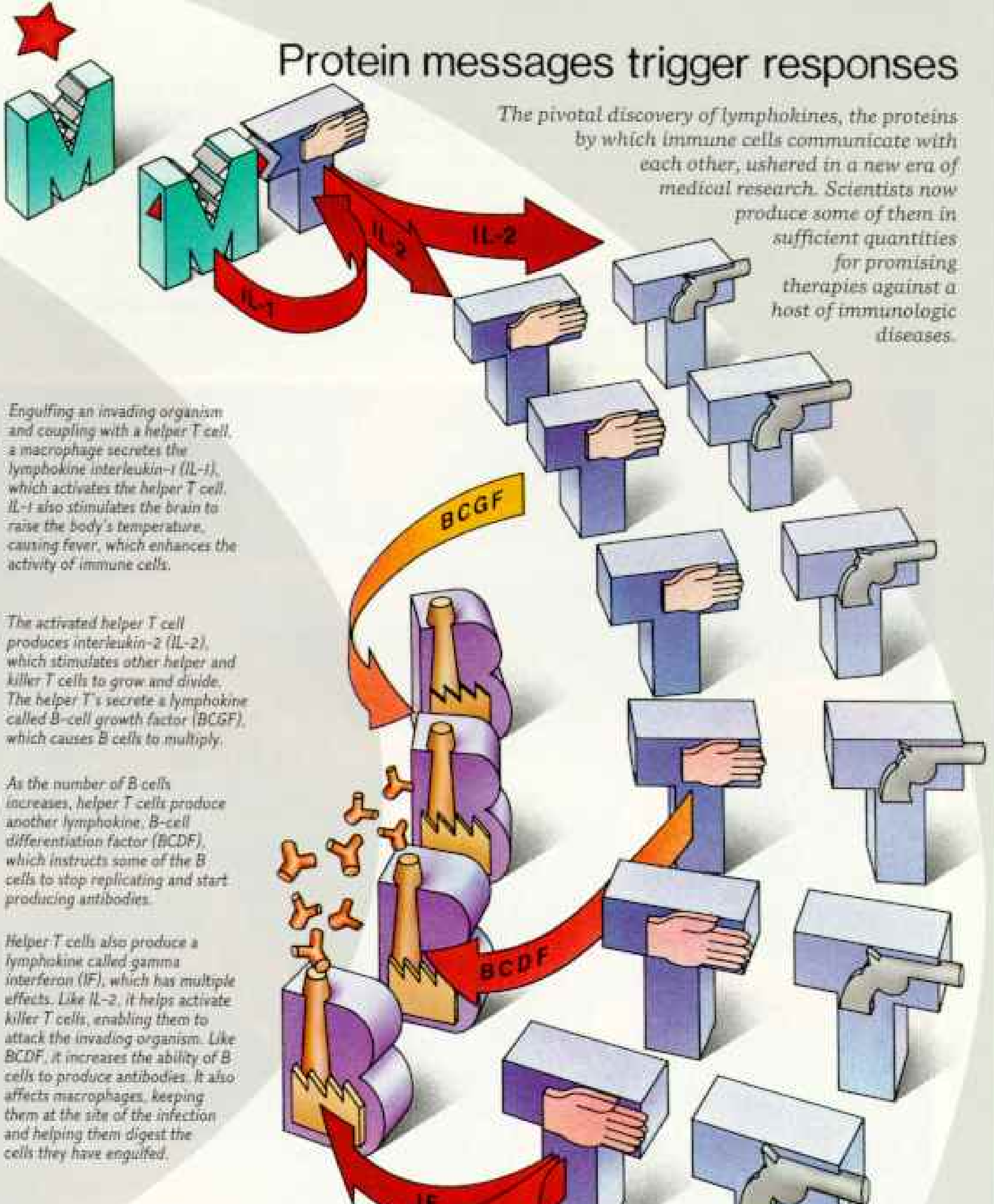
Of all the body's enemies, however, the virus is both the simplest and the most devious. A virus is a protein-coated bundle of genes containing instructions for making identical copies of itself. Pure information. Because it lacks the basic machinery for reproduction, a virus is not, strictly speaking, even alive.

But when a virus slips inside one of our cells, that bundle of genetic information works like our cell's DNA, issuing its own instructions. The cell becomes a virus factory, producing new, identical viruses. Eventually they may rupture the cell, killing it. Viral clones fan out to invade nearby cells.

"Keep in mind," said immunologist Steven B. Mizel of Wake

Protein messages trigger responses

The pivotal discovery of lymphokines, the proteins by which immune cells communicate with each other, ushered in a new era of medical research. Scientists now produce some of them in sufficient quantities for promising therapies against a host of immunologic diseases.



1 *Engulfing an invading organism and coupling with a helper T cell, a macrophage secretes the lymphokine interleukin-1 (IL-1), which activates the helper T cell. IL-1 also stimulates the brain to raise the body's temperature, causing fever, which enhances the activity of immune cells.*

2 *The activated helper T cell produces interleukin-2 (IL-2), which stimulates other helper and killer T cells to grow and divide. The helper T's secrete a lymphokine called B-cell growth factor (BCGF), which causes B cells to multiply.*

3 *As the number of B cells increases, helper T cells produce another lymphokine, B-cell differentiation factor (BCDF), which instructs some of the B cells to stop replicating and start producing antibodies.*

4 *Helper T cells also produce a lymphokine called gamma interferon (IF), which has multiple effects. Like IL-2, it helps activate killer T cells, enabling them to attack the invading organism. Like BCDF, it increases the ability of B cells to produce antibodies. It also affects macrophages, keeping them at the site of the infection and helping them digest the cells they have engulfed.*

DIAGRAMS BY ALLEN CARROLL AND DALE GLASGOW

5 *Gathering momentum with each exchange of signals between macrophages and T cells, a lymphokine cascade amplifies the immune response until the enemy is overwhelmed by sheer strength of numbers.*

On the attack, *malaria protozoa have multiplied inside two cells in a culture dish of red blood cells. One has burst open, releasing the parasites to infect other cells.*

While viruses and bacteria cause most of the common diseases in the developed world, protozoa are major threats in the undeveloped tropics, where malaria, amebic dysentery, and African sleeping sickness are widespread. The malaria parasite accounts for 15 percent of all clinical disease in Africa. As with many protozoa, part of its life cycle includes an insect host, in this case the female anopheles mosquito **(right).**

A number of potentially deadly protozoa are usually present in our bodies. Normally they are kept under control by the immune system. When the system is weakened, however, especially by malnutrition in children,

parasites become big killers. One, Pneumocystis carinii, resides quiescent in most of us. When the immune system is severely compromised, it can cause a lethal pneumonia that is a major cause of death among victims of AIDS.

11.8 (ABOVE) AND 11,500 ×, BOTH © LENNART NILSSON

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***First line** of defense against armies of dangerous microorganisms, skin tissue is able to mend itself rapidly after injury, thanks to the prompt intervention of immune cells.*

*Phagocytes rush to the site to combat invading organisms and consume the debris of damaged tissue. Other immune cells then help to stimulate the production of fibrin (**right**)—a protein, seen here covering red blood cells, that quickly closes the wound with a fibrous net.*

All of Lennart Nilsson's scanning electron micrographs in this article were transformed from black and white to color by Swedish artist-photographer Gillis Hägg, who has developed innovative color-enhancement techniques using light filters and dyes.

Forest University's Bowman Gray School of Medicine, "that a virus can create thousands of copies of itself within a single infected cell. Invading bacteria can double their numbers every 20 minutes. At first the odds are always on the side of the invader."

AT PURDUE UNIVERSITY I met one of these viral invaders face-to-face. But not before, by coincidence, I began to feel a scratchy sore throat and other symptoms of a cold. I was already sniffling and sneezing when I arrived at Purdue's life sciences building to actually confront my nemesis.

"Rhinovirus 14," biologist Michael Rossmann (page 721) said, introducing us. "One of the causes of the common cold." He handed me a multicolored sphere about the size of a softball, a three-dimensional model.

Rossmann and his colleagues selected the cold virus for study because of its relative simplicity. Nevertheless, to map the atomic structure of its surface, they had to determine exactly where each of more than 600,000 atoms was positioned in space. Purdue's supercomputer toiled a month to analyze some eight million data points. The resulting model presents a surface ridged with peaks and heavily corrugated with distinctive canyons. "Those canyons," said Rossmann, "probably let the virus grab on to the cell it will invade."

Researchers suspect that the virus roams the respiratory tract seeking a human cell with protuberances that precisely mirror the shape of its canyons. When canyon and peak meet, they lock together like pieces of a puzzle. The virus has a foothold. Quickly it injects itself through the cell membrane.

It has declared war on the immune system.

If I could have been a spectator at the viral invasion that set off my sniffling and sneezing, what would I have seen?

I would have taken comfort, first off, in knowing that of the one hundred trillion cells that make up my body, one in every

hundred is there to defend me. They are the white blood cells that are born in the bone marrow. When they emerge, they form three distinct regiments of warriors—the phagocytes and two kinds of lymphocytes, the T cells and B cells. Each has its own strategies of defense.

The first defenders to arrive would be the phagocytes—the scavengers of the system. Phagocytes constantly scour the territories of our bodies, alert to anything that seems out of place. What they find, they engulf and consume.

Phagocytes are not choosy. They will eat anything suspicious that they find in the bloodstream, tissues, or lymphatic system. In the lungs, for instance, they consume particles of dust and other pollutants that enter with each breath. They can cleanse lungs that have been blackened with the contaminants of cigarette smoke, provided the smoking stops. Too much cigarette smoking, over too long a time, destroys phagocytes faster than they can be replenished. Environmental pollutants like silica and asbestos also overwhelm them.

We can watch phagocytes at work when our skin is injured. Skin is our first defense line—until a cut allows bacteria and other microorganisms to invade. Immediately cells near the wound release substances that stimulate nearby blood vessels to dilate, causing swelling and reddening around the cut. Phagocytes flow in through the distended blood vessels, devouring the invaders. In time the body weaves threads of fibrin across the wound to restore the skin's barrier.

In my battle with the cold virus I see a troop of patrolling phagocytes happen upon remnants of a cell burst open by the fast-replicating rhinovirus 14. With gusto they gobble up the wreckage, consuming viruses in the process. But my phagocytes cannot destroy the foes fast enough to keep them from infecting nearby cells.

Now I observe a special kind of phagocyte called a macrophage. As the macrophage engulfs a stray rhinovirus, it plucks a special piece, an antigen, from the invader. It displays that

Minute invader, *a larva of one of the multicelled parasites called helminths penetrates human skin* ***(above)****. Entering the bloodstream, it lodges in the veins to reproduce, eventually causing schistosomiasis, a disabling disease that afflicts more than 100 million people worldwide. Schistosomes are able to camouflage as self by draping themselves with substances from host cells, thus avoiding detection.*

One of mankind's greatest inorganic threats, asbestos fibers ***(left)*** *are engulfed by a macrophage, which will probably die from its indigestible meal.*

small piece on its own cell surface like a captured banner of war.

That flag plays a critical role in the immune system's response: It alerts a highly specialized class of lymphocytes, the T cells. All my life a small contingent of those lymphocytes has circulated through my body, waiting for this particular cold virus. They recognize it, as the virus identified its victim among my cells, by shape. The antigens on the surface of the virus—the peaks Rossmann pointed out—fit exactly into these T cells' receptors.

HOW DID THAT PARTICULAR group of T cells know the shape of the rhinovirus 14 antigen? Their training takes place in the thymus, a mysterious pale gray gland that sits behind the breastbone, above the heart. (The T in T cell stands for thymus-derived.) This unsung little gland swells in size from birth to puberty and then begins to shrink. Somehow, as the T cells mature in the thymus, one learns to recognize the antigens of, say, the hepatitis virus, another to identify a strain of flu antigens, a third to detect rhinovirus 14, and so on.

"Most T cells die in the thymus," Mark Davis of Stanford University told me. "We don't know why. One guess is that the thymus is selecting only the best T cells, those with the sharpest powers of recognition."

And what a staggering task the thymus confronts. Nature can create antigens in hundreds of millions of different shapes. The thymus must turn out a group of T cells that recognizes each one. Remarkably, we have T cells trained to recognize even artificial antigens created in the lab—antigens the body has never encountered in its millions of years of evolution.

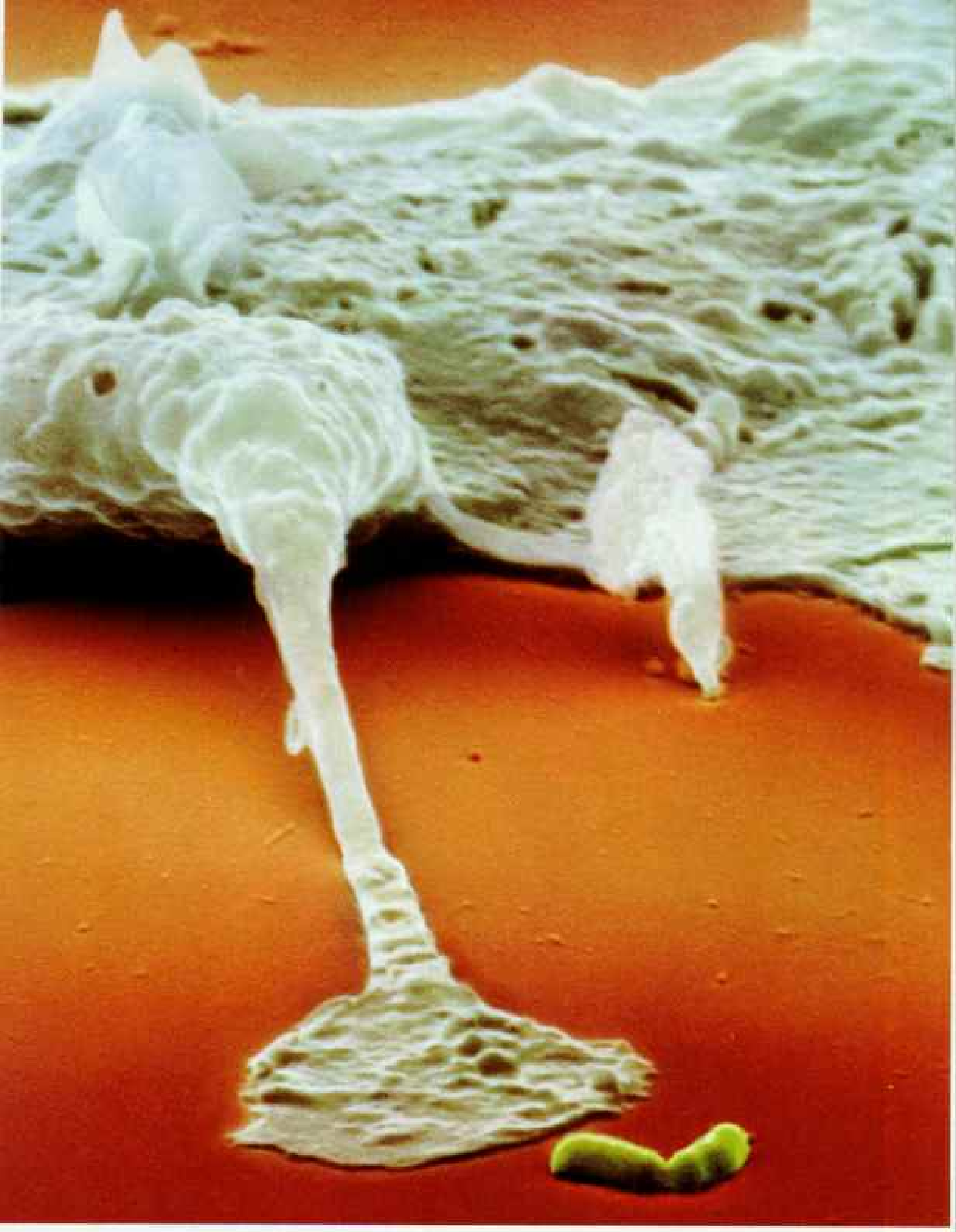
The thymus pumps out T cells by the tens of millions. Even though only a few of them may recognize any one antigen, the collective scouting force is vast enough to identify the almost infinite variety of antigens nature produces.

So diligent are our T cells that even desirable cells transplanted from one person to another are quickly recognized as foreign and destroyed. The process, called rejection, can defeat a life-saving heart or kidney transplant unless surgeons use drugs to keep the immune system at bay.

The T cells that first detect antigens, known as helper T's, carry no weapons. Rather they send urgent chemical signals to a small squadron of allies in my body—the killer T cells. The message: Multiply fast!

Like all T cells, killer T's are trained to recognize one specific enemy. When alerted by the helper T's, the squadron reproduces into an army. The killer T's are lethal. They can trigger a chemical process that punctures the cell membranes of bacteria or destroys infected cells before viruses inside have time to multiply.

Besides summoning the killer T's, helper T cells call more phagocytes into the fray. They also rush toward the spleen and the lymph nodes. There they will alert the last major regiment of my immune system, the B cells.



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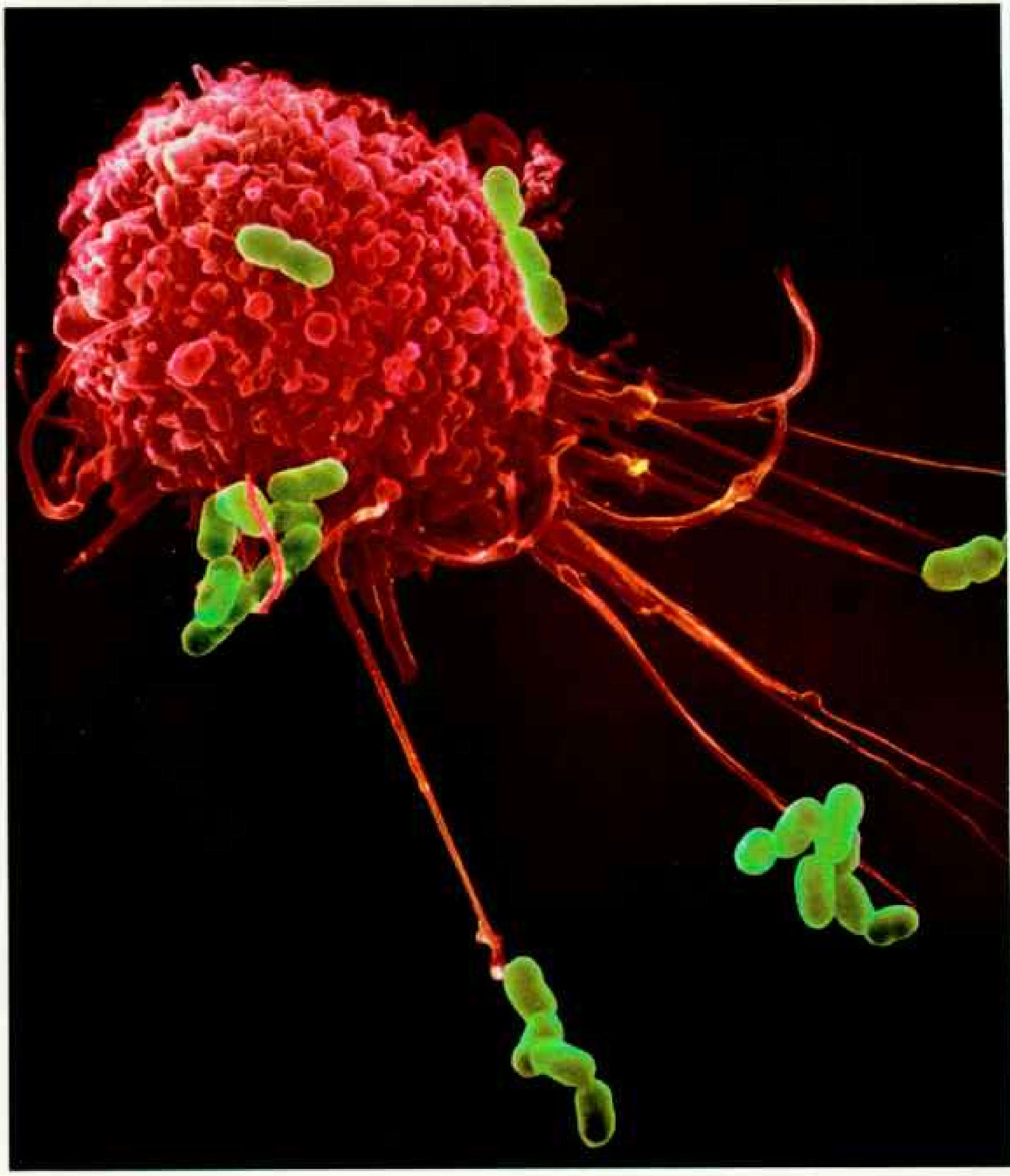
Like a vision from science fiction, *a macrophage reaches out to ensnare bacteria with a cellular extension called a pseudopod. Because they initiate and enhance the activities of other immune cells, macrophages are indispensable components of the immune system. Their discovery in the 1890s by Russian zoologist Elie Metchnikoff launched the science of immunology.*

***First step** in phagocytosis, or "cell eating," a macrophage extends several pseudopods from its single-celled form to embrace a number of* Escherichia coli *bacteria (**below**)—normally benign parasites that reside in the human digestive tract.*

*Two other macrophages are seen in a later phase of the process: Bacteria trapped within an extension of a macrophage membrane (**top right**) are absorbed one by one (**bottom right**). Powerful*



chemicals inside the macrophage will break down and destroy the components of the invading cells. The macrophage literally eats the enemy, digesting and metabolizing its materials.

Produced in the bone marrow, macrophages and other phagocytes called neutrophils are present throughout the blood and tissues of the body. Phagocytes are especially abundant in the liver, an organ with unusual concentrations of cellular debris, and in the lungs, where they cleanse the tissue of airborne pathogens and particles. In sufficient quantities, particles from cigarette smoke will destroy phagocytes.

6,000 X

4,500 X (TOP) AND 7,000 X (ABOVE); ALL © BOEHRINGER INGELHEIM INTERNATIONAL GMBH

5,000 X © BOEHRINGER INGELHEIM INTERNATIONAL GMBH

***Overzealous** immune responses, allergic reactions plague the some 35 million Americans who produce certain unnecessary antibodies. In hay fever sufferers, these bind to the surface of mast cells in mucous membranes. When allergens—which are carried by commonplace, harmless substances like pollen, dust, and animal dander—in turn bind with the antibodies, the mast cells explode, releasing chemically loaded granules (**right**). One of these chemicals, histamine, is largely to blame for the typical signs of allergy—itching, runny nose, and watery eyes.*

B CELLS MIGRATE after their birth in the bone marrow, with many of them concentrating in our lymph nodes. These small bean-shaped capsules are scattered along the intricate branchings of the lymph system. We are aware of them only during certain infections, when they become swollen and sometimes painful to the touch.

Our lymph nodes are small munitions factories, staffed by the B cells. Their product: the chemical weapons called antibodies.

By sticking to the surface of unwelcome cells, antibody molecules slow them down, making them easier targets—as well as more attractive ones—for phagocytes. Antibodies can also kill. Locking on to the enemy's antigens, which they precisely mirror in shape, the antibodies collect substances in the bloodstream called complement. When this complement comes together in the right sequence, it detonates like a bomb, blasting through the invader's cell membrane. At the peak of operation each of my B cells can churn out thousands of antibodies a second.

As my immune defenses gather, the tide of my battle with rhinovirus 14 turns. Within a week or so the invader is in retreat. Then the third member of the T-cell family takes over—the suppressor T, the peacemaker.

Suppressor T's release substances that turn off B cells. They order killer cells to stop the fight. Suppressor T's even command helper T's to cease and desist.

The battle is won.

In the aftermath phagocytes range over the area, cleaning up the litter of dead cells and spent substances. Tissue damage is repaired. The threat is over—but not forgotten.

Most of the T and B cells recruited for battle die off within days of an infection. But a large contingent will lead long lives. Before this rhinovirus's assault only a few sentries were trained to spot the invader's antigen. Now I have a virtual army of

so-called memory cells. Cold viruses, as well as the flu and other viruses, can bear many subtly different antigens. If a different form of the virus invades, I may still catch a cold. But should rhinovirus 14 return, I will defeat it without so much as a sniffle.

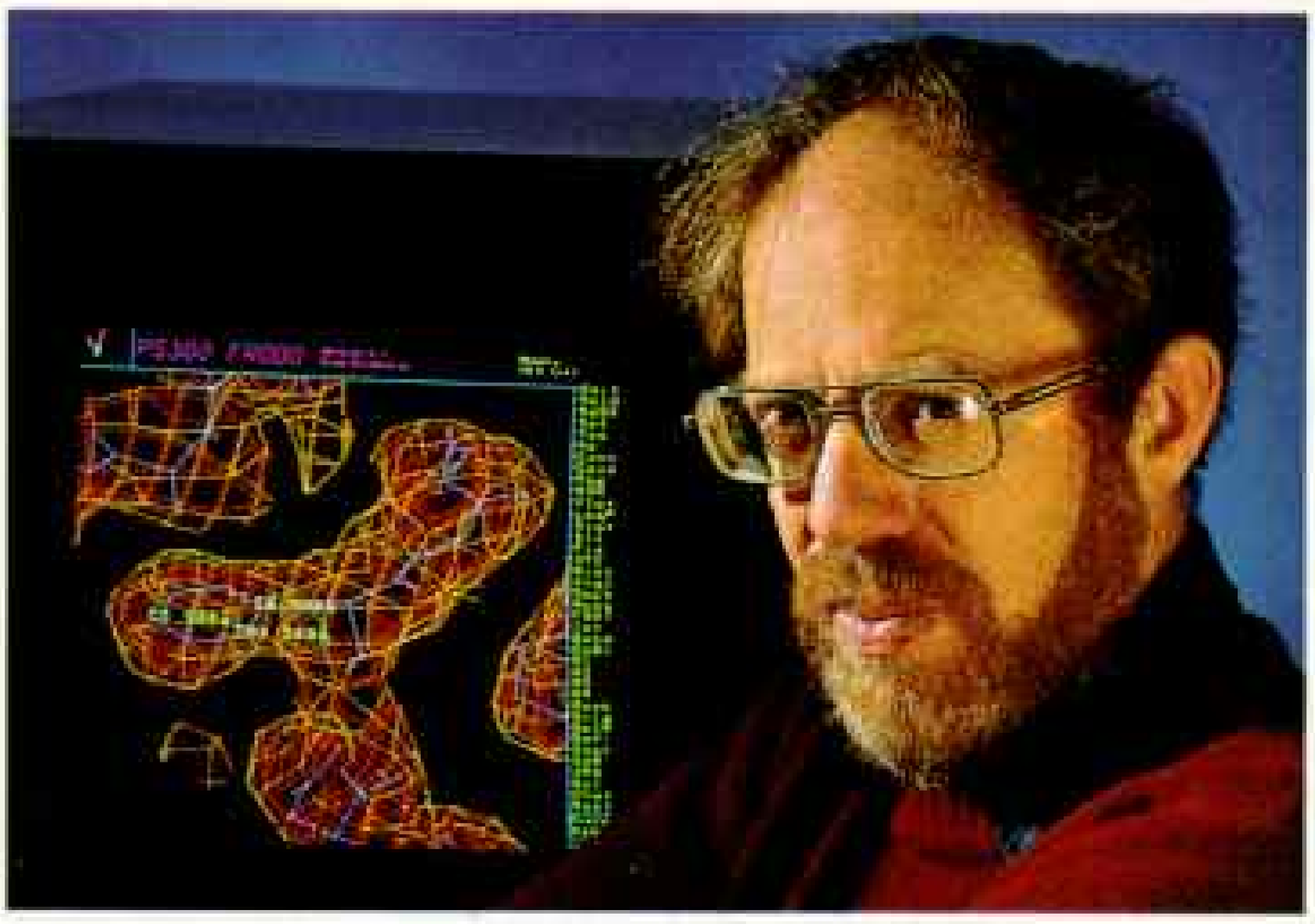
I am immune.

CONTAGIOUS MICROBES swarm around us all. Why did I catch cold while the woman next to me on the plane to Indiana avoided it? Why do only some of the people exposed to the AIDS virus develop the disease?

We don't have all the answers. Beyond mere exposure, enough enemy troops must invade to mount an effective attack. Even the route of attack matters. Certain disease agents, like the viruses of hepatitis B and AIDS, must get into the bloodstream swiftly. Exposed to the air, these viruses lose their power. For that reason they are extremely difficult to contract except through the intimate exchange of blood or semen. Other viruses—of flu and cold, for instance—are airborne and much hardier. Stress or the simultaneous presence of other microbes may make us more vulnerable.

Even more puzzling than AIDS is a devastating category of diseases called autoimmune disorders. In these diseases the immune system fails to recognize certain cells or parts of cells as our own, and it begins attacking the body it was designed to protect. In rheumatoid arthritis, for example, an immune response is mounted against the tissue and bones around our joints. The attack can leave bones pitted and scarred. The muscles of the heart come under siege in rheumatic fever. And in a rare disease called systemic lupus erythematosus, the immune system's assault can escalate into the destruction of skin, kidneys, and joints.

Making another error of recognition, the immune system sometimes mounts battles against imaginary enemies. Thousands of harmless substances—pollen, animal dander, even dust—carry the so-called allergens that cause allergic reactions



BILL BALLENBERG

10,300 X © BOEHRINGER INGELHEIM INTERNATIONAL GMBH

"Very devious" is how Michael Rossmann (left) of Purdue University describes rhinovirus 14—one of a hundred or so cold viruses, which constantly mutate to avoid detection. Using new techniques, he and his colleagues were able to map the topography of rhinovirus 14's surface, partly seen on the screen, and construct the first atomic model of a human virus.

*Just how totally viruses can overcome a healthy host is seen when an infected human cell ruptures (**above**), releasing a stream of new viruses (tinted blue) into the system.*

Attacking self cells as if enemies, *a renegade immune system has ravaged the femur (surgically removed) of a 50-year-old woman suffering from rheumatoid arthritis—the most common of several autoimmune disorders, which also include multiple sclerosis. Many convergent factors are believed to play a role in these diseases, including genetic predisposition and the presence of certain viruses.*

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in some 35 million Americans. Most allergies are mild. Others, like the allergic reaction to insect venom, can be strong enough to kill.

An allergen itself poses no threat. Some people can be exposed to pollen with no reaction at all. Hay fever sufferers happen to have antibodies that mistakenly recognize pollen as an enemy. Their reaction causes cells in our tissues to spill potent chemicals, such as histamine, that create a broad range of allergy symptoms. T cells may make matters worse by ordering B cells to produce more antibodies. The sniffles and runny nose of hay fever, just like the rash and itch of poison ivy, are simply the sound and fury of an overreacting immune system.

Since many allergies appear to be inherited, immunologists suspect that certain genes control how we respond to allergens. For most of us such immune-response genes halt the reaction to an allergen before it really gets started.

TWENTY YEARS AGO no one could have explained allergies or detailed my battle with rhinovirus 14. Until the late 1950s, immunologists had no idea how antibodies were produced. The distinction between T and B cells only became clear in the 1960s. Macrophages are still revealing new and surprising roles. Indeed, had AIDS struck 20 years ago, we would have been utterly baffled by it.

True, AIDS continues to kill despite one of the most concentrated research efforts ever mounted against a single disease. In San Francisco alone, AIDS claims two people a day. Two more learn that they have the disease. Across the country, nearly 20 people a day now die of AIDS.

But we have learned a great deal about this virus.

"There is one simple reason why the AIDS virus is so deadly," said Robert Gallo (page 732) of the National Cancer Institute in Bethesda, Maryland. "It kills the one lymphocyte most critical to the immune response: the helper T cell."

Gallo, one of the pioneers of AIDS research, was between planes when I met him at the San Francisco airport—on his way from a lecture in San Diego to research meetings in Japan. In a quiet corner of the airport lounge he described one of the ways the AIDS virus might operate.

Like Greeks hidden inside the Trojan horse, the AIDS virus enters the body concealed inside a helper T cell from an infected host. Almost always it arrives as a passenger in blood or semen.

In the invaded victim, helper T's immediately detect the foreign T cell. But as the two T's meet, the virus slips through the cell membrane into the defending cell. Before the defending T cell can mobilize the troops, the virus disables it.

Some researchers believe the AIDS virus also may change the surface of helper T cells in such a way that they fuse together. That strategy makes it even easier for the virus to pass from cell to cell undetected.

Once inside an inactive T cell, the virus may lie dormant for months, even years. Then, perhaps when another, unrelated

infection triggers the invaded T cells to divide, the AIDS virus also begins to multiply. One by one, its clones emerge to infect nearby T cells. Slowly but inexorably the body loses the very sentinels that should be alerting the rest of the immune system. Phagocytes and killer cells receive no call to arms. B cells are not alerted to produce antibodies.

The enemy can run free.

RARELY in modern times have we witnessed so swift and deadly an epidemic as AIDS. But for all its fury AIDS had claimed fewer than 10,000 lives in the United States by the end of 1985, the fifth year of the epidemic. That number is sure to rise. Even so, AIDS will almost certainly never equal the destructiveness of a killer that last year alone accounted for 460,000 deaths. Indeed, three out of every ten Americans will fall victim to the ravages of cancer.

"I think of cancer as being too alive," says a victim of the disease in David Leavitt's short story "Counting Months." "The body just keeps multiplying until it can't control itself. So instead of some dark interior alien growth that's killing me, it's that I'm dying of being too alive, of having lived too much."

Leavitt's passage captures a poignant contradiction of cancer: the body becoming its own worst enemy.

We do not know why a normal cell turns traitor. Many researchers believe that potential cancer cells arise constantly within us. As they turn cancerous, the antigens on their surfaces may change slightly—just enough to alert vigilant T cells. Ceaselessly the immune system seeks out and destroys these mutinous cells.

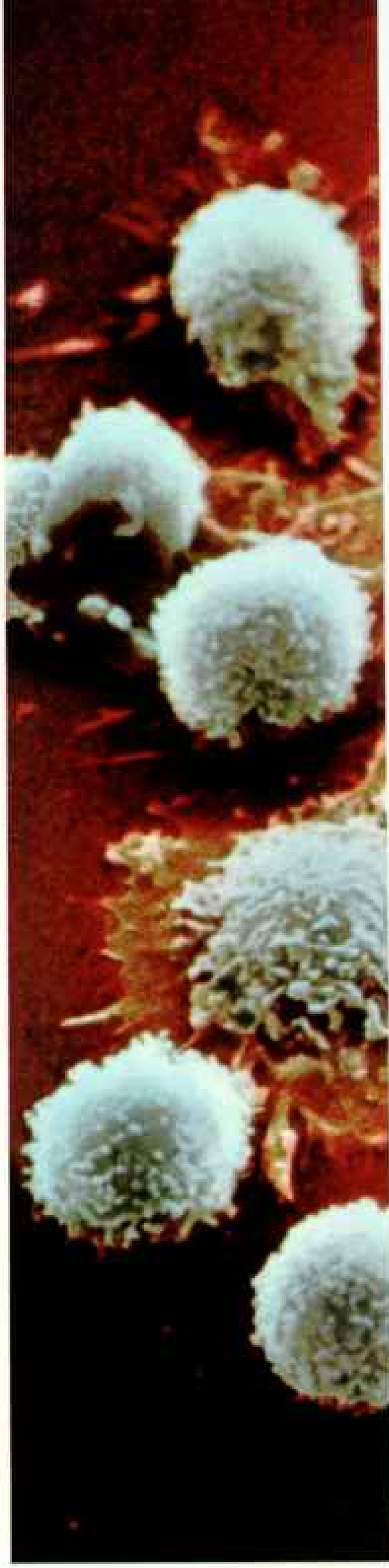
Sometimes, however, the mutineers survive to cause disease. Fortunately, as part of the war against cancer, we have begun to develop remarkable new defensive weapons—an arsenal borrowed from the immune system itself.

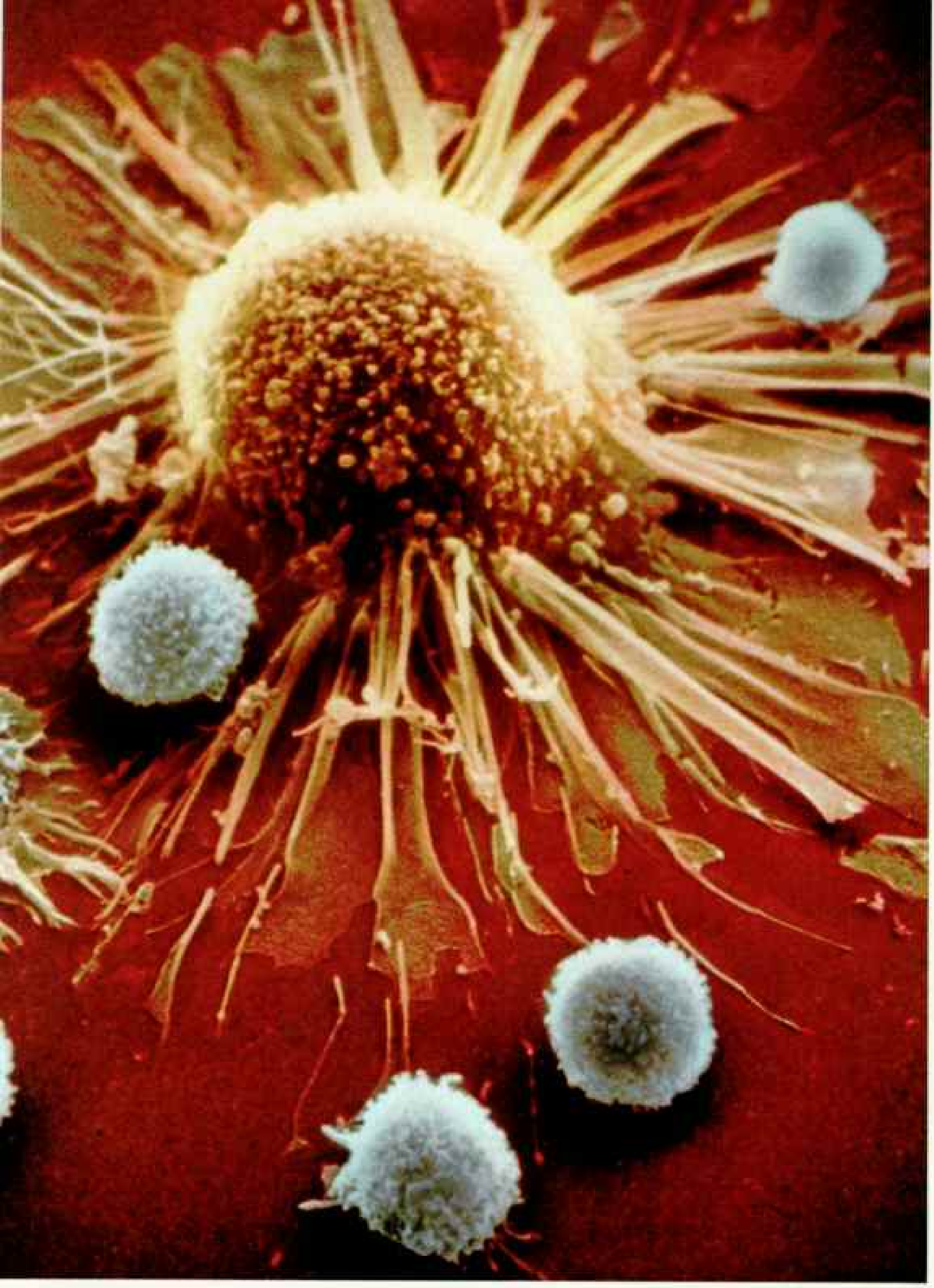
We are learning, for one thing, to make biologic guided missiles that can home in on cancer cells. Researchers can grow cells called hybridomas in the laboratory that produce unlimited amounts of specific antibodies. These monoclonal antibodies can be selected to lock on to specific types of cells.

"In effect, monoclonal antibodies allow us to explore the human body cell by cell," said Meenhard Herlyn of the Wistar Institute of Anatomy and Biology in Philadelphia.

"Monoclonal antibodies can seek out cancerous cells," researcher Jonathan Uhr of Dallas's Southwestern Medical School explained. "Tag that monoclonal antibody with a radioisotope, and in the image on a screen you can see the tumor lighting up in the patient. Arm that antibody with a powerful toxin, and it should be able to single out and kill the cancer cell, leaving innocent bystanders untouched."

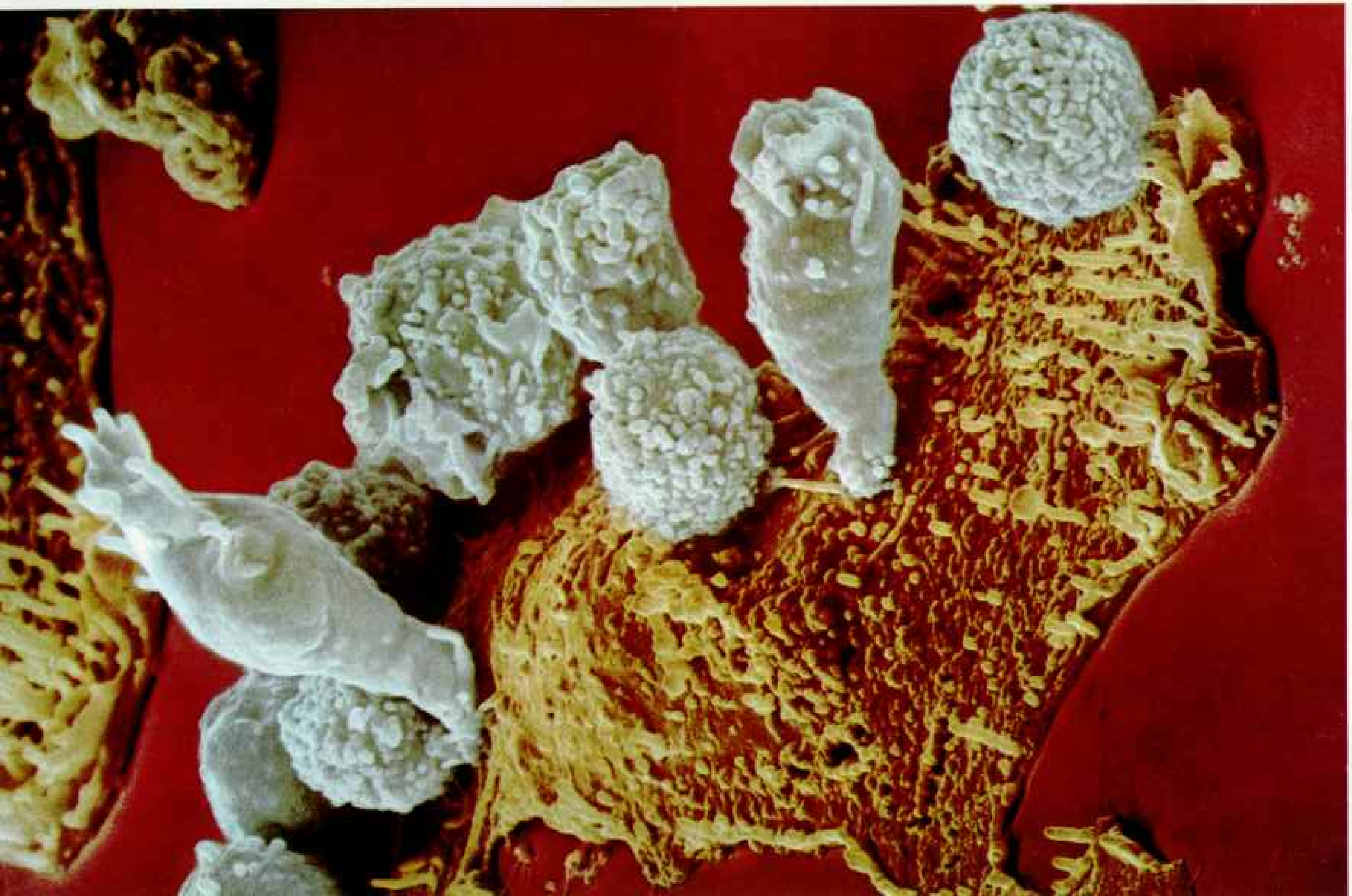
Man-made antibodies may one day also be used to destroy other unwanted cells—B cells involved in destructive allergic reactions, for instance. Or T cells that turn against our own tissues as in rheumatoid arthritis.

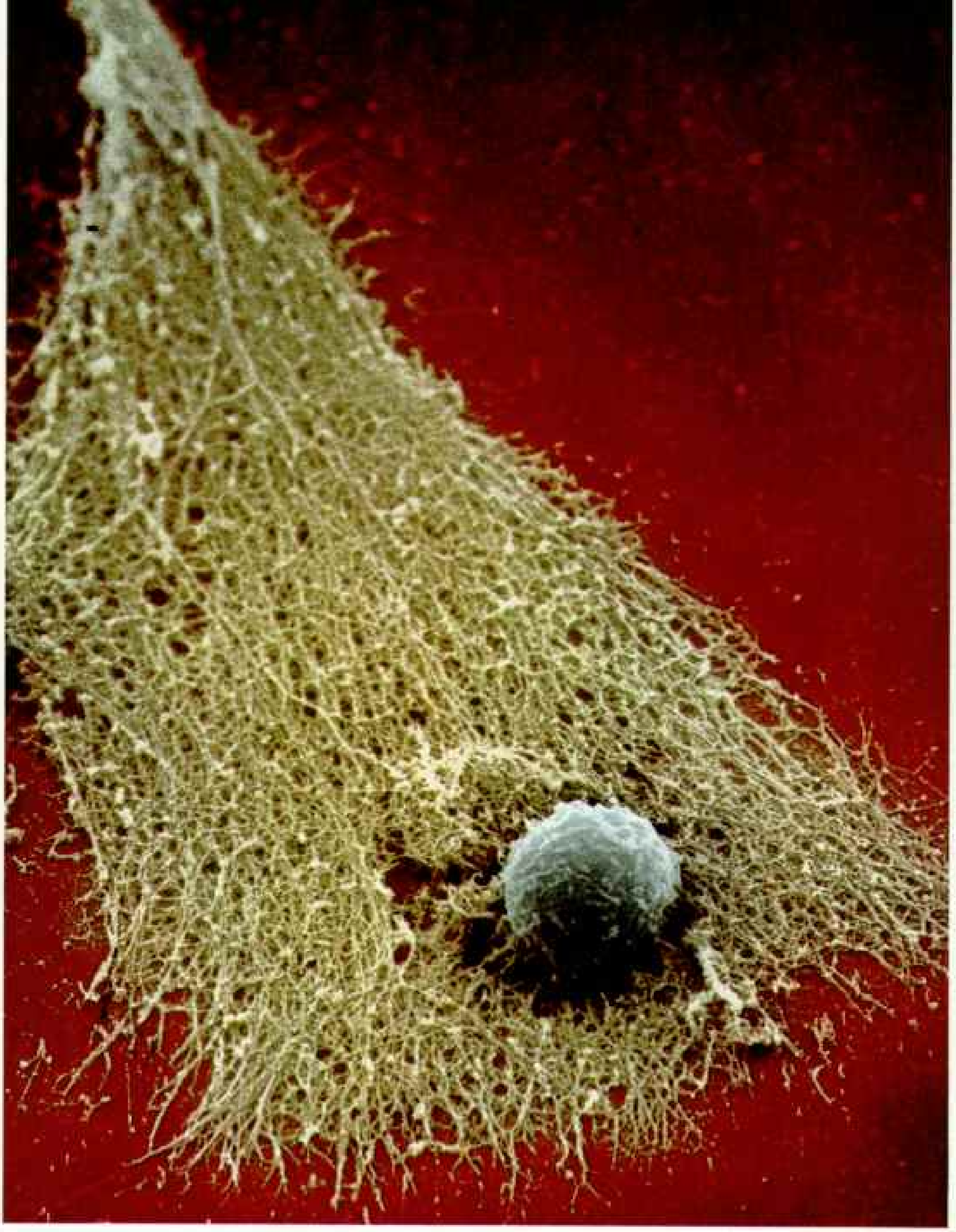




1,000 x © BOEHRINGER INGELHEIM INTERNATIONAL GMBH

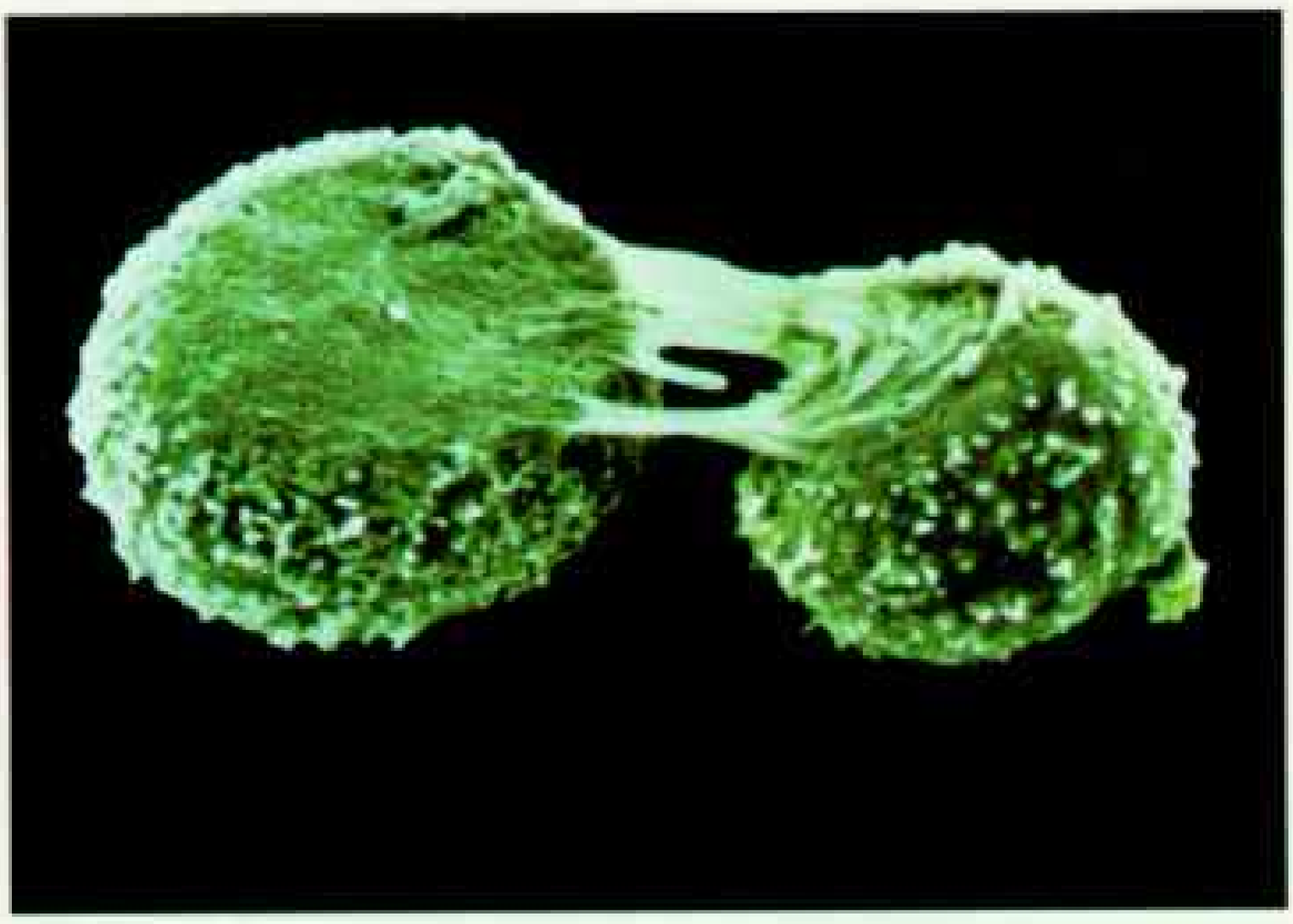
Mutiny in the body *is a constant occurrence, many believe, as healthy cells somehow escape the mechanisms that regulate cell growth and turn cancerous. Fortunately, antigens on their surfaces sometimes alter slightly, changing from self to nonself. Thus the cells become targets for killer T cells like those surrounding this large cancer cell. When the unregulated cells elude detection, they cause cancer.*





10,000 X (LEFT) AND 7,000 X, BOTH © BOEHRINGER INGELHEIM INTERNATIONAL GMBH

Frozen in action, *killer T cells appear remarkably alive as they attack a cancer cell* ***(left)****, although they were necessarily killed in preparation for the scanning electron microscope. Several of the normally round T cells acquire the elongated shape of active fighters as they subject their target to chemical attack, breaking down the cell membrane. After a cancer cell loses its cytoplasm, only a fibrous cytoskeleton is left, here surrounding a T cell* ***(above)****. Scientists are just now learning how to use the immune system's chemical code words, or lymphokines, to boost the body's natural defenses against cancer. Tumor necrosis factor, for example, has the power to destroy some tumors, while gamma interferon spurs the production of active killer T cells.*



Cloning *a new antibody factory, a laboratory-produced B cell divides. Created by fusing healthy B cells with cancerous ones, such hybrid cells, or hybridomas, divide out of control, each one of them a production line for biologic guided missiles capable of targeting specific antigens. Armed with toxins, they should be able to destroy cancer cells, leaving surrounding cells undisturbed. Though still largely experimental, monoclonal antibodies, as they are called, represent one of immunology's most exciting frontiers.*

9,000 X; PHOTOGRAPH © DAVID SCHARF

AT THE NATIONAL INSTITUTES of Health (NIH) in Bethesda, researchers have created another weapon against cancer—a brigade of man-made killer cells. Nowhere is the distance between basic research and clinical application shorter than at Building 10, the NIH Clinical Center. On each floor two corridors run parallel—one for research laboratories, the other for patients' rooms.

"The architect's idea," an NIH researcher told me, "was that investigators could draw a specimen from a patient, carry it across to a lab, and return with a flask containing the cure."

In the last weeks of 1985 that flask held a promising new cancer treatment. The investigator who carried it was NIH physician Steven A. Rosenberg.

I met Rosenberg a few weeks before a storm of publicity would trumpet the news of his research around the world. The busy doctor sandwiched me into an overload of appointments. Using a substance called interleukin-2, he told me, his research team was showing some early success in treating cancer.

Produced by the immune system, interleukin-2 is a lymphokine, one of a dozen or so known chemical "words" with which immune cells communicate during battle. When helper T cells encounter an enemy, they release a spurt of interleukin-2 that commands other lymphocytes to multiply.

Could interleukin-2 be used to artificially rally the immune system in its fight against malignant cells?

The answer is yes—but in a way that surprised even Rosenberg. Thwarted in his attempts to inject interleukin-2 directly into the body (even in high doses the substance quickly disappears from the bloodstream), he went the other way around. He removed inactive lymphocytes from mice with cancer and cultured them in an interleukin-2 solution.

Rosenberg soon discovered that he had created an army of super cancer killers. Injected back into the mice, along with

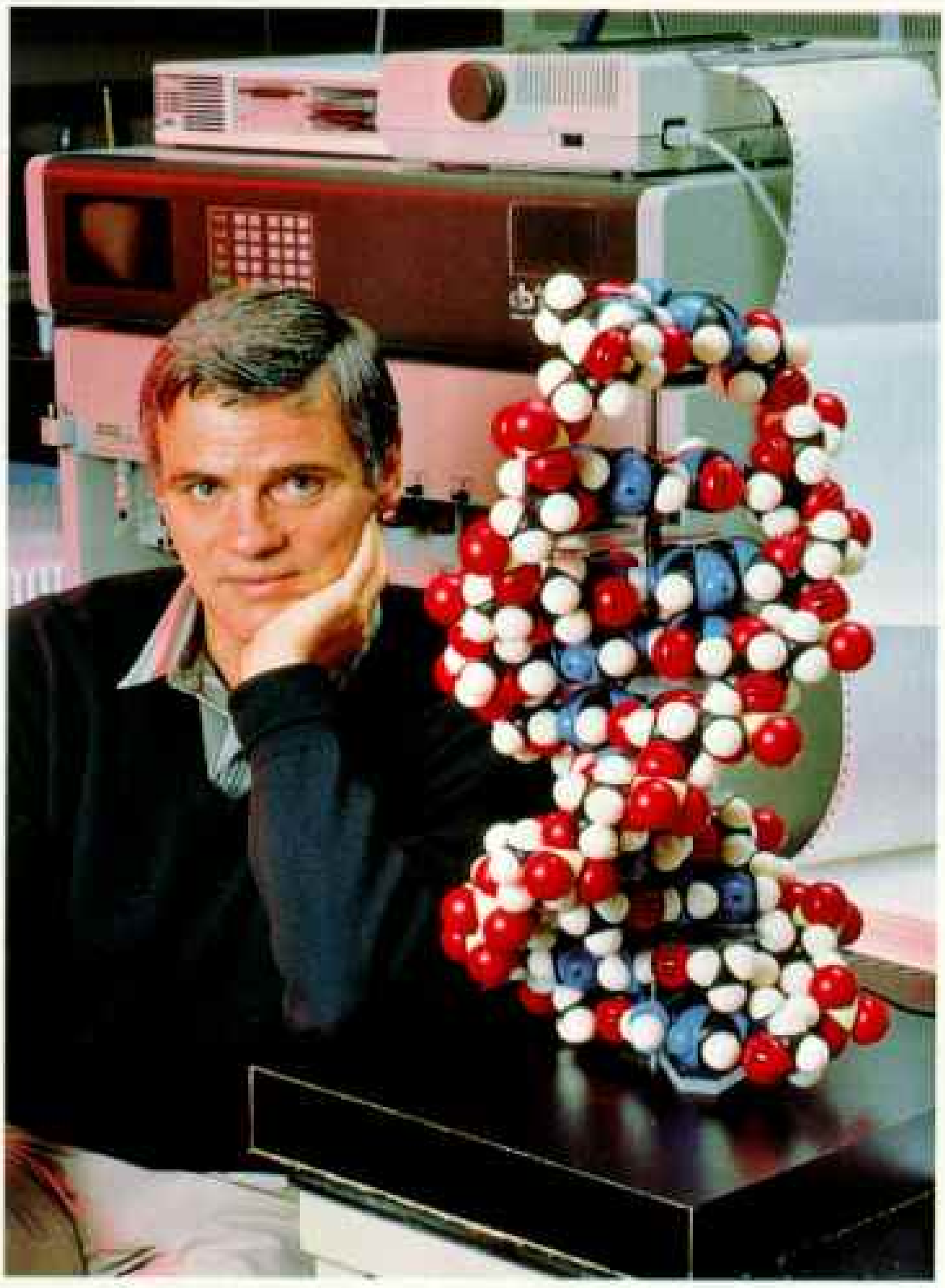
enough interleukin-2 to keep them growing, these cells swiftly attacked cancer cells. Tumors began to shrink. In some cases cancer disappeared entirely.

Rosenberg refers to these artificially created warriors as "lymphokine-activated killer cells." They may not even occur naturally in the body. No matter. They were killing cancer cells. And, in the closing weeks of 1985, news reports heralded the breakthrough: These supercells were wiping out tumors in human patients. Not in all of them, to be sure. And Rosenberg cautioned that the results were preliminary.

"But I have patients for whom all other treatments had failed; they were dying," said Rosenberg. "And they're alive today."

Ironically, even with sophisticated tools like monoclonal antibodies and lymphokines, we are still struggling to match the achievement of an English country physician who, 200 years ago and with no knowledge of the immune system, scored one of medicine's greatest triumphs.

Edward Jenner had no idea how or why his method worked. He only knew that people who came down with cowpox, a relatively mild infection, seemed protected against the far more serious infection of smallpox. Jenner's conclusion was simple:



GEORGE OLSON

Genetic architect, *biologist Leroy Hood of the California Institute of Technology displays a model of a gene fragment produced by the DNA synthesizer behind him, which he helped design. Hood's interest lies with those genes that contain the blueprints for the receptors on human cells that trigger immune responses. "By knowing their makeup," he says, "we will be able to manipulate the immune response, making it more effective in cases where it needs to be bolstered and suppressing it where it overreacts."*

Infect people with cowpox in order to protect them against smallpox.

The method worked. (It later gave rise to the term vaccination—borrowed from the Latin *vacca*, or cow.)

"Jenner's smallpox vaccine remains the most effective vaccine ever produced," said Bernard Moss, a virologist at NIH. "It actually eradicated a virus. Smallpox is the only disease that has been completely wiped off the face of the earth."

Jenner's triumph depended on a stroke of biologic luck. The virus that causes cowpox closely resembles that of smallpox—so closely that the immune system cannot tell them apart. Innoculated with cowpox, Jenner's patients developed the mild illness. Afterward, memory T and B cells provided immunity against both cowpox and its relative, the smallpox virus.

EIGHTY YEARS LATER, Louis Pasteur discovered the scientific principle behind vaccines. Again, luck played a part. Pasteur accidently left a culture of chicken-cholera bacteria out on a shelf. Two weeks later, returning from vacation, he injected the culture into several laboratory animals. The animals did not develop the disease. But they became immune.

Accident led to insight. Pasteur realized that he had weakened the bacteria in the culture just enough, and in just the right way, that they lost the power to cause disease but retained the power to confer immunity.

Later researchers tried a variety of ways to weaken viruses and bacteria. They dried them, heated them, broke them up into pieces. Sometimes the treated organisms lost their power to cause not only the disease but immunity to the disease as well. At other times they remained strong enough to engender full-scale illness.

In 1885 Pasteur developed a vaccine against rabies, but it was not until 1925 that researchers were able to create a reliable diphtheria vaccine. Another 12 years went by before the development of a vaccine against yellow fever. More recent are the combined diphtheria, pertussis, and tetanus (DPT) vaccine and vaccines against polio, mumps, and hepatitis B.

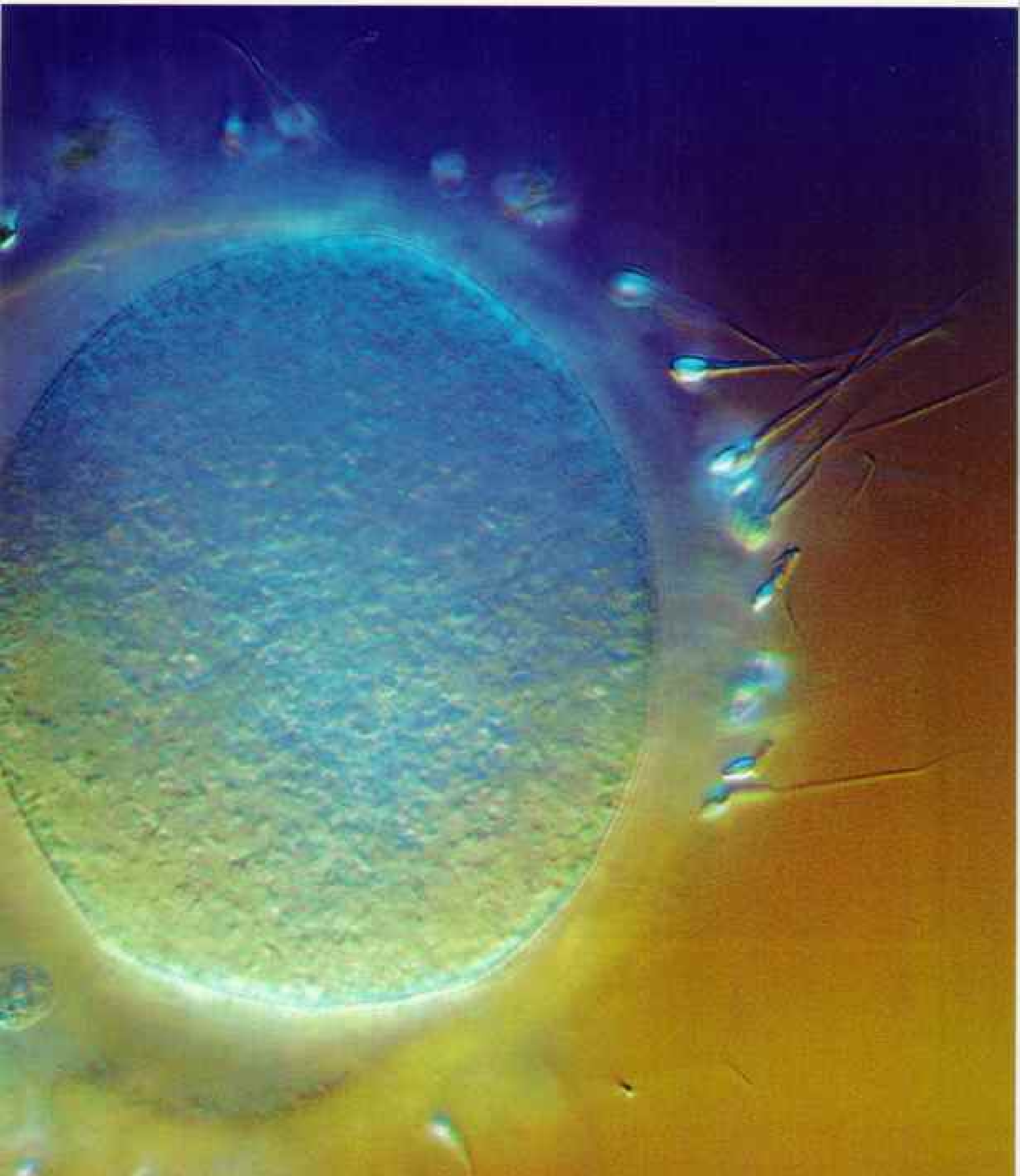
But today we may be on the verge of a new era in the creation of vaccines.

Genetic engineers can now dissect from an organism's genes the segment that blueprints its antigens. They then place those pieces of DNA into bacteria. As the bacteria multiply, they produce large quantities of antigen—in essence, a pure vaccine. Injected into the body, the antigen induces immunity.

Genetic engineers can also go the other way around—splicing out from a virulent microbe the genes that cause disease. Disarmed, the virus will trigger immunity but not illness.

Another approach is a provocative marriage of the smallpox vaccine with the latest biotechnical wonders.

"Smallpox is a very easy vaccine to administer," said NIH's Moss. "It's stable when it's dry. You don't have to keep it in a refrigerator. You can put it in your shirt pocket, go off to some



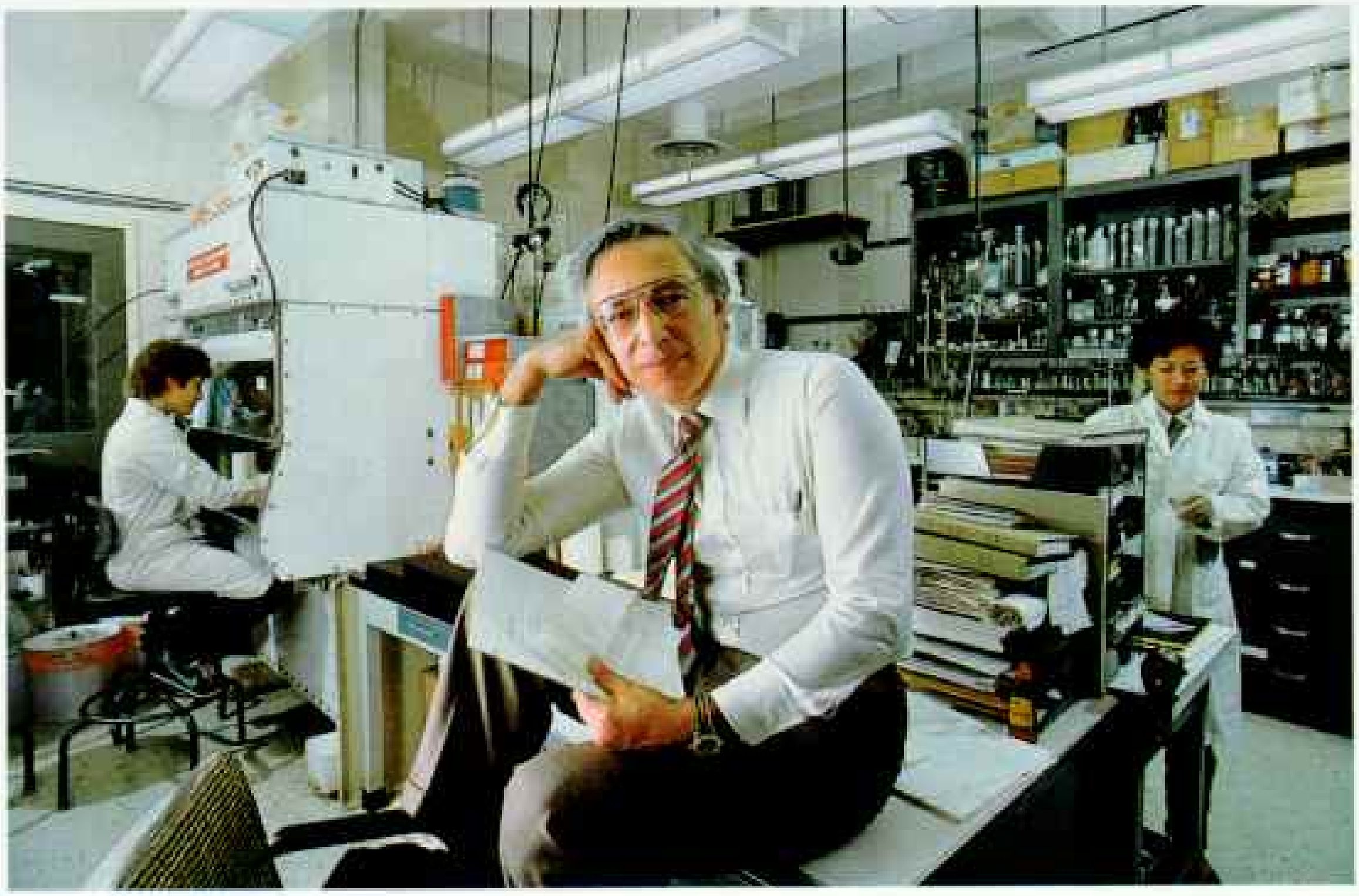
1,300 X © LENNART NILSSON

Masters of subversion, *human sperm cells seek to penetrate an ovum. Foreigners in a hostile body, they employ several strategies to survive their mission, including a fluid coating that may hide their antigens. If conception occurs, the egg has an even harder job, since it is marked as foreign and targeted for destruction throughout its nine months of development. The placenta allows the passage of vital oxygen and nutrients, but not blood, which is laden with immune cells. Understanding how sperm and fetus elude attack may help scientists develop new contraceptives and treat infertility.*

remote village, scratch it into someone's skin, and he's vaccinated. Our idea is to use the smallpox vaccine as a base in the preparation of other vaccines."

Moss and his colleagues have spliced into the vaccine the genes for the antigens of other diseases, including malaria, hepatitis, and rabies. Field tests soon will establish if Jenner's hardy, two-centuries-old vaccine, carried in a shirt pocket, can spark more revolutions.

Like many of the researchers I talked to, Moss tempered excitement with caution. "Just a few years ago there was talk that the era of infectious disease was over," he reminded me. "Yet today the end still seems far down the road."



JAMES L. STANFIELD

***In the center** of a storm, Robert Gallo and his colleagues at the National Cancer Institute in Bethesda, Maryland, are learning more every day about the deadly AIDS virus, which they isolated in 1983—about the same time as did a research team at Paris's Institut Pasteur. As the epidemic gains momentum, the pressure rises to develop a vaccine and find a remedy. Says Gallo: "I believe we will. I have to believe that."*

"WE PROBABLY know as little about the immune system now," said researcher Edward Bradley of the Cetus Corporation, "as Columbus knew about the Americas after his first voyage." Into what territories will the new frontiers of immunology lead us? Almost certainly deep into the nucleus of the human cell, where lie the elegant DNA spirals that make one cell a macrophage, another a T cell.

"We've gained a good understanding of the hardware of the immune system," Leroy Hood (page 729) of the California Institute of Technology told me. "But we know almost nothing yet about the software that runs the system—the genes that tell our cells what to do."

We also are beginning to suspect that a crucial role of our

immune cells may be communication. As Jay Levy, professor of medicine at the University of California at San Francisco, told me: "The cells of the immune system are constantly exchanging information with other cells. It's as if they're talking, comparing notes, perhaps even arguing about what should be done. Defense may be only one part of the job.

"An immune cell bumps into a bacterial cell and says, 'Hey, this guy isn't speaking our language, he's an intruder.' That's defense. The other job may be keeping each part of the body in touch with every other part."

Consider the macrophage. Since its discovery a hundred years ago it has been regarded as a big, primitive garbage collector. No longer.

"We know the macrophage is everywhere within us," NIH immunologist Michael Ruff explained. "It may be a critical agent in a vast communications complex, one that links not only the cells of the immune system but also hormone-producing cells, nerve cells, even brain cells.

"Macrophages can respond to the chemical messengers created by brain cells. Even more astonishing, they can produce many of those same chemicals. So there seems to be talking back and forth between the brain and the immune system."

Perhaps that isn't so surprising. After all, stress can actually make us sick. And many researchers believe a positive outlook can sometimes help us recover, even from serious illnesses.

Immunologists are discovering more about the links between the mind and body, the mechanisms of psychosomatic disease.

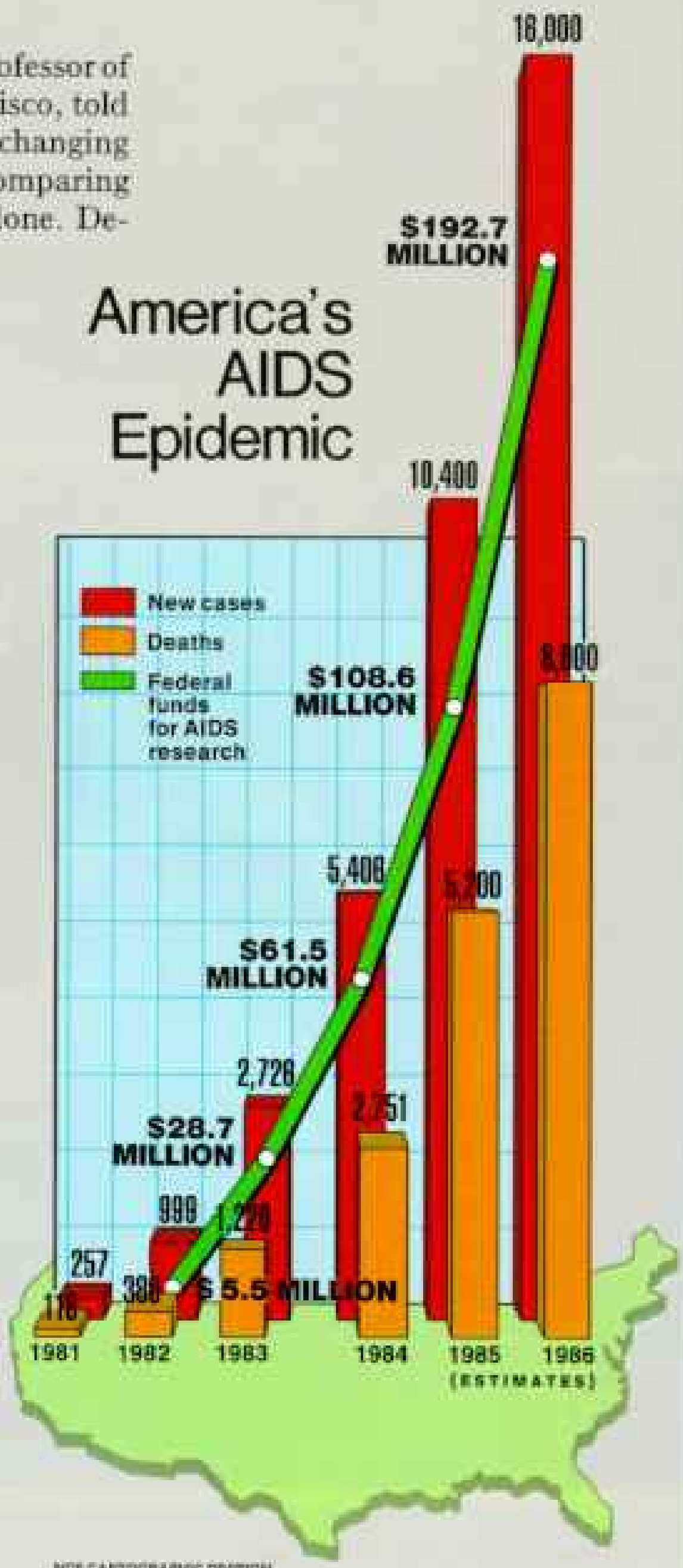
During stress, for instance, the body releases large amounts of a steroid called cortisol. We know now that macrophages recognize cortisol. And when they encounter it, they can no longer respond normally to infection.

Which sets me wondering. Perhaps the stress of looming deadlines allowed that cold virus to sneak through my defenses. And perhaps the best antidote that I know of for stress—a long jog through nearby Golden Gate Park—does more than simply take my mind off my worries.

Exercise, we are just discovering, may enhance the immune system. It stimulates the brain to release chemicals called endorphins and enkephalins. Both substances are natural painkillers. They also seem to reduce anxiety and create a sense of well-being. Even more startling, some studies suggest that they affect macrophages and T cells.

Exercise may also result in increased levels of interleukin-1 and interferon, both of which strengthen our defenses.

AIDS patients in San Francisco have already recognized an apparent link between exercise and the immune system. Some of them who exercise before their checkups have seen a



Dramatic increases in the number of new AIDS cases each year—a rate that has begun to decline slightly—are trailed by death tolls reflecting an average survival time of less than two years. Federal expenditures are only a fraction of AIDS's material cost to society, estimated in the billions of dollars.

ILLUSTRATIONS TEXT BY
LARRY KOHL
SENIOR EDITORIAL STAFF

temporary increase in their white blood counts—as if those decimated warriors are still fighting bravely.

And I met others, like Jay Young, who fight for survival with the power of hope.

"I knew I had two ways to go with this disease," Young told me on an unseasonably cold night just before Christmas. "Either lie down and die or stand up and do something."

Young leaned on a cane among a cluster of small tents and mattresses on United Nations Plaza in San Francisco. A wheelchair stood empty beside a man asleep on one of the mattresses.

BOTH BY PHIL SCHERMEISTER

Spotlighting *their disease, men with AIDS-related complex—a more prevalent manifestation of the killer virus—keep an all-night vigil at San Francisco's old Federal Building, where Father Robert Howard celebrates Christmas Mass.*

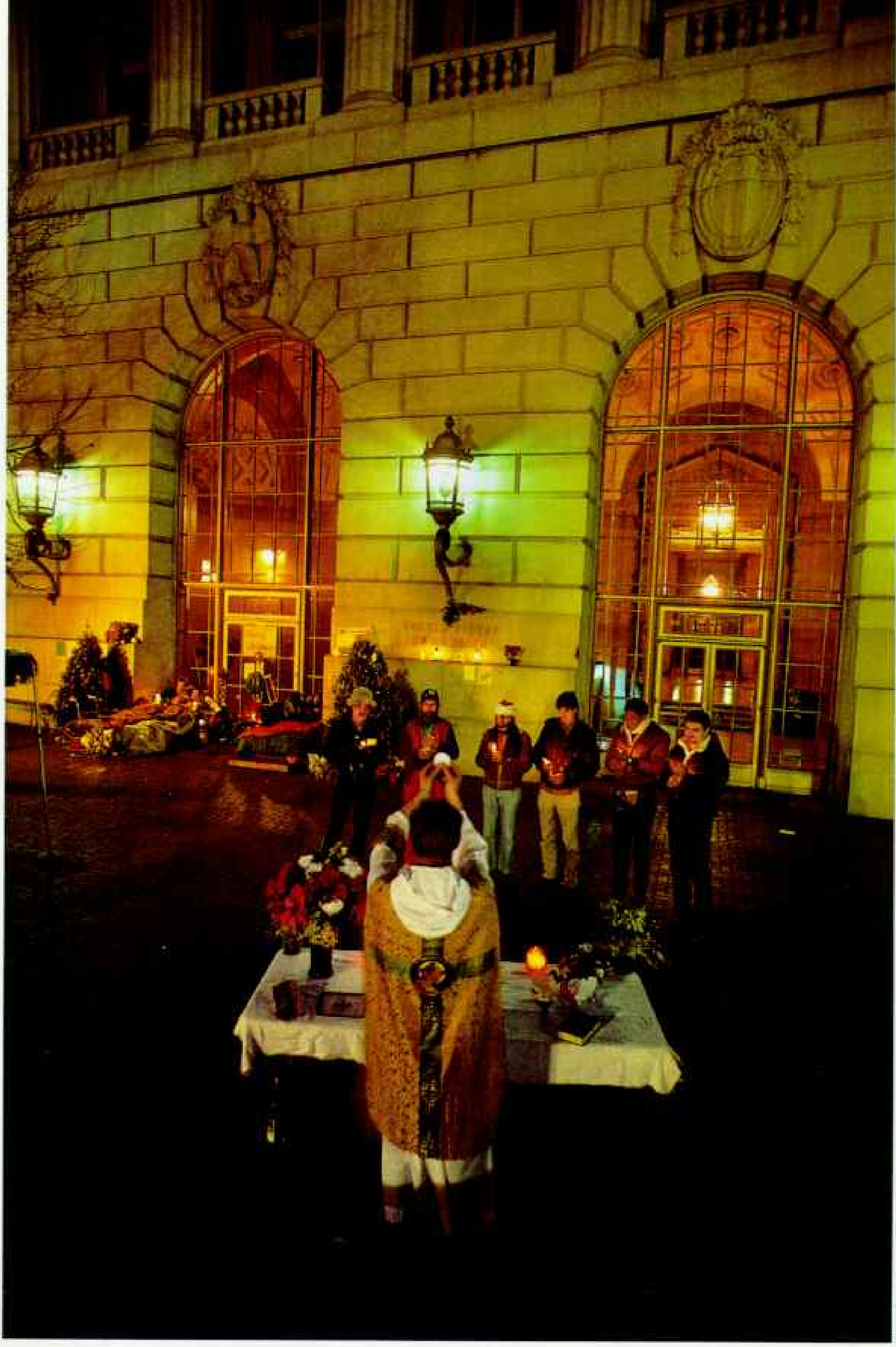
Racing against time, scientists in many countries endeavor to stem the tide of the AIDS epidemic—efforts that promise to broaden our understanding of the immune system.

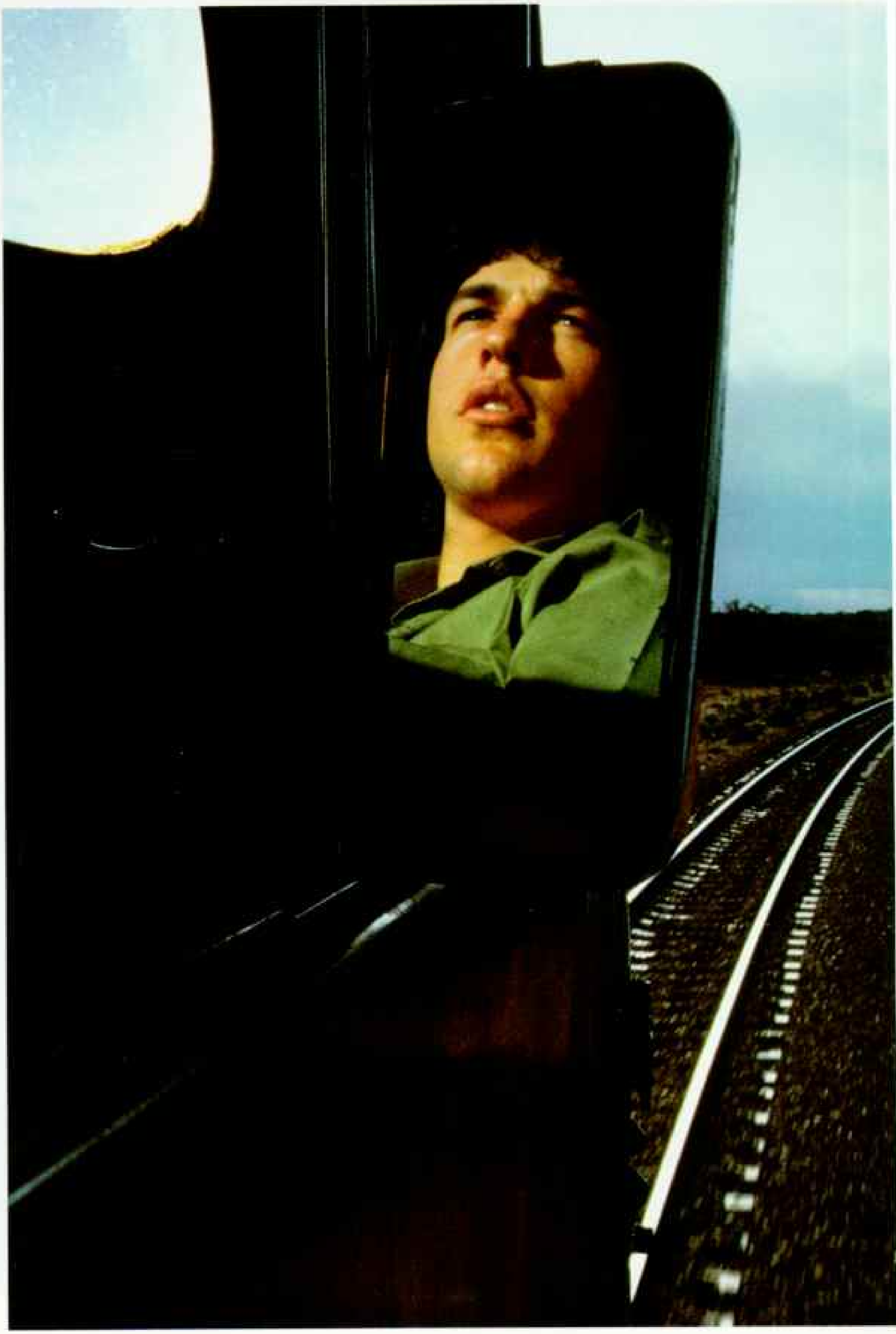
Volunteers had helped decorate two small Christmas trees and had hung stockings nearby. A gaunt young man went from person to person offering the warmth of coffee.

What might have been a scene from wartime was instead Day 55 of an AIDS vigil. San Franciscans afflicted or concerned with AIDS had kept this vigil night and day for almost two months to urge faster funding of research.

"I was in the hospital when I heard about the vigil," said Young. "I came straight here and have stayed ever since. This gives us hope. Hope is keeping me alive."

Sadly, six weeks later I learned that Jay Young had died. But the vigil he helped inspire goes on, giving hope to others. In the battle against disease, such hope may be the strongest weapon we have. □





THE
TEA & SUGAR
Lifeline in Australia's Outback

By ERLA ZWINGLE

Photographs by

WILLIAM ALBERT ALLARD

MAGNUM

Anything you can't get on the Tea and Sugar Train you can well do without. KAY LAWRIE, RAILWAY WORKER'S WIFE

Only show in town, *the Tea and Sugar Train calls at the tiny depot in Forrest, Western Australia. Dozens of such tiny settlements—existing only to house the workers who tend the Trans-Australian Railway—dot the vast Nullarbor*

THE WEDDING WAS OFF. By the time I rolled into Zanthus that night on the Tea and Sugar Train, the preparatory celebrations had reached dangerous levels. In a fit of prenuptial nerves, aggravated by more than the usual quota of beer, the bride-to-be (or not-to-be) and her intended had come to blows. Rumors flew along with the fists: confused accounts of who had started it, how she had gotten her three or more brothers to hold her beloved down while she hit him, and who had gone after whom with the scissors.

It was clear to the guests (some of whom had driven 15 hours to see the couple joined in holy wedlock) and to the Reverend Henry Noack (who had come out on this run to do the joining) that a pastor's services would not be required. Mr. Noack, who has a long-standing professional interest in minimizing the unsanctified living arrangements of rail-way couples, covered his disappointment with a mixture of hard-bitten irony ("She's just given him a great thwack on the head, and then they're going to talk about love and honor?") and high evangelical hopes ("There's a good sermon in this"). But there was a bright side to it as well: The train crew believed that this meant we might reach Kalgoorlie a little ahead of schedule.

When the Tea and Sugar leaves Port Augusta, South Australia, every Thursday

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Erla Zwingle, a former editor of *American Photographer,* has written for many national magazines. She lives in New York City. **William Albert Allard** has contributed to 16 articles in the GEOGRAPHIC and photographed the Society's *The American Cowboy in Life and Legend.*

(meaning treeless) Plain. The townsfolk, in turn, depend on the train for supplies. Known officially as slow mixed-goods train No. 5205, the Tea and Sugar consists of special cars attached once a week to the train's regular run.

morning for Kalgoorlie, Western Australia, there is really no way to predict what will happen along the way. Chance takes its customary toll of us all, of course, but along the 1,050 miles the train travels, the odds seem to favor the queer, the unexpected, the

When the heat comes in on the Nullarbor, it separates the boys from the men.

RAILWAY WORKER AT KARONIE

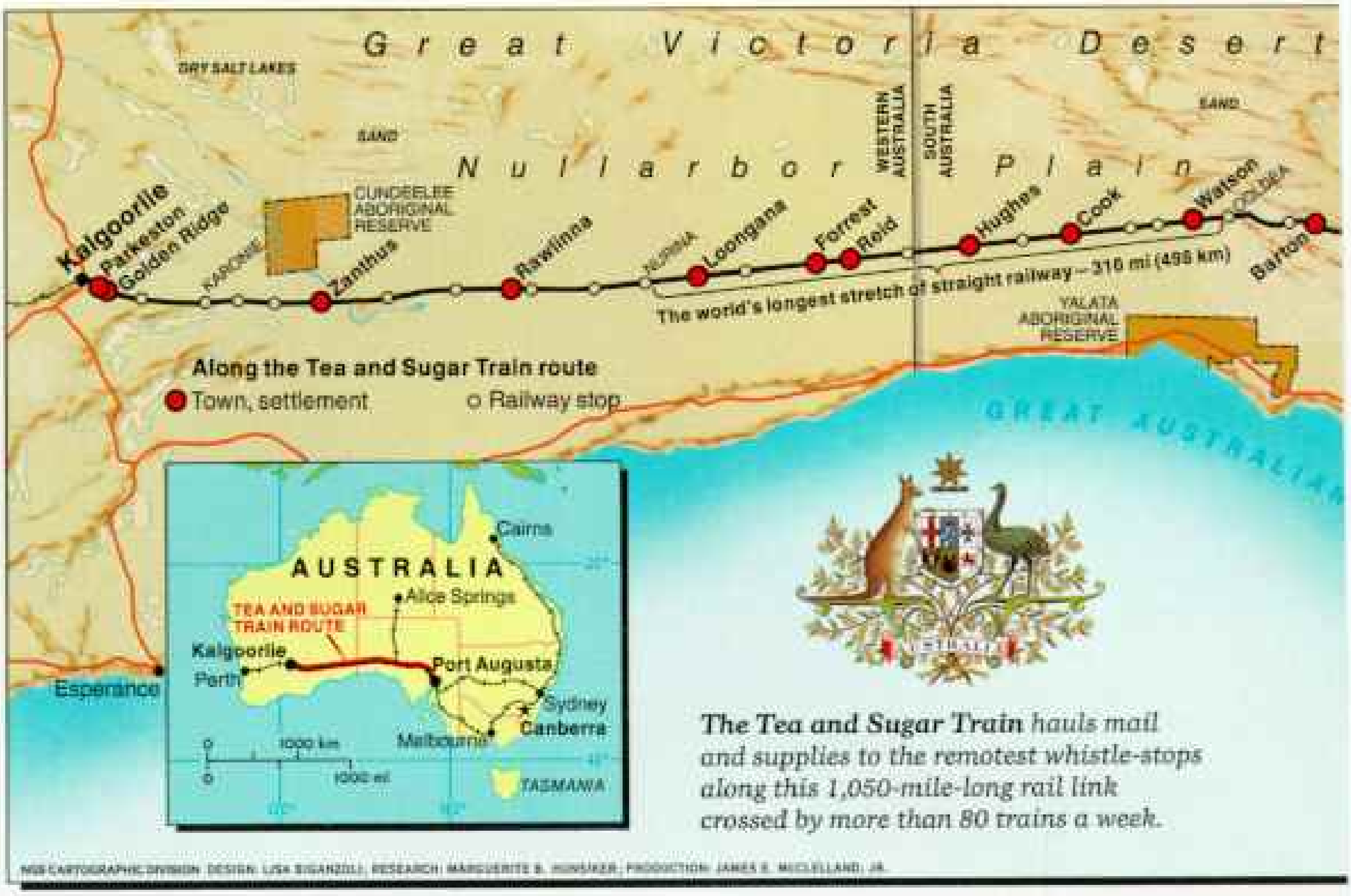
incongruous. All things considered, nothing less would make sense, for the Sugar (technically, slow mixed-goods train No. 5205) is unique, a combination historical relic and modern lifeline to the lonely few living in isolation and hardship in one of the most desolate regions of the world: Australia's Nullarbor Plain.

As a historical relic, the Tea and Sugar is more robust than most. It started as a supply train for the gangs building the Trans-Australian Railway line, which opened on October 22, 1917. As they inched their way across the scorching, treeless limestone plateau, accompanied mainly by teams of camels, the navvies, or fettlers, counted on the Tea and Sugar to bring them literally every necessity of life. Maps still mark their camps, but the settlements are smaller now. Many have been abandoned as the need for on-site maintenance crews has diminished.

In the early 1950s the steam locomotives, which required frequent stops for coal and water, were replaced by diesel-electrics able to go 500 miles without refueling, and the

I can go all day without talking to anyone. But it's lonelier in a city than out here — if nobody calls you in the city, you get upset. GLORIA PLANT, GANG FOREMAN'S WIFE

No one cramps the style *of a couple drifting across the dance floor in Rawlinna, Western Australia. Along the railway the meager attractions of such "community clubs" are often the only semblance of nightlife. With television reception poor or nonexistent, the videocassette recorder has proved a blessing.*



The Tea and Sugar Train *hauls mail and supplies to the remotest whistle-stops along this 1,050-mile-long rail link crossed by more than 80 trains a week.*

The Trans-Australian Railway *makes a beeline across the Nullarbor Plain, a 100,000-square-mile swath of barren land averaging less than ten inches of rain a*

vulnerable old jarrah-wood sleepers are gradually being replaced by concrete ties expected to last an average of 50 trouble-free years. Only 13 settlements remain of 52, and the Tea and Sugar has gone through several corresponding incarnations.

TODAY THE TRAIN may lack the more picturesque qualities it had in the days before refrigeration, when a butcher would travel in a special van with the livestock to be slaughtered on the way. Or when the theatrette car, a refitted 1917 passenger van, would pull up to the camps to show films. Now the district engineer sends out three videotapes a week in a little metal box. Still, as long as there is a railway worker along the Trans line, there will have to be a Tea and Sugar, and the only way to appreciate what the train means is to throw your swag aboard and make the run.

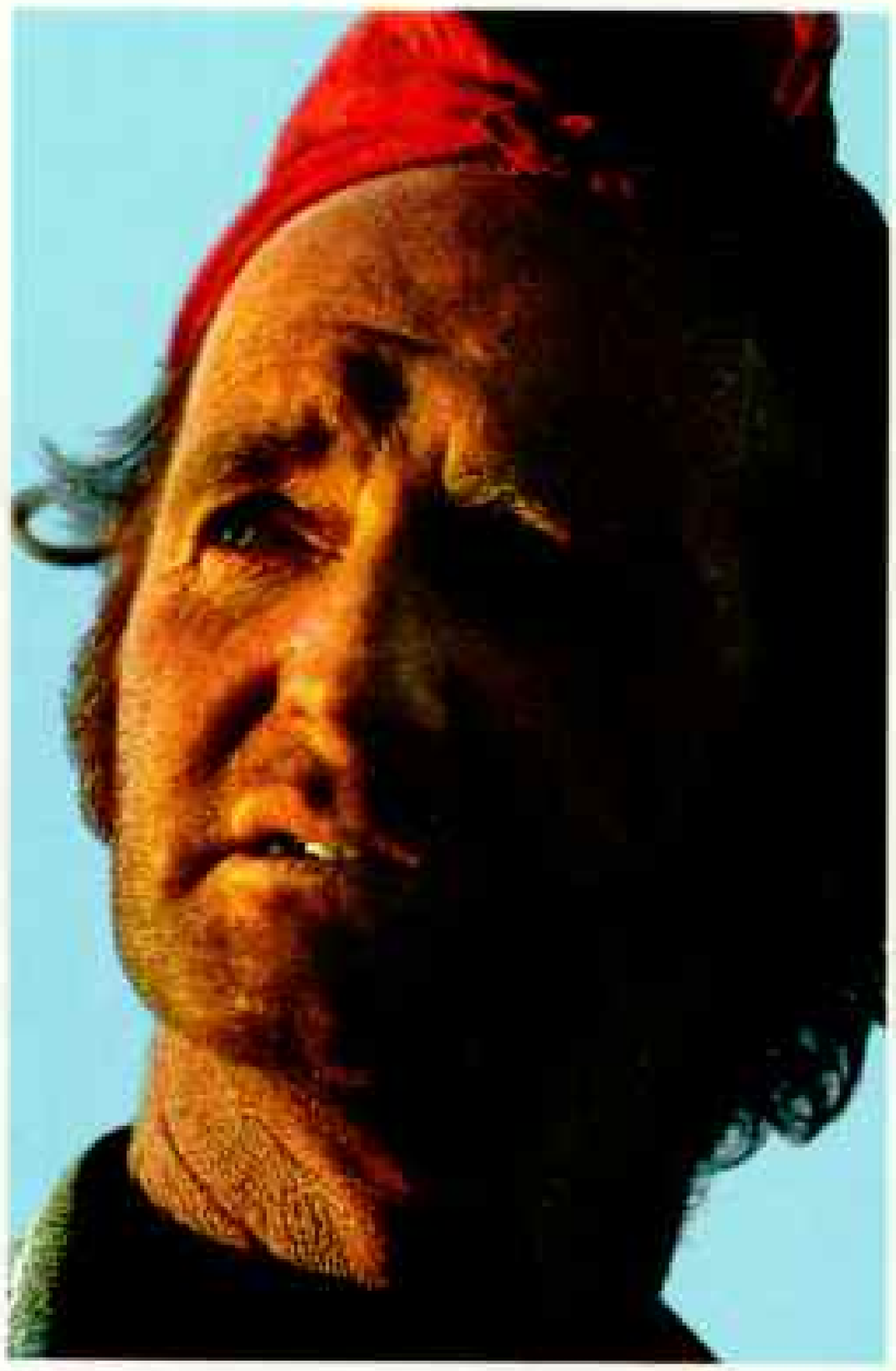
Eight-fifty a.m., Spencer Junction train yard, Port Augusta, October 1984. The sun is already hot and bright as the Sugar starts with a jolt. I would get to know a lot about jolts—freight trains have quite a vocabulary of them, from the tentative uphill-start nudge to the crash of the unexpected midnight shunt. This is a working train, thank you very much.

Home for the next three and a half days will be car OWS, the old community-service van, still used in winter by the community-health teams. Antique electric fans are the only cooling devices, and the myriad small wooden shutters and screens are filmed with five decades of talcum-powdery red bulldust. It does have a shower, though, and an excellent refrigerator crammed with all the mineral water it can hold.

Once you've spent a bit of time out here, you always end up coming back. It has a bad habit of growing on you.

BOB O'REILLY, FETTLER

Off the right-hand side of the train is the distant violet smudge of the fertile Flinders Ranges; to the left, the acid brilliance of the Spencer Gulf. Ahead, only miles of red



*year. Though the perimeter supports a few sheep and cattle stations, the interior is left mostly to rabbits and kangaroos, game for hunters such as Barry Saunders (**above**).*

sandhills covered with saltbush and bluebush and desiccated acacia trees. Humidity does not exist.

Today's train is fairly typical: 54 cars, including a number of empty ballast hoppers to be left at the granite quarry at Woocalla, boxcars, and the mandatory tankers, or "gins," each containing 14,000 gallons of water or diesel fuel.

The cargo varies from week to week. There might be a flatbed van of rails salvaged from the old narrow-gauge line up north, destined for the gold mines in Kalgoorlie, or a replacement section car for the special gang laying concrete sleepers at Karonie, or a truckload of potted plants for the garden club at Pimba. There are four drivers in green uniforms and two guards in brown (working in seven-and-a-half-hour shifts around the clock, being replaced halfway along at Cook). And there you have a very ordinary freight train.

But not quite. Every other week the bank van is attached, with a paymaster aboard, to distribute the payroll, in cash, as well as to serve as a no-frills post office. About every month a community-health team comes out, and every spring and fall the railway retail store in Port Augusta sends out a refitted lounge car with the newest clothes and appliances for major shopping sprees. The train also pulls a battered old van to carry what few passengers—primarily railway people or Aborigines—may want to travel between intermediate points, for which they pay the guard a per-kilometer rate.

On the first Thursday of December, Santa Claus (locomotive inspector Alf Harris) comes out, as he has since he took over from an older Santa 24 years ago. Sweltering in his full regalia, complete with bag of presents (one each for every child up to the age of 14), Harris listens to the usual requests—a baby brother or sister, a bicycle, a doll. He knows that his visit really means Christmas to the children, who often meet the train dressed in their Sunday best.

"The kids on the line don't see too many other people," he says, "so they're not confused by a Santa on every street corner. To them there's only one Santa, and he comes on the Tea and Sugar Train every year."

Some think they'll be able to save some money, then find out their expenses are just as high. PETER MILLER, RAILWAY PAYMASTER

Remaking the bed, *workmen claw old wooden sleepers, or ties, from beneath the rails* ***(above)*** *before inserting concrete replacements expected to last 50 years.*

Clerk Phil Hughes ***(left,*** *at right) totals the bill of Ziggy Wieczorek in the retail van, the train's supermarket on wheels. In earlier days the train carried livestock and a butcher who cut meat to order during travel. At Watson* ***(right)*** *a woman hoists the groceries while her mate trundles away a bountiful supply of beer.*

I was a town girl till I met Bob. Now I can't stand being in a town more than two or three days. MARGARET O'REILLY, FETTLER'S WIFE

Then there is the indefatigable Reverend Noack, who is now in his mid-70s and still at it after 26 years on the line. In July, October, and around Easter he makes the run, lavishing tracts and exhortation on anyone who doesn't actually run away.

From the minute the train stops at a settlement to the minute it blows the whistle to leave, Mr. Noack is spreading the Word. Wearing a gray cotton knee-length dustcoat to protect his worn clericals from the dogs, dust, and domestic dirt, he flaps from house to house or hovers near the train to intercept anyone finished doing business. He has no illusions, is impervious to despair, and is universally respected for his dedication, though many of the unconverted listen patiently with secret little smiles.

"My job is to meet as many people as I can, even if only once," Mr. Noack explains. "That way they can't say to the Lord, 'I didn't have a chance.' I tell the lads that when I go to heaven I'm going to tell Jesus, 'I have a whole string of lads from along the line, and they want to come in too.' They listen to that. I think rough men can be softer inside than a woman. They know everything is crook, and it shouldn't be that way. I tell them, 'You keep on the rails, and you'll get there.' To me, the line is holy ground."

MOST IMPORTANT of all, every week comes the retail van, a literal supermarket on wheels, with its next-door neighbor, a freight car crammed with cases of beer (150 for Karonie alone), for thirst is a dangerous thing. The retail van, appropriately, is the heart of the Tea and Sugar, serving every function of the old-fashioned general store from soap to sympathy. The week's run really begins here every Wednesday when it is stocked up at the railway retail store in Port Augusta.

The meat has been collected from Superior Meat on Commercial Road, where Neville Fuller and his staff have spent the morning cutting and packaging both special and standing orders, from the usual 16 kilograms of mutton chops for Ziggy Wieczorek's seven dogs in Barton to 5,000 beef sausages for general sale, and a variety of roasts, steaks, and cold cuts as well. The last butcher van made the run on June 30, 1982, a date lamented even now by most of the women on the line, who felt they got better quality when the meat was cut to order.

***Right at home** in a land of loners, a portrait of rebellious movie idol James Dean broods in the living room*

of Sonya Rorke. As she holds her son, Kelly, Sonya displays her own individual mark: a dove tattoo. Far from antisocial herself, Sonya organized an exercise class for the women of the tiny Western Australia town of Zanthus.

The idea of running a self-service store was manager Jim Averis's inspiration. An unflappable, good-humored man on the verge of retirement after 40 years with the railway, Averis described the store's evolution to me as we wandered through the warehouse, which was in a state of controlled chaos as department heads checked off various items for loading.

"Until 1979 everyone along the line used to send in orders for whatever they wanted. But we found that the cost of handling goods was too high, and I began to get a lot of complaints from people that they weren't receiving what they'd ordered, so I decided to make the van a self-service one."

Besides the 47-page manifest of items the van normally carries each week, the railway retail stores will supply a remarkable assortment of clothing, appliances, gadgets, toys,

In the worst heat I used to con the butcher into letting me sit in the refrigerated part of his van. ALF HARRIS, LOCOMOTIVE INSPECTOR

Santa's sleigh *is a railcar for Alf Harris, who greets Aborigines in South Australia. "I remember giving gifts to certain children," says Harris, a locomotive inspector who has played Santa for 24 years. "Now I give presents to their kids."*

and foodstuffs, all paid for by cash or bi-weekly paycheck deductions to the tune of 350,000 Australian dollars a year. "The other goods and passenger trains go right through the camps," says Averis, "so the Sugar is still an absolute necessity for them."

FIRST STOP: a pillbox at Tent Hill, just half an hour along. The start of a pattern, for where camps once thrived, there often remain only these little concrete sentries with their locked doors, from which the train guards phone train control to report our progress and receive any new instructions. These instructions are usually bad news, for in the great scheme of train control we come absolutely last. "We 'sit down' in favor of all other trains," guard Andy Colebatch wearily explains. After all, there is only one set of tracks to be used by all trains, east- or west-bound, so somebody has to step aside onto the crossing loop to let them pass.

We make it to Pimba by sunset. We have already stopped at Bookaloo to deliver a slat-sided van of expensive pedigreed merino and Corriedale rams for nearby Pernatty sheep station, and to pay the few fettlers manning the camp; they bought only sundries in the retail van, because it's not a difficult drive into Port Augusta. We have paused at McLeay to pay the men who are laying new signal cables. And we have seen the landscape reduce itself through an interminable, breathless afternoon from arboreal scrub, with vibrating too-close hues of red-brown soil and magenta wildflowers, to the scattered salt pans once harvested for salt and potash and now only immense, gray, scabrous mirrors glaring back at the sun. On the empty moorlike uplands of Pimba, the wind ought to blow harder to scatter the mosquitoes.

The Nullarbor grapevine is the fastest in the world, so I'm told. Any trouble causes a chain reaction right along the line as the fettlers take sides.

BETH VAYNE, METEOROLOGIST'S WIFE

Pimba doesn't need our water, being on the silver-gray pipeline from the Murray River that has snaked along the tracks. Pimba has a sort of uncommitted air about it, but in most respects it is the first typical stop. Identical square, metal-roofed houses line up facing the tracks on the south side, and people push wheelbarrows to meet us, or lounge against their "utes" (small utility trucks). Men head for the bank van to collect their pay, women invade the retail van, where everyone eventually converges.

Finally we get the signal to proceed, and Ron Nicol, this week's vanman (one of three assigned in rotation), can relax. The sky is a velvety purple-blue sieved with stars. A tremendous full moon gives an eerie silvery sheen to the landscape, like daylight turned inside out, complete with shadows. Delicious coolness and calm, crickets purring.

DAWN COMES to Barton before the retail van opens at 6 a.m., and its few residents are already up and about. Here begins the land of jolly misfits, that special breed beyond civilization's casual reach that tends to gravitate toward life in the back of beyond. Ziggy, for instance, a dependable worker but an unabashed misogynist who dotes on his seven dogs (all, strangely, female). Ziggy, who hurled his mop at me to drive me away from his little compound. "Bloody tourist!" he yelled over the snarling animals.

There is no typical Tea and Sugar customer. Regulars can range from steady Scottish cattle rancher Peter Hogg at Rawlinna, whose bagpipe skirling blends weirdly with the whistling desert wind, to the anarchy of the concrete sleepering gang at Karonie, mostly single men certifiably unemployable at any other job. There are people hiding from the law under assumed names, and there are committed railway people, like roadmaster Siggy Scafidi and his wife, Maria, who have lived in Rawlinna for more than two decades, whose son is an engine driver; and Paul and Daphne Smith, with young Adam and Amara, who moved out to Forrest to work at the weather-observation outpost and get away from the hassles of big-city life; and Rahman Timsar, the elegant Iranian geophysicist working under contract to a diamond-prospecting company.

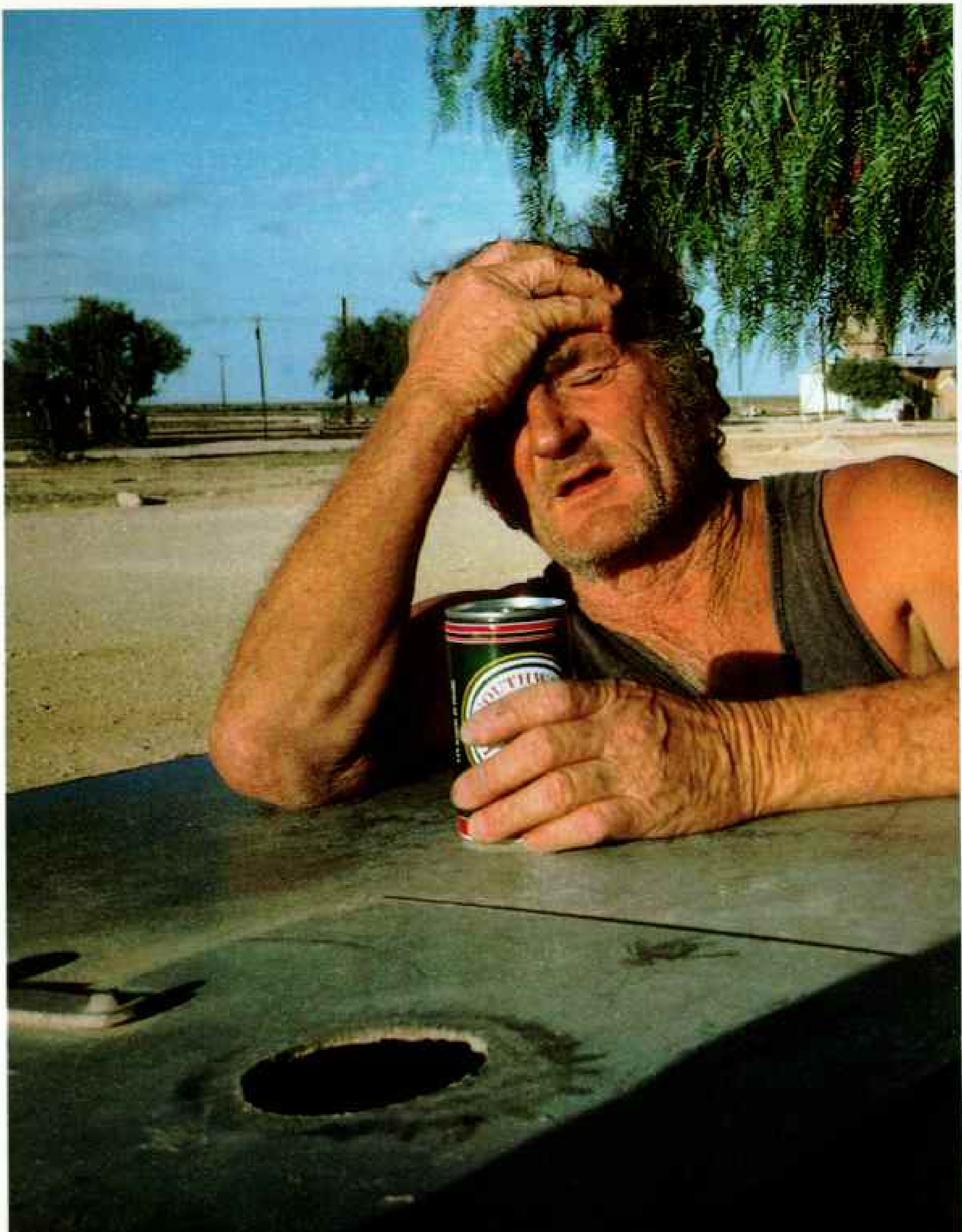
But a few generalizations are safe. Most are railway workers, often (especially on the Nullarbor) those who can't get anything else, and the railway takes them because it can't get anybody else. And where the wives were once railway children accustomed to the conditions, now they're often too-young city girls with few resources and children as small as their husbands' prospects. Some of the worst conditions have been improved over the years—the wood-burning stoves, kerosene lanterns, and artesian water too hot to bathe in, or so full of chemicals it gave you sores, have been replaced by electric appliances, plenty of clean water, air-conditioning here and there, and the now ubiquitous video. Yet it is a demanding environment, especially for the women. Never has the bromide "Life is what you make it" been illustrated more clearly than in the empty reaches of the Nullarbor.

"IN A LITTLE CAMP there's always one of them that's a disturber," says a railway supervisor who traveled the line for years as a guard. "I don't know why, but there always seems to be one of them. One of the women will stir up a bit of strife and set this couple against that couple."

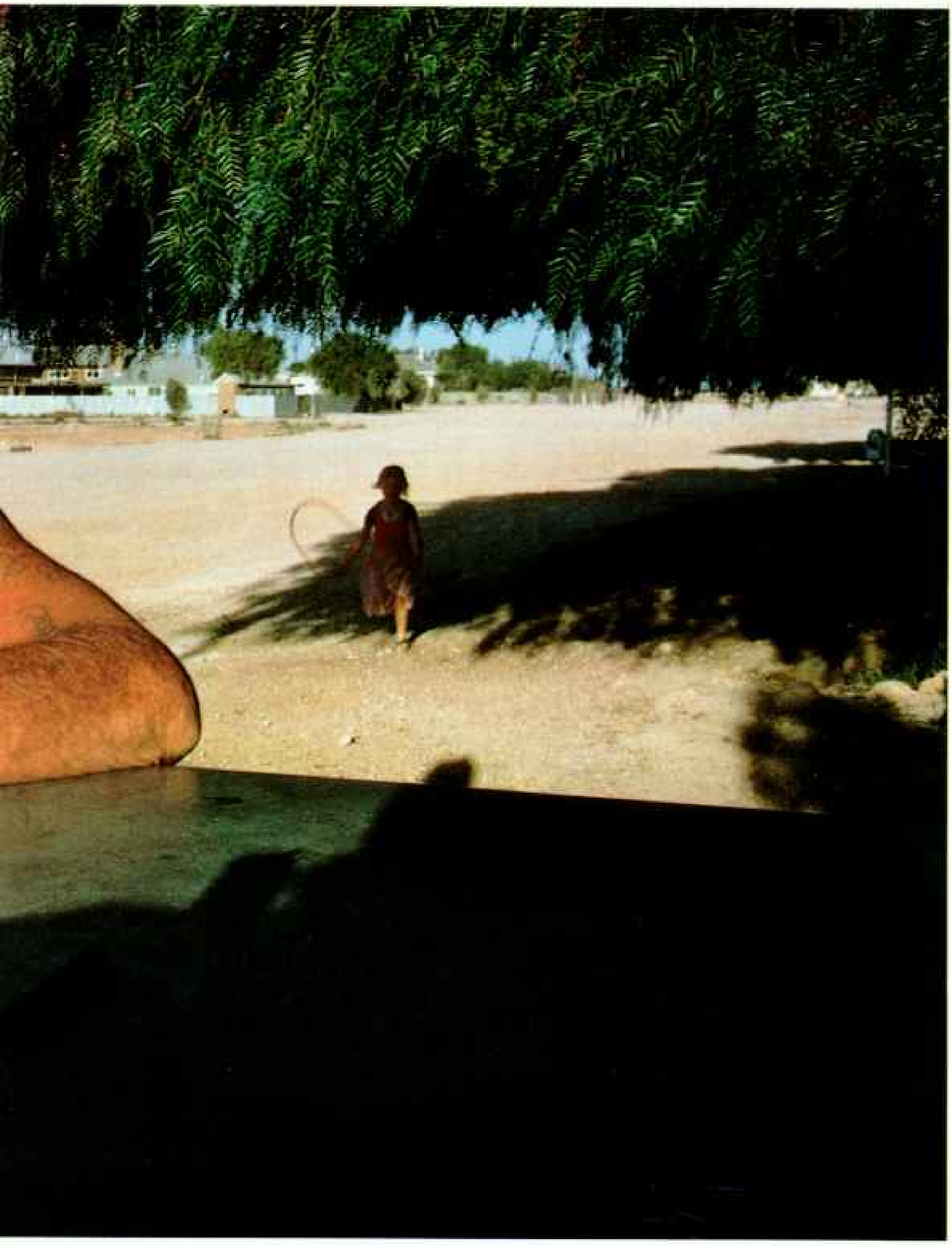
Community-service coordinator Susan Surguy says, "It doesn't really surprise me that there's occasional unpleasantness among the women, when you think of the situation, especially in the summer. To me, it's really amazing that they all do get on so well together."

But, says Pat Bell, wife of the railway retail-store manager in Cook, "We do a fair bit to keep ourselves occupied. We have three basketball teams and a tennis court, and I'm a Brownie Scout leader. It's not really hard here—it's like anywhere else. But most of the women find it hard; you know

Off-hour diversions *of darts and pool are always close at hand for the fettlers, members of the special work gang upgrading the track with concrete ties. Stocked with amusements and plenty of beer, this recreation room is housed in a mobile home set on a flatcar that travels with the constantly moving workers.*



I saw enough of the bloody Nullarbor in me kid days. I hate the country—don't like it one bit—but the work's good. HENRY COX, TRAIN EXAMINER



Thirst aid *comes in a beer can for Henry Cox, taking a break beneath December's summer sun in Cook, South Australia, where the temperature often exceeds 100°F. The Tea and Sugar doesn't pull away without an okay from "Coxie," a train examiner who checks brakes and car couplings for safety.*

what they're like, they live for the shops."

"Lack of shops doesn't bother me," states Gloria Plant, a no-nonsense Yorkshire woman married to the ganger at Watson and a veteran of 16 years in the bush. "We make our own entertainment. We read a lot. I knit, I embroider, I crochet. I don't know why they buy videos out here—none of them has an air conditioner yet. They're too young, they've done nothing. I have a hearing problem—I hear too much!"

"You do tend to become very introverted because you don't have the people to reach out to," says Margaret O'Reilly in Hughes, who at age 31 calls herself "ancient" by railway-wife standards. "If somebody's got a bad habit, you either overlook it or put up with it—you can't escape it. For a newly married couple this is the best start you could get. You have nowhere to run to, and you have to learn to talk to each other."

Helping to solve these dilemmas is the job of the traveling community-service women—in South Australia called the RICE team (for Remote and Isolated Children's Exercise), founded in 1974 to aid outback families with young children. Nurse Colleen Slattery and toy librarian Roslyn Schrader go out every two months, sometimes with other part-time helpers, but they all feel a certain frustration at not being able to maintain closer contact.

"You go back to Port Augusta wondering, What can I do?" says Roz. "Colleen can refer medical problems to the flying doctor for his regular twice-a-month clinic, but you really

Pint-size batsman *gets coaching tips as Henry Cox's family plays a cricket match in Cook. Lack of traffic makes the main street an ideal playing field. The game's popularity reflects Australia's traditional ties with Great Britain. Today Aussies*

aren't in any one place long enough to feel you can help people with routine troubles."

Heidi Kerspien, a homemaker with the Kalgoorlie-based team, comes out each month. She grew up along the line, so she has a special understanding of its demands and rewards. While some of the children are getting their periodic inoculations, others play amid a welter of toys, cut-up drinking straws, and mangled egg cartons, their mothers browsing through the books and magazines in the small but wildly eclectic library. "The important thing is to overcome the assumption that only people with problems visit the community-service van," Heidi told me.

"We offer some activities and crafts for the children, or just sit and have a cup of coffee and a chat with the mothers. But if they feel you're pushing, they'll back off. I feel that the modern vices have caught up with people, for all that they're so isolated."

add a bit of Yankee flavor, sprinkling the Tea and Sugar route with softball diamonds and basketball courts.

THE NULLARBOR is an arid ocean that we cross without changing course, for it contains the longest stretch of straight track (310 miles) in the world, beginning between Ooldea and Watson and ending at derelict Nurina. Surveying the scene from the engine, I can see why driver Jeff McKenzie has what he jokingly (I think) calls a "vigilance-control button" to keep him awake. If he fails to press it sometime during a 90-second cycle, a warning light flashes, then a whistle blasts, then the automatic brake stops the train. Fear of this sequence is supposed to keep the driver alert. The system is not infallible. However, it does give the driver something to do besides watch the wedge-tailed eagles or hit the occasional kangaroo, sheep, cow, or wild camel.

An expensive freight train traveling 50 miles an hour does not brake for animals, especially those that creep out at dawn to lick the dew off the rails. "Of all the animals, emus are the worst," driver Tommy French shudders. "You get feathers for miles."

By late afternoon on Friday we are at Cook, the halfway mark, a major refueling station, and not a bad-size town either: ten permanent railway workers and families. They have a water bore and desalination plant, a 43-student, 12-grade school—and even a swimming pool. As we are almost to the Western Australia border, everything changes here, the crews as well as the clocks (we set our watches back an hour and a half). The "doctor" is in attendance—he being the southerly wind that blows up from the Great Australian Bight about this time every day—and is bringing new weather. From a

It's difficult in these small communities to find people who get on well together. People don't realize how difficult it is to run these remote camps.

MONTE LUKE, RAILWAY DISTRICT ENGINEER

noontime high of about 108°F, we are now down into the 60s, and the dust is whirling.

"Feeling crook? Come to Cook" invites the sign outside the six-bed Bishop Kirkby Church of England Hospital—another mark of Cook's more evolved civilization. And because Cook has one of the railway's six branch stores, the retail van is closed.

Next is Hughes, which I remember for the enormous gold-rimmed purple clouds parting to reveal a colossal marigold moon, and Margaret O'Reilly explaining the finer points of how to cook wombat. At Forrest the weather station north of the tracks huddles in its own blessed little parklike grove of trees. Loongana means a visit to Red Roo Ronan, the baby kangaroo that Shirley Ronan rescued from its dead mother.

And then Rawlinna, about the same size as Cook but with so much more personality, thanks in part to Carole Dhu's astonishing garden, resplendent with color, which faces the dusty street. She and her husband, Trevor, the schoolteacher, live in this little oasis with a collie and a piano and their infant daughter, Rhiannon. It was Carole who uttered the resonant statement, "You know, I lived here six months before I had time to walk up to the end of the street."

The vast limestone plateau is riddled with blowholes. In a mysterious form of vegetable segregation, the blond green wardweed keeps to the north side of the tracks, while the bluebush covers mostly the south. And now, off to Zanthus.

THE TREES are beginning to get their strength back, and my impression of Zanthus, reached after dark, is mainly of the floating canopy of ghostly peppercorn trees illuminated by the train's headlight. Drowsy, bug-eyed children in their pajamas clamber on and off the retail van begging for candy and ice cream. By now the pickings are pretty slim, but it's only 125 miles to Kalgoorlie, and many people here drive the rutted dirt road into town to shop. Clusters of Aborigines hover on the fringes, waiting their turn —always last.

After Zanthus we sleep, waking Sunday morning to the dregs of Saturday night as the single men crawl onto the pay van at Karonie. Pleasant as each may be when given no reason to be otherwise, this is a hard bunch, and no mistake. Drinking and fighting are their main leisure pursuits, which for young men of much energy and little imagination is not surprising. Boredom plays its insidious part. After watching the gang do its mind-benumbing, tedious, and repetitive work,

No one likes to live in a void. The Nullarbor is a void of land in a way. And the Tea and Sugar is a small way of letting them know, 'We know you—hang on!'

PATSY ADAM-SMITH

Shadow play: *The camera captures the image of photographer William Albert Allard aboard the Tea and Sugar as it*

removing the old timber sleepers and installing the new concrete version (one and a half miles, or an average of about 3,000 individual sleepers, every five days), I was thirsty for a couple of "stubbies" myself.

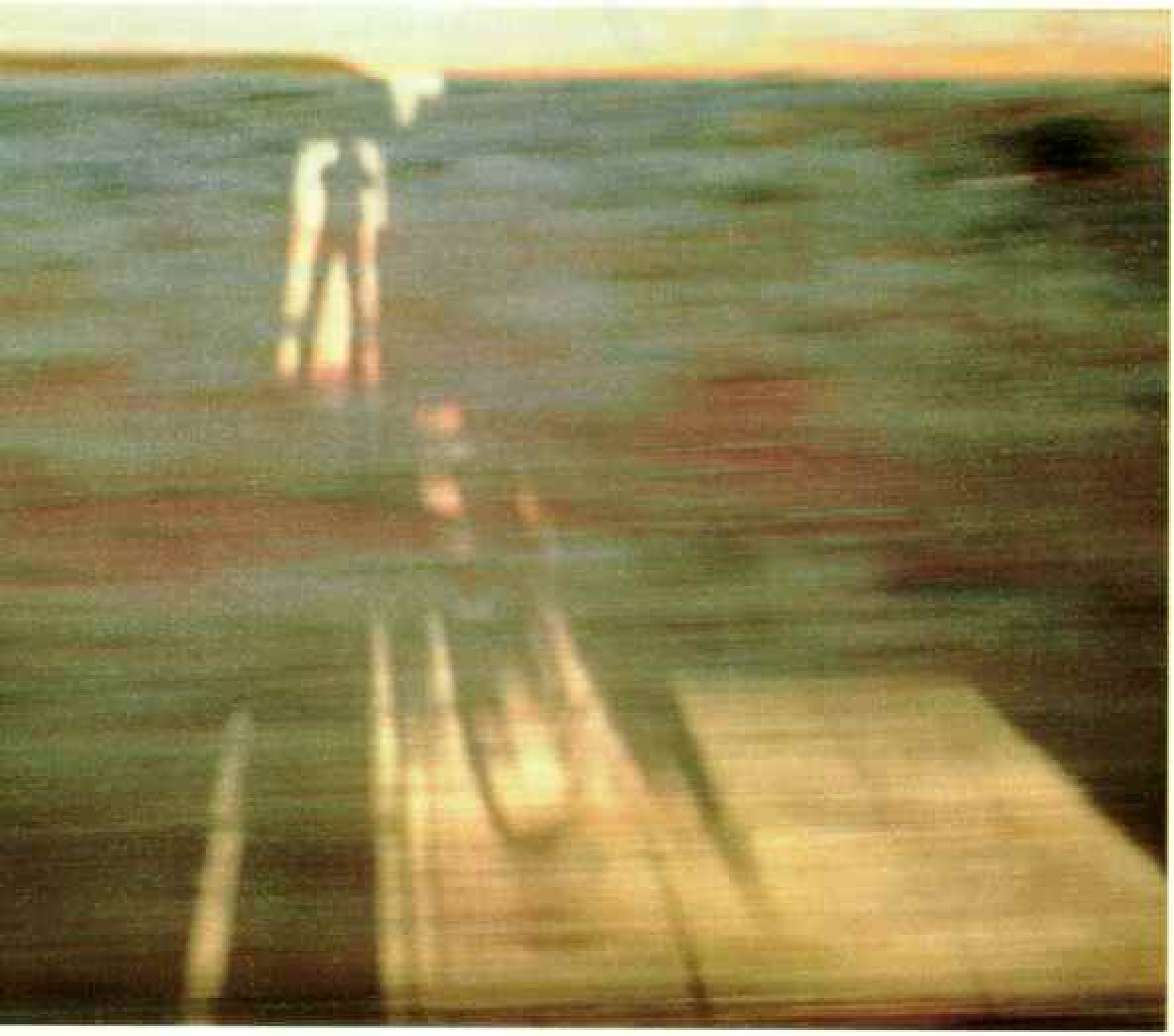
We have slowed to a creep now, clattering over tracks still untamped and unaligned after the recent surgery. The country has returned to its senses. The right-of-way is lined with crimson wild hops and at last an abundance of trees, mostly blackbutt, gimlet, and white gum, with its polished silver flanks and myriad slender branches topped with glittering bunches of leaves. Sandalwood is also harvested around here by a few hardy entrepreneurs.

We will reach Parkeston, the railway terminus outside Kalgoorlie, by noon. The tired crews will book off, glad to see the end of the run with its constant starts and stops.

"When I get off a Tea and Sugar run, I'm just shattered," says David Oates, a young guard. "I had to get up at 4 a.m. yesterday morning to shunt. It takes me 24 hours to recover—the whole thing really throws your system out of whack."

We can all go home content, though; there was a surprise happy ending to the Zanthus wedding saga. The cautiously pleased padre told me later that the couple calmed down shortly after the train had departed, drove into Kalgoorlie to the registry office, discovered the fee had risen beyond their means, and so, properly penitent, intercepted him on his return via another train. It is possible that they are, even now, still married. □

races over the Nullarbor Plain. The train and the desolate land it traverses can evoke grudging admiration. Said one resident: "There is some aura of the outback—of the unknown, of the remarkable—there on the Tea and Sugar."



The World of TOLSTOY

By PETER T. WHITE
NATIONAL GEOGRAPHIC SENIOR WRITER

Photographs by SAM ABELL

Literary lion of the 19th century, Count Leo Nikolayevich Tolstoy enriched the art of the written word with such novels as War and Peace and Anna Karenina and a treasury of shorter tales.

Haunted by the immemorial problems of poverty and inequality, the Russian aristocrat—born to privilege in 1828—turned his pen to a philosophy of charity, simplicity, and nonviolence that helped shape the 20th-century politics of Mahatma Gandhi and Martin Luther King, Jr. In peasant dress he sat for this early color photograph by Sergei Prokurin Gorskii, taken on the Tolstoy estate in 1908, two years before his death at age 82.

SOVFOTO/PHOTO AGENCY

ONE OF THE STRIKING THINGS about Count Leo Nikolayevich Tolstoy—who died three-quarters of a century ago, at 82, and is among the world's most widely translated authors—is that so much in his hundreds of works and thousands of letters still speaks to so many today so warmly and urgently.

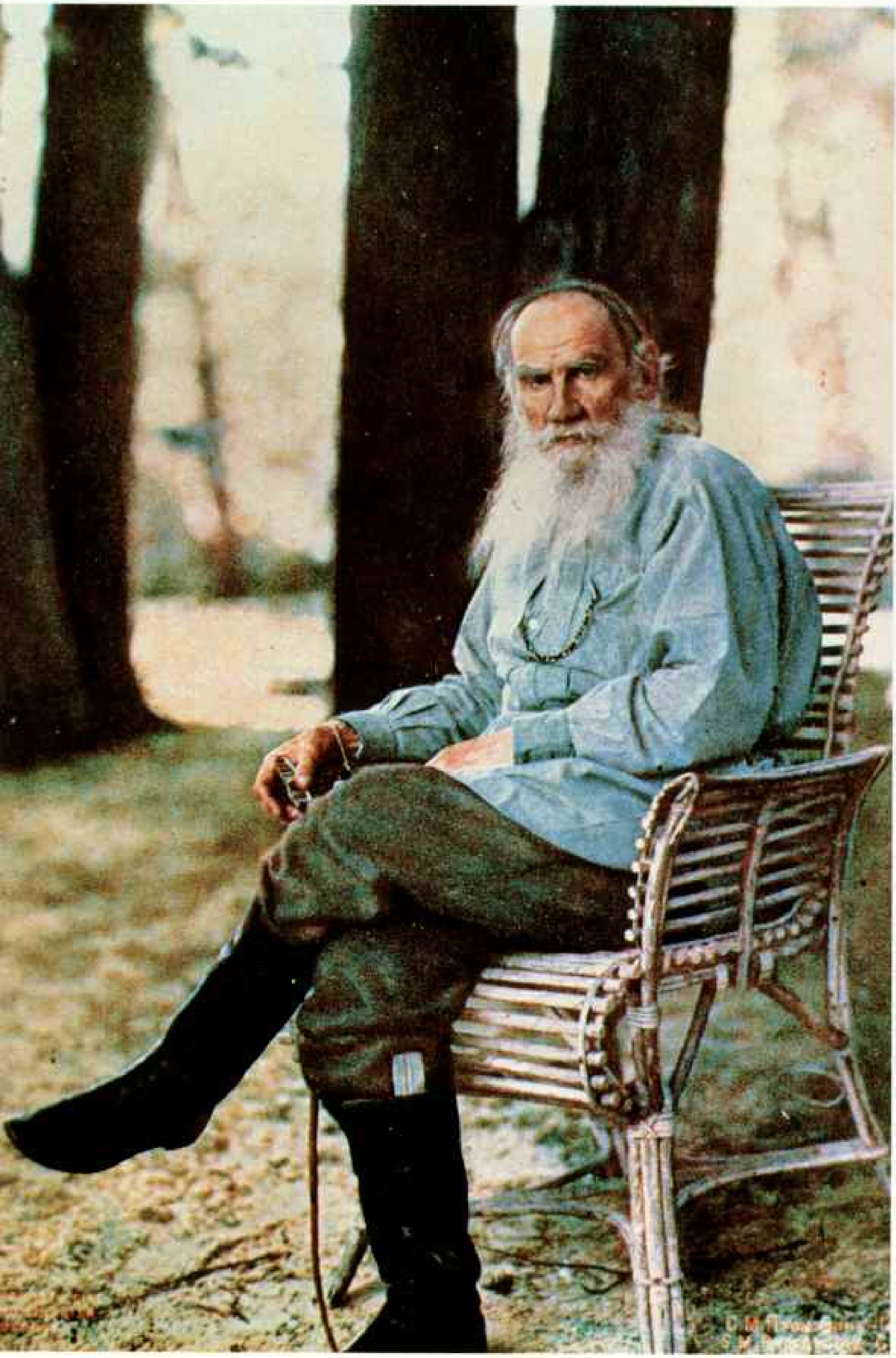
For example, to the tenth graders in Mr. Ronald Briley's European history class in Albuquerque, New Mexico; they've been studying that epic panorama of emotions set against Napoleon's invasion of Russia—*War and Peace*.

The girls share the anxiety of young Natasha at her first grand ball. *Is it possible no one will ask me, that I shall not be among the first to dance . . . that not one of all these men will notice me?* Said one girl about Tolstoy's descriptions of Moscow society circa 1810: "It's like 'Dallas'!"

The boys react to the battle scenes, to what Natasha's brother Nicholas thinks as the French close in. *Can they be coming at me? And why? To kill me?* Me *whom everyone is so fond of?* It makes them wonder about war, says Mr. Briley. "Before you know it, you're discussing Nicaragua."

How did Tolstoy get to know so much—this aristocrat who chose to dress like a peasant and was torn all his life, it's been said, between a sensual temperament and a supersensitive conscience? Whose eyes "saw everything through and through." And whose words, as we shall see, affected Lenin, profoundly, and Gandhi, decisively. Also Richard Nixon, at least temporarily—especially the philosophical works, as Nixon recalls from his college days: "At that time in my life I became a Tolstoyan."

Some years ago I set out to follow Tolstoy, not only through his books but also in his footsteps in his native land, where the settings in which he spent most of his life are meticulously preserved. I didn't suspect that before the end of my Tolstoy odyssey I would find a Tolstoyan answer to a most perplexing question of our time: Why is it that *(Continued on page 764)*



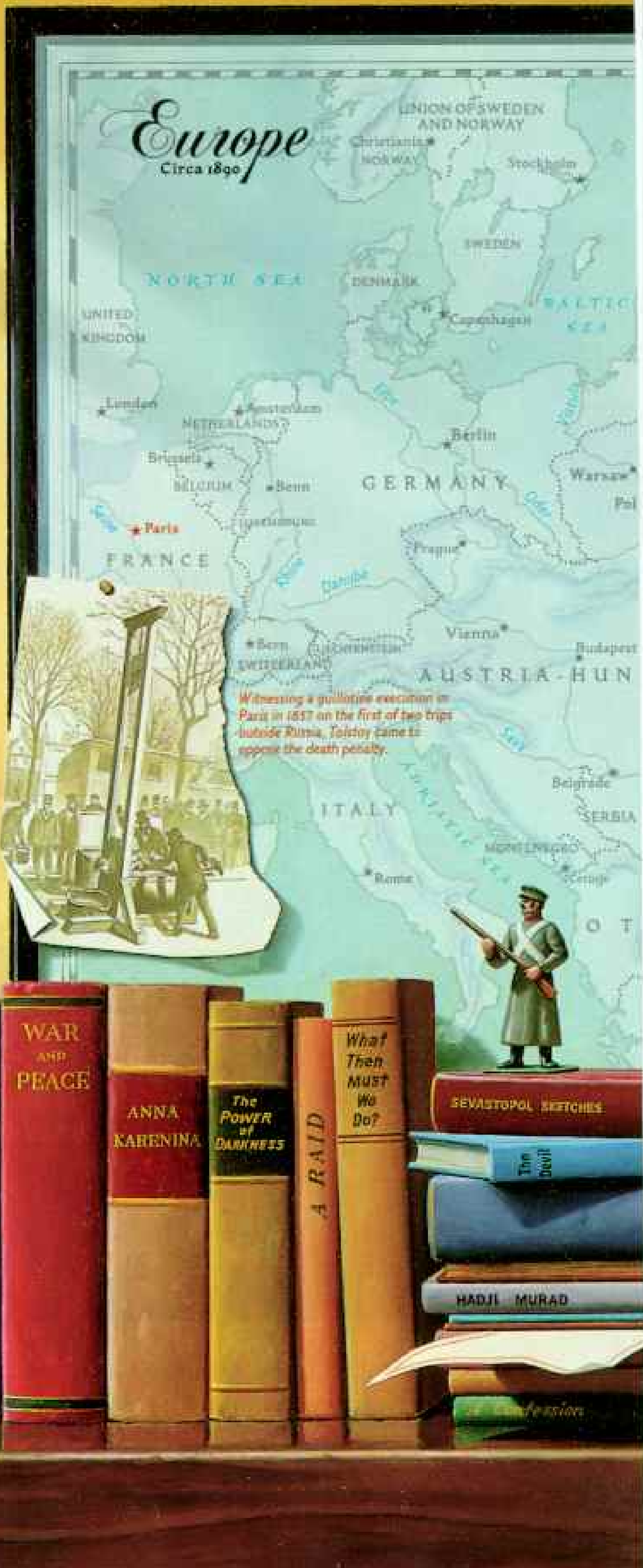
"What's the use? What is going on in the world?" War and Peace hero Count Pierre Bezukhov looked at Moscow society in 1811 and wrestled with his conscience. Like this character in his epic novel, Tolstoy questioned his own life; he eventually became a

vegetarian and espoused religious views that drew fire from the Russian Orthodox Church and the government. He often visited the Kremlin, right, where he met and proposed to his wife, Sofia Andreyevna Behrs, a court doctor's daughter.

NOVOSTI PRESS AGENCY

"*She was adept at telling the most intriguing stories,*" *Tolstoy was told of his mother* (**above**)*, who died in 1830 when he was two years old. His father's death in 1837 left Leo, three older brothers, and a younger sister to the care of relatives.*

Considered to be the brightest light in Russia's 19th-century literary awakening, Tolstoy raised Slavic pride during an era dominated by western European artistry. Soviet citizens still echo the sentiment etched on a paperweight, below, given to him by glassworkers in 1901: "Russian people will always be proud of you; for them you will always be great, dear, and beloved."



St. Petersburg

Moscow

Suzdal

Kazan

Volga

Battle of Borodino [1812]

Ryazan

Tula

Yasnaya Polyana

Astapovo

Bryansk

Born on his family estate, Yasnaya Polyana near Tula, Tolstoy died in the small town of Astapovo, now named for him.

RUSSIA

Ukraine

Tsaritsyn

Combat experience in the Caucasus Mountains and the Crimea led Tolstoy to write of war "in its true aspect — blood, suffering, and death."

Kishinev

Crimean War [1854–1856]

Caucasus campaigns [1850s]

Crimea

Sevastopol

Yalta

Gaspra

ROMANIA

BULGARIA

Sofiya

BLACK SEA

Sinop

Constantinople

OTTOMAN EMPIRE

CASPIAN SEA

PERSIA

Caucasus Mountains

Ural Mountains

0 200 km

0 200 mi

Map reflects modern shorelines and drainage

Whether tooling with peasants on his estate or writing in his study, Tolstoy spent most of his life in rural Russia. This representative painting by Ned Seidler includes his inkwell and pen, English translations of most of his published works, and a photograph of the consummate storyteller with two of his 28 grandchildren.

(Continued from page 758) when a widely hated regime is at last overthrown, what follows is often no better and sometimes worse?

WINTER in Moscow—there's Tolstoy in the air. Inside the Kremlin wall, in the Palace of Congresses, 6,000 spectators see Moscow burning on the gigantic stage—it's Sergei Prokofiev's operatic version of *War and Peace*. The next evening, at the Bolshoi Theater, I can sense the ecstasy, the anguish, of a worthy woman trapped in adultery, giving up her little son, dying a suicide—it's Tolstoy's *Anna Karenina*, danced by the great Maya Plisetskaya (pages 774-5).

The doomed Anna challenges Western actresses generation after generation—Greta Garbo, Vivien Leigh; most recently it was Jacqueline Bisset, two hours on TV, playing to an estimated 15 million sets. The splashiest Tolstoy screen extravaganza ever was the Russian *War and Peace* of 1968, and I've seen it all on video—six hours!

"No, eight," says the director who made it, Sergei Bondarchuk, at the Mosfilm studio. "Some tradesman in America cut it without my knowledge." Did he really use 120,000 soldiers for the battle of Borodino? "That is exaggeration, all I had was 12,000." Would he ever try such a thing again? *"Ni v koyem sluchaye*—No way!"

"I noticed this beauty . . . and fell in love with it," recalled Tolstoy 60 years later, writing of the birch-lined avenue to Yasnaya Polyana, his ancestral estate 110 miles south of Moscow. "Without my Yasnaya Polyana, it would be hard for me to imagine Russia." The present house grew from one wing of the original; Tolstoy sold the main house to pay gambling debts in his bachelor days.

Gardens and orchards on the vast estate grew to 96 acres in Tolstoy's time, reflecting his interest in land management. An amaryllis from the still tended greenhouse brightens a winter window (**right**).

*"I was insatiable," Tolstoy confessed to writer Anton Chekhov as he reminisced on a profligate youth. Educated early by his brothers in the ways of women, wine, and gambling, he was less diligent in formal studies at the University of Kazan, failing a number of courses, taking treatment for venereal disease, and finally withdrawing at age 19. While in school he started a diary that he would keep until the end of his life. It records his short-lived effort at age 21 (**left**) to study law at the University of St. Petersburg—today's Leningrad—where student behavior in study hall follows age-old patterns (**below**). The diary notes in December 1850, "I am living like a beast," as he caroused in Moscow night after night with his beloved Gypsies—still a cultural presence in the capital at the Gypsy Theater (**right**).*

"I am 24 years old and I have still done nothing," he later wrote in the Caucasus, having joined the army. "I am sure it's not for nothing that I have been struggling with all my doubts and passions for the past eight years. But what am I destined for? Only time will tell. Shot three snipe." The next day he learned that his first story, Childhood, was accepted for publication.

NOVOSTI PRESS AGENCY (FACING PAGE)

AT LAST I'M OFF to the main stage of Tolstoy's real-life drama—a hundred miles south by train, past snowy fields and forests to the city of Tula, then ten miles by car to Yasnaya Polyana, the country estate where he was born in 1828 into a landowner's world of serfs and tutors, horses and hunting. Even when he was a little boy, family serfs would bare their heads before him and address him as count; all serfs were freed by imperial decree in 1861, but Russia's rigid social structure changed relatively little in the 82 years of Tolstoy's life and this, as we shall see, bothered him increasingly to his last months here at Yasnaya Polyana, just seven years before the Bolshevik Revolution. . . .

Silvery flakes dance in the wind, an avenue of birches leads to a stately white house in knee-deep snow. Upstairs a grandfather clock is ticking—the guide says it was brought from England by Prince Volkonsky, Tolstoy's maternal grandfather. "You can find this house in *War and Peace*, in the description of Prince Bolkonsky's house. Tolstoy spent most of his life here."

Yasnaya means something clear, luminous, bright, and *polyana* is a clearing in a forest, a meadow, so Yasnaya Polyana can be translated as "bright meadows" or "sunlit meadows." Much of the natural setting here, the trees, ponds, mushrooms, along with the life once bustling in it—dogs, bees, children—shows up in Tolstoy's writings, beginning with his first publication, *Childhood*. It is a fictional memoir, happy and sad, narrated by a boy much like little Leo—exuberant, willful, introspective, and tenderhearted, cushioned in comfort and love.

The real Leo loses his mother at two, father at nine, a guardian aunt at 13, and must go away to another aunt, in Kazan, where he enters the university at 16 and follows the ways of young noblemen—drinking, women, treatment for venereal disease, flunking courses. He inherits Yasnaya Polyana but soon goes to Moscow and St. Petersburg, gambles heavily, loses a lot, and returns at 21, hoping to make a go of farming.

At 23 he sets out for the Caucasus to join the tsar's army endlessly fighting Muslim mountain tribes between the Black and the Caspian Seas. He narrowly escapes a grenade, is nearly captured. At 26 he's deep in the bloodbath of the Crimean War, commanding a battery defending Sevastopol against the French and English.

His early stories of this war—as seen by different participants—bring him acclaim in St. Petersburg society and literary circles, but he tires of that. He travels abroad, in western Europe, then settles down at Yasnaya Polyana and establishes a primary school for children of his illiterate peasants, on principles strictly his own. No compulsion, no punishment—pupils keep their own hours and work at what they like best. Eventually he writes primers and children's stories. He loves to teach. The kids love him.

At 34 he brings home Sofia, his 18-year-old bride from Moscow, but not to the 32-room mansion he was born in; he lost that at cards while in the army, and it was carted off, bit by bit. Only a stone marker remains today. He and Sofia settle down in what had been a separate two-story wing; they'll expand it as their family grows year after year.

Now amid his daily riding, walking, swimming, and talking to peasants and visitors, Tolstoy works long hours on what will become *War and Peace*. He writes a few pages and rewrites them again and again; every night, sometimes beyond two in the morning, Sofia copies the changes from his nearly illegible script, knowing that tomorrow he'll probably cross it all out and rewrite it for the sixth or seventh time. "How patient and hardworking he is," writes Sofia in her diary. "It is astounding!"

The result, after seven years, is one of the wonders of world literature, more than a thousand pages of adventures and feelings of dozens of major characters and scores of minor ones, sprinkled with Tolstoy's novel reflections on history, on war. Wars interest him, not in the sense of maneuvers devised by Napoleon or other generals, but the reality of war—"under the influence of what feeling one soldier kills another." Generals don't matter as much as they think; what decides battles and finally the war is a combination of unforeseeable circumstances. . . .

IT'S BITINGLY COLD at Yasnaya Polyana, minus 2°F, but what's this—a girl in a wedding dress, a boy swinging a champagne bottle, emerging from the wintry woods? They drive off in a

streamer-decorated taxi. The guide says one couple started it a few years ago, now it's a tradition around here: After leaving flowers at the Lenin statue, and the memorial to Tula's defenders in World War II, newlyweds bring flowers to Tolstoy's grave.

The guide says I'd better come back in May, in the time of the apple blossoms, the nightingales. I tell her I will.

Back in Moscow, school groups troop through the L. N. Tolstoy State Museum established in a pillared old patrician house. All Soviet youngsters study Tolstoy, a teacher says. In primary school, dozens of his children's stories; later all read *War and Peace*. Here they see a mass of memorabilia, paintings of Tolstoy, impressive sculpture. I'm impressed by a manuscript he produced when he was seven. He called it *A Natural History*. "The owl is a very strong bird. The eagle is the tsar of birds. . . ."

A gray-haired man pauses before a showcase. He wears the gold star of Hero of the Soviet Union. How did he get it? He says he was a partisan, in Nazi uniform behind enemy lines in the Ukraine; he adds with a modest smile that a man often thinks more of himself than he really is. I didn't know it then, but he was paraphrasing Tolstoy.

The museum director says that in summer Tolstoy exhibits will go to the far ends of the country. Into the wilderness of Central Asia with the exhibition train *Komsomolskaya Pravda*, visiting workers building the Baikal-Amur Railway. And 4,000 miles east to the Sea of Okhotsk, where fishermen will tie up to the exhibition ship *Korchaginets* and climb aboard for lectures on "Tolstoy in

On the track of bear, hunting guides break trail in the Caucasus Mountains for wealthy international sportsmen. Here for most of his four-year army stint, Tolstoy fought a guerrilla war against Muslim tribesmen—fodder for two early short stories, The Raid *and* The Wood-Felling. *"His work is timeless," says author Peter White. "His descriptions brought to mind my experiences in Vietnam."*

the contemporary world" or "Leo Tolstoy, the pride of Russian literature."

In a sense there are Tolstoy exhibits across Moscow. Places that appear in his books, such as the massive mansion that was the English club; it is now the Museum of the Revolution. And places he stayed in, such as a little house near the center of town in which he briefly rented rooms upstairs while leading what my translator calls the "disorderous life of a bachelor." This house is dear to us, I'm told, because here he began his serious writing, with *Childhood*. Most meaningful and most touching is the small estate farther out, at No. 21 Leo Tolstoy Street in Khamovniki, where things are as he left them, where many of the very objects to be seen speak of a dramatic turning point in his life.

In 1881, when Tolstoy was 53 and had published *Anna Karenina*, another instant success, and Sofia had by then borne 11 of their 13 children—eight would survive to adulthood—she insisted that the family move to Moscow for the cold months. The boys must go to good schools, she said; the oldest daughter must be introduced to society, go to balls, meet the right young men. He gave in, at first renting a house, then buying one on three wooded acres in what was then a suburb (page 776). The Tolstoys moved in with servants and staff—housekeeper and cook, tutor and governess, seamstress and nurse, maids, valet, coachman, gardener. He was not happy.

For quite some time he had been seeking the meaning of life in his past, in his conscience, and in religious texts, and writing essays about that. *Confession. Examination of Dogmatic Theology. Translation and*

NOVOSTI PRESS AGENCY

*"Nature . . . . is a friend you will never lose until death—and even when you die, you disappear into nature." The outdoors was a church to Tolstoy, and he often meditated while strolling down a cathedral walk of linden trees at Yasnaya Polyana (**left**). Many of his works were written in the study there, where he consulted in 1909 (**above**) with disciple Vladimir Chertkov, who sits on the couch on which Tolstoy was born.*

Harmony of the Four Gospels. Now he was struck by the poverty in the city, that it was so much worse than in the villages. He talked to tattered, sickly-looking people, some who hadn't eaten for two days, waiting in the freezing cold to be let into stinking doss houses, while he himself went home to comfort, to take off his fur coat and sit down to a five-course dinner served by two white-gloved footmen. It bothered him.

He went as a census taker into Moscow's poorest district and wrote down what he encountered—filth, drunkenness, child prostitution. His friends tell him all this misery is a natural urban phenomenon, it's worse in London. But he thinks no, that when thousands are exposed to starvation, cold, and humiliation, while he and others gorge themselves on fillet of beef and sturgeon, it is a crime, committed not once but continuously; and that he, with his luxury, not only incited it but also takes part in it.

Every day he becomes more conscience-stricken and upset.

BOLSHOI THEATRE BALLET (LEFT)

TODAY Tolstoy's little estate nestles amid a brewery, a textile factory, and a 13-story ophthalmological hospital. The brewery was there in his time, and so were factories making costly cloth and perfume. In the morning at five he would hear a whistle—women, children, and old men began their mind-deadening work. The whistle for stopping work came at night at eight. Around eleven, fine carriages—including his—would carry perfumed, expensively gowned ladies to a ball, to enjoy themselves until six in the morning. . . .

Tolstoy distilled these city experiences into a 300-page treatise, *What Then Shall We Do?* It's a remarkable blend of investigative reporting, politico-economic analysis, and a guide for individual action, first of all for himself. Charity is no answer, he says; he must simplify his needs, and not let others do things for him but do things for others.

He'll divide his day into four periods. Before breakfast, hard physical labor. From breakfast till dinner at 1 p.m., activity of the mind, writing. From dinner until supper, activity of dexterous workmanship, artisan labor. And after supper, talking with family and guests, music, chess.

Tolstoy's Moscow estate shows how he sought to live up to his expectations. With this shovel he cleared snow from the courtyard, in that shed he sawed and split wood; then he carried it to the ten stoves in the house. A barrel sits on a sled—he dragged it to the well, to bring water for the kitchen. Next to his study I see tools and a sample of the tall peasant-style boots he made with them for himself, relatives, and friends.

In the upstairs reception hall, with a grand piano and a table extending to seat 50, Sofia would sit behind the samovar, pouring tea, while Tolstoy greeted guests in his long,

"All happy families are alike; every unhappy family is unhappy in its own way." So begins Anna Karenina ***(left)****. Tolstoy's sketches* ***(left,*** *top) may have aided illustration of the novel, written in 1873-77. Denied her son by her abandoned husband* ***(above,*** *in ballet) and fearing she was losing her lover, the unforgettable heroine takes her life.*

peasant-style blouse—that's how he dressed now, in his quest for the simplified life. . . .

Sofia, as her diaries show, wasn't happy either. She didn't mind being terribly busy—in fact she liked that, giving the smaller children lessons in French and music, making preserves, embroidering her beloved Lyovochka's monogram on his socks. And she'd take dictation from him and handle his voluminous correspondence. But she did not share his zeal for reform and for his new way of life. Making himself a brew of barley and acorns because coffee is a luxury! Insisting on sweeping his room and taking out his own chamber pot! And why does he keep working on those pugnacious tracts that put people off, when he could be doing more of those wonderful novels that would bring in lots more money?

On her desk, littered with bills and party invitations, I see a copy of a letter from her soliciting subscriptions to a 12-volume

edition of his collected works—nine rubles, including postage. She was now in the business of printing and selling his writings, earning a good part of the family income. He didn't care about money but she had to, or what would become of the children?

Undeterred, Tolstoy pursued religious themes, in *What I Believe* and *Where Love Is, There God Is Also*. He now believed that church dogma—which approves the condemnation of other religions and condones

A standing ovation in Moscow's Bolshoi Theater for ballerina Maya Plisetskaya as Anna Karenina echoes the thunderous praise that met the novel. But the applause rang flat for the depressed author. Later, while walking in his woods, "At the thought of God, happy waves of life welled up inside me. Everything came alive, took on meaning." Tolstoy for a time veered from fiction and set out on a religious odyssey.

war—in fact turns men away from the essential teaching of Christ, which stresses love and compassion and man's duty to man. He had found inspiration in the Sermon on the Mount, especially Matthew 5:39—"resist not evil." One should return good for evil. This was to become the heart of his doctrine of universal love, moral self-improvement, and nonviolence as eventually expressed in *The Kingdom of God Is Within You*.

THE BIBLE for Tolstoy studies today is a 90-volume edition published in Moscow between 1928 and 1958. "There's thought of a 100-volume edition," says Dr. K. N. Lomunov, a leading Tolstoy specialist. He has just received the latest volume of a new 22-volume set—a million copies, sold out in advance! "Interest in Tolstoy is greater than ever. We thought we knew all about him, but every year we come up with new information about his life."

At lunch at the Writers Union, in an old palace with a 1960 Tolstoy statue in front, Dr. Vladimir Lakshin, a critic and anchorman of a popular literary talk show on television, tells me that this is known as the house where Natasha Rostov and her family lived.

"That's only a legend," he says, "but to us Natasha is alive. And so are other Tolstoy characters. They are part of our national culture, we can touch them, they seem more real to us than people we know in real life."

How would he define Tolstoy's place among Russian literary giants?

"We like Chekhov, admire Dostoyevsky, love Pushkin, but Tolstoy? As a combination artist, philosopher, public figure, and human being he is *neobychny*," meaning unparalleled, incomparable, unique. Dr. Lakshin adds that some Tolstoy notions once considered mistaken have turned out to be extremely important for our day.

What, for instance?

"His protest against industry and cities destroying the landscape. He was one of the first to warn us, to understand the problem

*"I am a participant in a crime . . . so long as I have superfluous food, and another man has none. . . ." Uneasy in his comfortable Moscow home (**left**) after meeting "that class who really freeze to death," Tolstoy wrote* What Then Shall We Do? *Hoping his beloved youngest child, Ivan, would "carry on God's work after me," he was devastated by the boy's death at seven in 1895. Sofia preserved his toys in the nursery (**above**), and Tolstoy wrote: "I feel caught in a situation there is no way out of."*

"A Christian should pray for his enemies, not against them," Tolstoy reasoned, and believed that church and state distorted Christ's teaching of compassion. Sacraments were "sorcery" to him—and he opposed child baptism, here awaited at the Church of the Holy Ghost in Leningrad ***(above right)***.

Russian society dubbed him "the 13th apostle," and wondered if the tsar would imprison its most popular writer in the monastery near the Cathedral of the Nativity in Suzdal ***(above)***. *Excommunicated in 1901, Tolstoy responded with serenity: "I believe in God, whom I understand as Spirit, as Love, as the Source of all. I believe He is in me and I in Him."*

of ecology, of conservation of the environment." But nonviolence is another matter. "We argue with him on this point. . . ."

So did Lenin. Before coming to power, he wrote articles praising Tolstoy as a genius who drew incomparable pictures of Russian life and castigated social falsehood and hypocrisy; but as to his advocacy of nonresistance to evil, that's "crackpot preaching." Tolstoy, he wrote, couldn't understand the class struggle—that a better life could come only through violent overthrow of capitalism by the proletariat.

Yet when Lenin took power seven years after Tolstoy died, he urged that everything Tolstoy wrote be printed, every comma. At least, that's what's said in Moscow nowadays. And when he felt overworked in the Kremlin, he would read *War and Peace*. He

especially liked the wolf-hunting scene; it gave him serenity and strength.

I'M BACK AT YASNAYA POLYANA late in May. Where there was snow and silence, there now is greenery and purposeful activity. Early morning fog drifts over the big pond, two boys are fishing and then some men, a dozen ducklings come and hop in. On the slope leading up to the village, women tend their vegetable plots with watering cans. Then they bring calves, drive stakes, tether the calves, and leave them to graze.

Amid warm breezes and birdsong I walk past the big house to the formal grove called *kliny*, the wedges, because eight double rows of tall linden trees divide it into wedge-shaped triangles. Here Tolstoy walked in the morning, alone with his thoughts. He called this his morning prayer.

By ten o'clock, visitors bustle up the main avenue of birches by the busload—the busy season is afoot. Some 400,000 a year come and go quickly. I feel privileged, being permitted to stay overnight, in the building next to the stables where the house servants once lived, so that I can appreciate the spring here, and especially the trills of the nightingales—all so beautiful, Tolstoy once said, it would rouse a dead man.

At Yasnaya Polyana he'd sweat with the poorest peasants—plow, cut hay with a scythe, spread manure on a widow's field. Anyone wanting to see him could do so, and many did, local people and visitors from afar. For he was becoming world famous and, in his fashion, powerful.

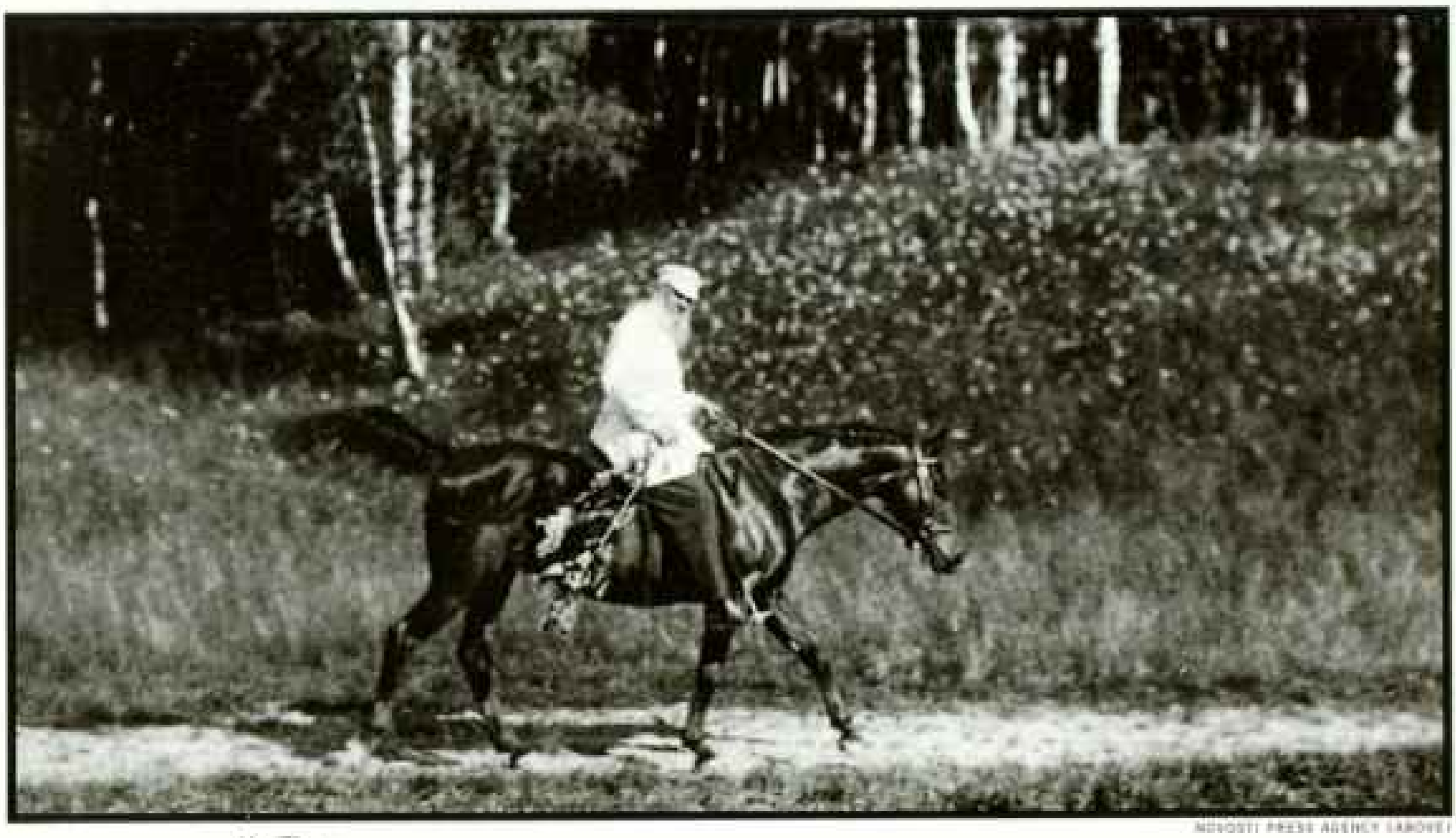
Not only did his books cause a stir among the sophisticated as they circulated by the tens of thousands in Russia, as well as abroad in French, English, Japanese, but also literally millions of brochures with his tracts and moral tales spread his ideas among all classes across the lands of the tsar. Censors proscribed much of his work; it circulated anyway—duplicated in various ways and sometimes in handwritten form, passed around even among political prisoners in Siberia. A journalist said there are two tsars in Russia, Nicholas II and Tolstoy: The difference is that Nicholas can't do anything with Tolstoy, and Tolstoy all the time is shaking Nicholas's throne. . . .

LETTERS CAME TO TOLSTOY from China, India, America—as Maxim Gorky put it, "from everywhere, living, throbbing threads stretch out to him." Invariably he responded, pulling no punches in speaking his mind.

A young German asked what's more useful, to become a good teacher or to suffer for refusing to serve in the army? Tolstoy replied that the question was falsely stated, it should be: "What should a man do who has been called upon for military service—that is, called upon to kill or to prepare himself to kill?" His "incontrovertible answer" was that a moral person "must refuse to take part in military service no matter what consequences this refusal may have."

When a prominent admirer asked for a message to the American people, he wrote back that he'd like to thank them for the great help he'd received from American writers—Emerson, Thoreau, Walt Whitman. "And I should like to ask the American people why they do not pay more attention to these voices (hardly to be replaced by those of Gould, Rockefeller, and Carnegie) and continue the good work. . . ."

No wonder that Tolstoy's unorthodox views also drew rebukes from abroad. When a Tolstoy disciple criticized "American militarism"—and when Tolstoy in his novella *The Kreutzer Sonata* propounded that it was better to stay chaste even in



NOVOSTI PRESS AGENCY (ABOVE)

"You must have been a horse once yourself," said writer Ivan Turgenev, complimenting Tolstoy on his communication with animals. Crossing Yasnaya Polyana on Delir (**above**) in 1909 was part of his daily regimen of exercise and physical labor. The hands of a farmer on the estate today (**right**) recall writer Maxim Gorky's praise for Tolstoy's—"Not beautiful . . . yet full of a singular expressiveness."

NOVOSTI PRESS AGENCY

marriage—Theodore Roosevelt called him a man of genius with a "complete inability to face facts" and *The Kreutzer Sonata* "revolting," appealing "only to decadents."

IN 1909-10 TOLSTOY exchanged a series of letters with a middle-aged lawyer from India, Mohandas K. Gandhi, who had read *The Kingdom of God Is Within You* and been overwhelmed, he said. Then he read what Tolstoy had written about India:

What does it mean that 30,000 weak and ordinary people have been able to subdue 200 million vigorous, clever, freedom-loving people? "Do not the figures make it clear that it is not the English who have enslaved the Indians, but the Indians who have enslaved themselves?" Tolstoy's advice to Indians was not to resist evil with force but also "do not participate in evil—in the violent deeds of the administration, in the law courts, the collection of taxes and, what is more important, in soldiering, and no one in the world will enslave you."

Gandhi soon called himself a devoted adherent and humble follower of Tolstoy. It was the sage of Yasnaya Polyana, he said, who cured him of skepticism and made him a firm believer in *ahimsa*, nonviolence.

Gandhi, then practicing law in South Africa and struggling against anti-"coloured" prejudice there, founded a community he called Tolstoy Farm. Later, in India, he founded others, also on Tolstoyan guidelines. And in 1920 he proclaimed a program

of nonviolent noncooperation at a time when Indian politics was full of bomb throwing. That subsided, and after nearly three decades of his nonviolent struggle India was at last free from British rule.

BY FIVE in the afternoon the visitors are gone, and Tolstoy's study is still full of light. Through the tall windows I see rows of white-barked birches, those friendly trees emblematic of Russia. I can visualize him being here himself, amid family photos and pictures of the Sistine Madonna, of Schopenhauer, of the American reformer Henry George. And his books. Montaigne, Goethe, Dickens. A concordance of the Bible. Buddhist sutras, texts from Lao-tzu, the Koran, the Talmud.

There are 22,000 books around the house, carefully cataloged, and I'm allowed to look into some, at his penciled markings. "Good." Or "nonsense." Or simply the Cyrillic letters for NB, meaning "nota bene," mark it well. But where's his copy of Thoreau's *Walden*, Boston, 1854? And *Civil Disobedience*? He found much food for thought in those—respect nature, do hard physical work and handicraft, pay no taxes to a government you don't agree with. Alas, the Thoreau books cannot be found. Perhaps he gave them away.

His desk chair is strikingly low—just 17 inches high—so that when he wrote, his chin was only about seven inches above the desktop; he was nearsighted and didn't want to wear glasses. On the desk are tokens of love. A little bronze dog from "Aunt Toinette." A green crystal paperweight from the workers of a glass factory in Bryansk, engraved with a message: Let the Pharisees and the Holy Fathers excommunicate you as they wish; the Russian people will always hold you dear.

The Russian Orthodox Church had long been angered by Tolstoy's comments on the state religion, especially in *Resurrection*, a novel published in 1899. It tells of a prince who seduced a servant girl, later finding himself on a jury judging this woman who has become a prostitute and is accused of murdering a customer; she is marched to Siberia, and the prince—full of remorse and newfound spirituality—follows her, wants

*"Should the muzhiks' children learn to write from us, or should we learn to write from them?" Loath to dampen creativity, Tolstoy took the motto "Do as you like" for his schools for peasant children at Yasnaya Polyana village. Visiting about 1908 (**facing page**), he bends to ask for a folk dance from Anna Kandaurova, one of 900 residents living there today (**below**).*

to marry her. . . . *Resurrection* savagely indicts the tsarist courts and prison system, and also the practices of the church. The Holy Synod struck back with notices on church doors proclaiming Count Tolstoy a false prophet, undermining the faith. A man in the street called him a devil in human form. He was excommunicated.

But there also was an outpouring of sympathy for Tolstoy. When he walked Moscow's streets, supportive crowds followed him. Students acclaimed him a hero. His rebuttal was published around the world, and *Resurrection* acquired special meaning for the sect called Doukhobors—Spirit Wrestlers—who refused military service and were brutally persecuted. Tolstoy sponsored a fund to collect money for them, and

NOVOSTI PRESS AGENCY (ABOVE)

*In a healing Black Sea breeze and the warmth of the Crimea, Tolstoy spent his 74th year in a villa in Gaspra near Yalta (**left**), recuperating from successive bouts with rheumatism, malaria, pneumonia, and typhoid fever. Today called the Yasnaya Polyana Sanitorium, it treats childhood respiratory diseases with similar remedies (**above**).*

Recognizing Tolstoy's popularity despite his celebrated 1901 excommunication, authorities issued secret orders to prohibit demonstrations in event of the writer's death.

from the sale of the book he contributed 80,000 rubles—then worth as much as half a million dollars is today—to help settle thousands of Doukhobors in Canada, where their descendants are now thriving.

NEXT MORNING I set out to circumnavigate Yasnaya Polyana on foot, starting in the village. It has a school, a clinic, a movie theater, and 900 inhabitants in 435 families, says the local Communist Party chairman—mostly descendants of people who were here in Tolstoy's time. A few work in the museum, and some in a nearby fertilizer factory with a big sign, "Glory to Labor," but most are in agriculture on the Yasnaya Polyana state farm, concentrating on breeding dairy cows.

Away from the cluster of little houses all is green and quiet. I pass a modern cow pen, and young hikers with fishing poles and a guitar, and walk on for hours through the meadows and orchards and forests Tolstoy loved. Where the little Voronka River is only ten feet wide, I sit and lean against an oak and wonder about this man who from here let his thoughts range over problems of his age that are in fact ageless.

Can all those paintings and statues do him justice? Gorky described his hands—"not beautiful, but knotted with swollen veins, and yet full of a singular expressiveness and the power of creativeness. Probably Leonardo da Vinci had hands like that." An American writer visiting here a hundred years ago saw his face as "molded with the fist and polished with the pickaxe," conveying "self-reliance and unconquerable strength."

And what might Tolstoy tell us about certain disturbing aspects of life today?

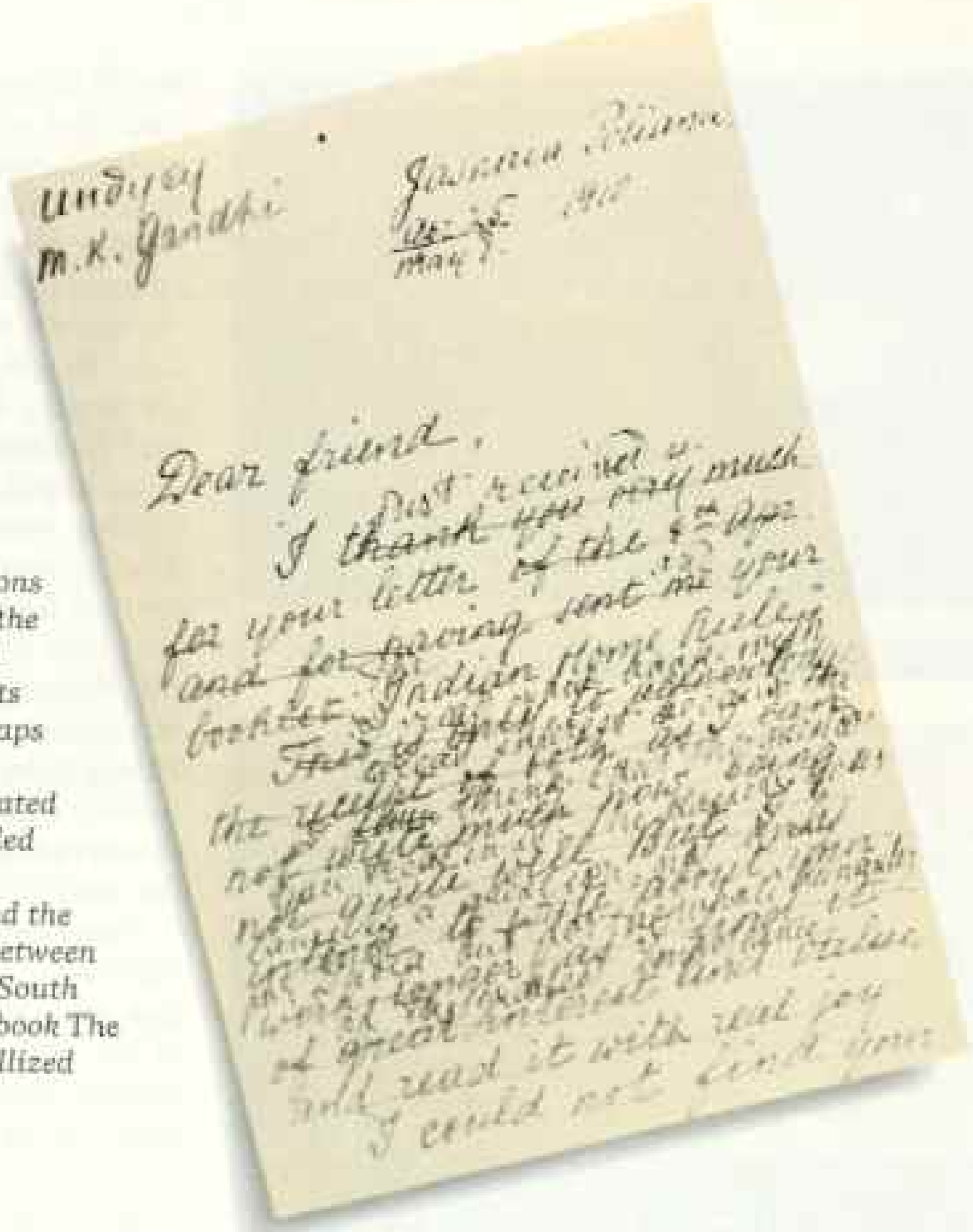
In Moscow I'd seen a Soviet film titled *Tolstoy, Our Contemporary*. One scene shows students in a Western European capital demonstrating against nuclear missiles, being beaten by police; a voice intones, "Tolstoy is with them." No doubt. But isn't it also possible that if Tolstoy were here with us he would condemn not only those beatings but also some of what goes on in the Soviet Union? After all, he thundered that the state is bad, authority is bad, political imprisonment is terrible. . . .

Dr. Uran Guralnik of the Institute for

"Ours was a house of glass," daughter Tatyana recalled of Yasnaya Polyana, where a parade of her father's often fanatical devotees could "penetrate into the intimate details of our family life."

Summertime meals and conversations centered in everyone's favorite room, the grapevine-draped veranda (**left**). *At a picnic, family and the inevitable guests posed for a photograph* (**below**), *perhaps taken at the direction of Sofia, an accomplished photographer. She is seated at far right in front of the white-bearded Tolstoy, then 68.*

Correspondence arrived from around the world. Several letters (**right**) *passed between Tolstoy and Gandhi, then working in South Africa as a lawyer. Reading Tolstoy's book* The Kingdom of God Is Within You *crystallized Gandhi's belief in nonviolence.*



NOVOSTI PRESS AGENCY (TOP AND ABOVE)

"My departure will cause you pain and I'm sorry," Tolstoy wrote to his wife, then stole away before dawn on November 10, 1910. Increasingly estranged and tormented by the psychic pain they were inflicting on each other, he hoped to live out his life in a quiet retreat. About 150 miles from home on November 13, he fell ill with pneumonia and was removed to a tiny train station, now named for him (**facing page**).

Like a passing traveler today (**top**), Sofia arrived by railroad car. She was not allowed to see her husband of 48 years until he was unconscious.

The station clock records his time of death on November 20 at 6:05 a.m. A railway worker traced Tolstoy's profile on the wall in the stationmaster's quarters (**above**).

World Literature in Moscow has told me I can't put a question in this way—my approach is mistaken, the correct one is the historical approach. He repeats that what Tolstoy said *then* doesn't apply today, it's a completely different way of life. "The basics of relations between the people in our society are different, and Tolstoy would be a different person. We could spend hours on political education for you."

Perhaps I should have argued back that to Tolstoy every form of coercion, like every form of violence, was inexcusable, no matter how high the aim. Or simply have cited his blunt comment when someone insisted that there is a moral difference between killing done by an idealistic revolutionary and killing done by a tsarist policeman. Tolstoy replied: "There is as much difference as between cat shit and dog shit. But I don't like the smell of either one or the other."

Now, not feeling bound by the historical approach, I can speculate on another question that perplexes many in the second half of the 20th century. Why is it that when a country overthrows a widely hated regime, what comes after is sometimes just as bad, or worse?

Because, I think Tolstoy would answer, all dictatorships and revolutionary movements share the same basic assumption. As Dr. James Billington—a historian of Russian culture and director of the Woodrow Wilson International Center for Scholars in Washington, D. C.—puts it: "This assumption is that as long as violence is controlled by some disciplined party organization or national state, it is an acceptable means to a desirable end. Tolstoy challenged that in a way that nobody has since."

IN HIS LAST dozen years, Tolstoy kept busy as ever—walking, riding, writing, seeing visitors, speaking out.

When dozens of Jews perished in a pogrom in Kishinev, he blamed the government and wrote three stories for an anthology to raise money for survivors. About conferences in Europe seeking to promote peace, he wrote that they were hypocritical, that governments, so long as they rule by force, will never reduce their military power but constantly try to increase it, ostensibly for the sake of peace; and that

this cannot be changed by "liberals, socialists, and other so-called representative people, who are enmeshed in their own wordiness."

For his 80th birthday Thomas Edison sent him one of his first "phonographs," actually a dictating machine recording on wax cylinders, and so we have Tolstoy's voice in Russian, French, German, English: I've heard him read from *I Cannot Be Silent,* an impassioned plea for the abolition of the death penalty.

He also finished one more novel, *Hadji Murad,* about a Muslim guerrilla in the Caucasus who fights the Russians, then joins them, and dies fighting them again; his hero has been called the embodiment of *volya,* freedom, in the sense of personal freedom or will, the expression of the self. No advocacy of nonviolence there.

But Tolstoy is increasingly unhappy, because of family squabbles and because of his conscience. Sofia is vexed by assorted followers of Tolstoyan ideas who come and go more and more, many of unacceptable social position with poor manners. She calls them "the dark ones," and fears they'll get Tolstoy into even more trouble with the censors and the secret police.

Above all, she's been tortured by jealousy—especially of a peasant woman on the estate with whom Tolstoy once had a long liaison and a son. She knows this because just before her wedding, in a fit of contrition and remorse, he made her read his bachelor diaries, which were full of very explicit language. She also fears he's made a secret will, leaving his writings to the dark ones for God knows what causes. So they argue, he threatens to leave, she threatens suicide; they make up again, and each writes embittered diary entries knowing the other will read them. . . .

What also bothers Tolstoy is his growing

conviction that his life hasn't been sufficiently in keeping with his high principles. Long ago he'd written about people asking him, "You preach, but how do you live?" He wrote that this was a most natural question, and "that it always shuts my mouth." He added that he hadn't fulfilled a thousandth part of Christ's commandments, not because he didn't wish to, but because he was unable; but he was trying with all his heart. Now he writes in his diary that he rarely met a man with more vices than himself—voluptuousness, self-interest, malice, vanity, and especially self-love. He thanks God that he's still struggling against all that.

By 1910 Sofia makes hysterical scenes almost daily. On November 8 Tolstoy writes in his diary: "More and more I am oppressed by my life." The following night he hears Sofia rummaging in his study. Is she looking for that will? After 48 years of marriage he writes her a farewell letter—the situation at home has become now unbearable, he says, and aside from that he can no longer bear to live in luxury.

Well before dawn he leaves Yasnaya Polyana for the last time, quietly, accompanied only by his doctor. Some think he hoped to go to a monastery and then become a penniless pilgrim.

Tolstoy fell ill on a southbound train of the Ryazan-Urals Railway and was taken to the stationmaster's house at Astapovo (page 788). For a week all Russia and much of the

*Tolstoy's death mask lies amid funeral wreaths (**below**) in Yasnaya Polyana. Attuned to his spirit, newlyweds leave flowers at his grave on the estate (**right**). He chose this site where, as a child, a brother claimed to have buried a stick bearing the secret of happiness. "The whole meaning and joy of life," Tolstoy concluded, lay in the search for perfection and understanding of God's will.*

world—informed by telegraph—held its breath. On November 20, 1910, he died.

FIFTY YEARS LATER—at a ceremony in the Bolshoi Theater in Moscow, in the presence of the general secretary of the Communist Party of the U.S.S.R.—the main speaker, the author Leonid Leonov, said Tolstoy's name is paired with those of Homer, Luther, Buddha. Last fall on the 75th anniversary of his death, powerful and eloquent men again met to praise Tolstoy. But I cannot imagine a more memorable tribute than what I've witnessed at Yasnaya Polyana in the spring.

The grave is a mound in the woods, amid two maples, three elms, and an oak. This is the place Tolstoy requested—near a ravine where he and his brothers, when they were little, believed a green stick was buried on which was written the secret of happiness for all human beings. There is no cross, no marker. The wind is still. Birds sing.

A newly married couple and three attendants approach on the path, everyone talking, the couple laughing and kissing. They walk the last hundred feet in silence. The bride, with a gesture as graceful as a ballerina's, places her flowers on the grave, and all stand a while. They leave without having said a word. When they begin to talk again, he playfully tugs at her skirt and she takes his arm. □

Tracking the Elusive Snow Leopard

ARTICLE AND PHOTOGRAPHS BY
RODNEY JACKSON AND DARLA HILLARD

Rare, shy, and solitary, the snow leopard haunts the roof of the world like a phantom, storied but seldom seen. Its handsome coat serves well as camouflage, but in the past made the cat a victim of poachers. Man continues to threaten the leopard by encroaching on its lofty habitat. On a prowl through the Himalayan night, a snow leopard steps on a hidden pressure pad (left) and activates a concealed camera, creating one of the first three self-portraits ever made of this magnificent, endangered animal.

IN THE SNARE was an animal so rare and mysterious—so long anticipated—that I hardly dared to trust what the spotting scope had shown me from base camp. I scrambled up the steep embankment and pushed cautiously through dense bushes lining the trail high above Nepal's Langu River. Beyond the large boulder ahead was the trap.

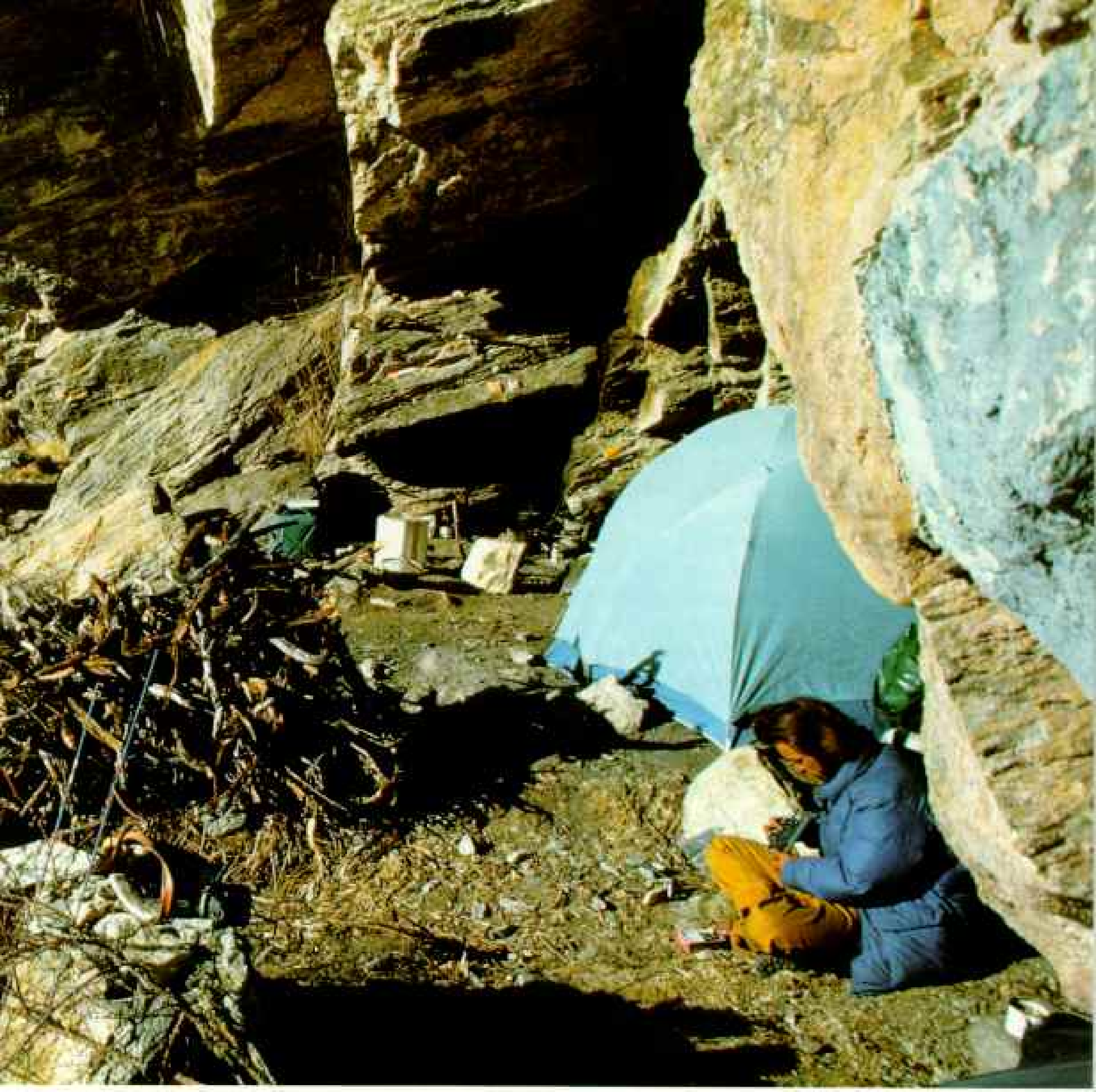
In it waited my quarry, a snow leopard, crouched low to the ground, ears flat, eyes icy green, mouth wide in a deep growl. I had to get close enough to aim a four-foot jab stick with an immobilizing drug into the cat's flank. A prime male, he was in no mood to cooperate. He twisted and lunged, hissing and snarling, harmlessly restrained by the snare to a radius of two feet—just enough to foil my aim.

My Sherpa guide, Lopsang, approached from the opposite side; the cat hesitated, and in that instant I found my mark and injected the drug. We retreated out of sight to wait for the tranquilizer to take effect.

The cat was down, eyes wide and dilated. He lay unmoving as I took the snare from his forepaw, covered his head against the bright spring sun and the stress of seeing humans, and placed a radio collar around his neck. A small tattooed "1" on the inside of his left ear would identify him in the event the collar was shed and he was retrapped. Standing about two feet at the shoulder, his three-foot tail nearly as long as his body, he weighed around a hundred pounds.

I checked my watch—less than 15 minutes since the drug, a light dose, had taken effect. The cat began to recover, muscles rigid and straining against my hands. Soon he would regain mobility. We repacked instruments, took last-minute photographs, and filled our eyes with the image of dense smoky gray fur dappled with black rosettes, thick tail, huge paws with claws extending as he rolled to his feet and moved unsteadily up the slope. He did not go far, but lay in the shade of a wild peach tree.

We returned to camp and tuned in the telemetry receiver. The world's first radio-collared snow leopard was on the move, beginning to give us information on his almost completely unknown habits in the wild.



Aerie for cat watchers *at 14,475 feet, Tillisha Cave (**above**) gives coauthor Darla Hillard, center, a spectacular view of Langu Gorge in western Nepal, site of the snow leopard project. Research associate Gary Ahlborn, right, works on equipment used to track and photograph five cats fitted with radio transmitting collars. Since signals emitted from the collars were deflected by valley walls, the team established several lofty tracking stations to increase accuracy. Ahlborn also assisted by mapping vegetation and landforms such as prominent cliffs and watersheds.*

*Hands intent on helping the species get no assistance from a snarling adult male (**left**), captured for collaring. Stalking a tethered goat left as bait, the cat tripped a loop snare, which at most leaves only a slight bruise. As a Sherpa guide, left, approaches to distract the animal, coauthor Rodney Jackson lunges with a jab stick tipped with a sedative. While immobile, the cat was fitted with a collar, then released unharmed. Information gathered by the team during the four-year study will be used by the Nepalese government to improve its snow leopard protection program.*

"IT CAN'T be done" was the typical reaction to my proposals for a radiotelemetry study of *Panthera uncia* in its inhospitable mountain habitat.

No one was willing to fund such a "high risk" project, until I received one of five Rolex Awards for Enterprise in 1981. His Majesty's Government of Nepal, through the Department of National Parks and Wildlife Conservation, approved my application for a joint study and assigned Karan B. Shah, a Nepalese biologist, to work with Darla Hillard and me. He would gather data on the snow leopards' major prey species, the bharal, or blue sheep. The National Geographic Society, the New York Zoological Society, the World Wildlife Fund, the International Trust for Nature Conservation, the California Institute of Environmental Studies, and the International Snow Leopard Trust provided funding for four field seasons, averaging eight months.

A RESEARCH PROJECT SUPPORTED IN PART BY YOUR SOCIETY

An aura of mystery surrounds the snow leopard, one of the rarest of the world's large, endangered cats. Snow leopards inhabit the remote and rugged mountains of inner Asia, their historic range of some half million square miles.

Until now almost nothing was known about the species' habits and life history in the wild, hardly surprising given its shyness, superb camouflage, and challenging habitat. Few people have been lucky enough to glimpse the cat. Most encounters involve villagers searching for firewood or herding livestock and big game hunters stalking a trophy: Suddenly their quarry is scared off by a snow leopard in search of a meal. The first photographs in the wild, taken by George B. Schaller, were published in the November 1971 NATIONAL GEOGRAPHIC.

In selecting our study area, I committed myself and my associates to living and working in one of the world's most remote and formidable regions. Only a few mountaineers have visited Langu Gorge since British explorer John Tyson first mapped it in 1964.

We carefully considered everything needed for at least eight months. If we forgot something, too bad—the nearest store was at Nepalganj, 160 miles south by foot. Staples such as rice and flour filled much of the 2,000-pound capacity of our chartered aircraft. Potatoes—and little else—could be bought from the nearest village, if the harvest was good.

We flew to the small town of Jumla, roughly 200 miles northwest of Kathmandu. Its dirt airstrip ties a few government employees and aid program workers to the lifeline of Kathmandu, and us to our study area (map, pages 800-801). At least 30 porters were needed to carry our supplies and equipment from Jumla to base camp. The journey north covered some 60 miles. It took ten days over two high passes; storms can cause delays in any season.

Base camp rested on a small river bar two days (eight miles) beyond the village of Dolphu, population 200. No permanent path exists beyond the village, so we used wildlife trails and constructed log bridges where necessary to cross the Langu.

WE LEARNED TO ACCEPT the Langu's weather extremes, the monotonous diet, backbreaking terrain, and isolation, for it is a stronghold of snow leopards and their wild prey—a natural stage for spectacular moments like the hunt recorded by Gary Ahlborn, who joined us in 1983 as my research associate.

While looking for firewood, Gary came upon a herd of bharal feeding above him in alpine grassland. Surprisingly, they showed no undue concern at his approach, particularly the adult males. It was the rutting season, and they were distracted.

Suddenly a male sheep came plunging down the steep slope directly toward Gary, followed immediately by a large snow leopard. Both were taking huge strides, traveling at top speed. After a hundred-yard chase, the leopard drew within reach of the bharal. He lunged forward, catching the sheep on the left side of its rump and sending a cloud of pelage into the air. The bharal veered sharply and ran off to safety.

Born in South Africa, wildlife biologist **Rodney Jackson** is seeking a doctorate from the University of London. **Darla Hillard** is at work on a book about the ongoing snow leopard project. Both live in California.

Self-portrait of the snow leopard

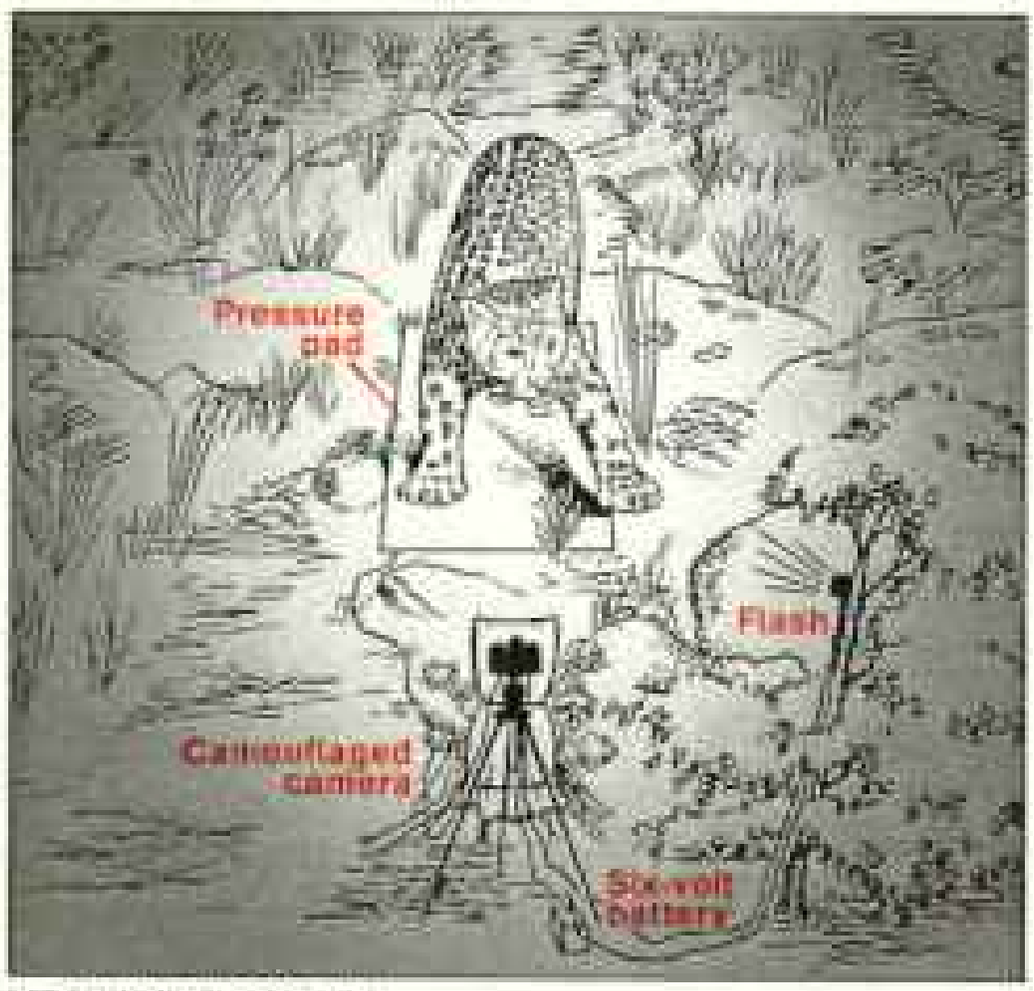
THE CLICK of the camera captures a leopard's frosty stare. In the glare of the flash, the cat's eyes glow with a greenish hue reflected from a mirror-like membrane behind the retina that enhances night vision.

Snapping candid shots of snow leopards in the wild presented a complex challenge, including extreme temperature variations, dust, and constant servicing of equipment. Patience and resourcefulness, allied with technology, paid off with rare photographic coverage. The two self-portraits in this article and the one on the cover are the only ones in existence.

The team selected a site marked by scent sprays, droppings, and scratchings on a wildlife trail that crosses a riverine terrace next to the Langu River. There they placed a pressure pad of the type used for security systems. From the pad wires led to the camera assembly, prefocused at 13 feet, as seen in the diagram (**right**) that shows how the cover photograph was made.

The researchers carefully covered the pad with dirt and restored the site to its previous condition, using pictures taken beforehand. The camera and tripod, well camouflaged with brush, drew current from a six-volt solar-powered battery.

During the 561 nights that a camera was in place, only two dozen or so cats ventured near the pad. The only nonfeline subject to show up on film was a startled villager.



NGS CARTOGRAPHIC DIVISION

Although the pursuit had brought the leopard within a short distance of Gary, he didn't see Gary standing there for several minutes. Then the man became the focus of all the cat's attention. For six tense minutes the leopard stared intently, undergoing a remarkable transformation. Pulling his ears back tightly against his head, he seemed to melt into the low vegetation. Lying prone, he was nearly invisible.

Gary's first thoughts, stimulated by the cat's potent stare, were to tell himself, "I'm not a bharal. I don't look anything like leopard prey." Was it true, he asked himself, that there had never been a substantiated report of a snow leopard killing a human?

Finally the leopard looked away several times, but more minutes passed before he made his move. For the first 75 yards, he barely lifted his belly off the ground as he crept away through short shrubs and tufts of grass. His body made very little motion, as if he had somehow located a moving sidewalk.

With a final glance back at Gary, the cat stood and broke into a full run for a couple of hundred yards, following the path the bharal had taken. As the animal approached the ridge on the horizon, he stopped, looked back, then walked out of view. Gary took his first full breath and suddenly realized

Nimbleness and nerves *are pushed to the limit by Hillard as she follows a guide down Tyson's Cliff, 500 feet above the Langu River. Says Hillard: "You have to keep going because if you stop, you get too afraid to go on." The local name for the cliff means "dropped plate," apparently referring to a mishap by a previous traveler. Using a cable and sling seat, Ahlborn inches over the rushing Langu River en route to base camp. In winter, when water was lower, the team bridged the gap with logs resting on boulders.*

that it was nearly dark and very cold.

All told we have collared five cats: three males, wearing collars 1, 2, and 3; a prime female, 4; and a young female, 5. All live on the Langu's north side. There may have been as many as five uncollared cats in the study area at any time, for our research shows the presence of transient individuals.

In spite of Gary's phenomenal experience, the Langu's leopards uphold their species' reputation as shy and secretive. They are easily concealed, and we have spent many hours—the radio giving us a cat's exact location—looking in vain for a glimpse of sinuous tail or two revealing black ear flags.

LIKE TIGERS and other large cats, leopards advertise their presence by leaving distinct signals along their travel routes. Scent sprayed on boulders and tree trunks, scraped depressions in sandy soil often accompanied by urine or feces, and raked trees all communicate to other leopards that this range is occupied.

These essentially solitary cats briefly associate during the mating season, January through March. While snow leopards do not roar like other large cats, their high-pitched yowls pierce the frigid nights of winter.

We frequently heard yowling in February of 1984. As we found out later, Leopard 4

Mangu Basin

Leopard 4 seen with her two cubs.

Radio collar from Leopard 2 discovered here.

SHEY

PHOKSUNDO NATIONAL

Rock outcrops

Leopard 4 (♀)

Leopard 2 (♂)

Tillisha Peak
5,127 m 16,820 ft

Tillisha Basin

Rock outcrops

Bhukyel Stream

Ahlborn encounters leopard in its pursuit of sheep.

Tillisha Cave
4,412 m 14,475 ft

6,276 m
17,310 ft

Leopard 1 (♂)

Leopard 5 (♀)

Leopard 3 (♂)

Tillisha Gorge

Tillisha

Dhukyel
(temporary)

To Dolphu

Spring-summer route

Log bridge

LANGU

Pine

Leopard 4's den site

Tyson's Cliff

Captured, Leopard 2 bites Jackson.

Eding
(base camp)
2,874 m 9,430 ft

Mugu Stream

GORGE

Pukchang

Temporary camp

Cable bridge

Nisan Phu

Pukchang Stream

PARK BOUNDARY

HISTORIC RANGE OF THE SNOW LEOPARD

0 400 km
0 400 mi

MONGOLIA

U.S.S.R.

XINJIANG (SINKIANG)

CHINA

India-Pakistan line of control

QINGHAI

AFGHAN

XIZANG (TIBET)

SICHUAN

PAKISTAN

NEPAL

Kathmandu

STUDY AREA

BHUTAN

BANGLADESH

INDIA

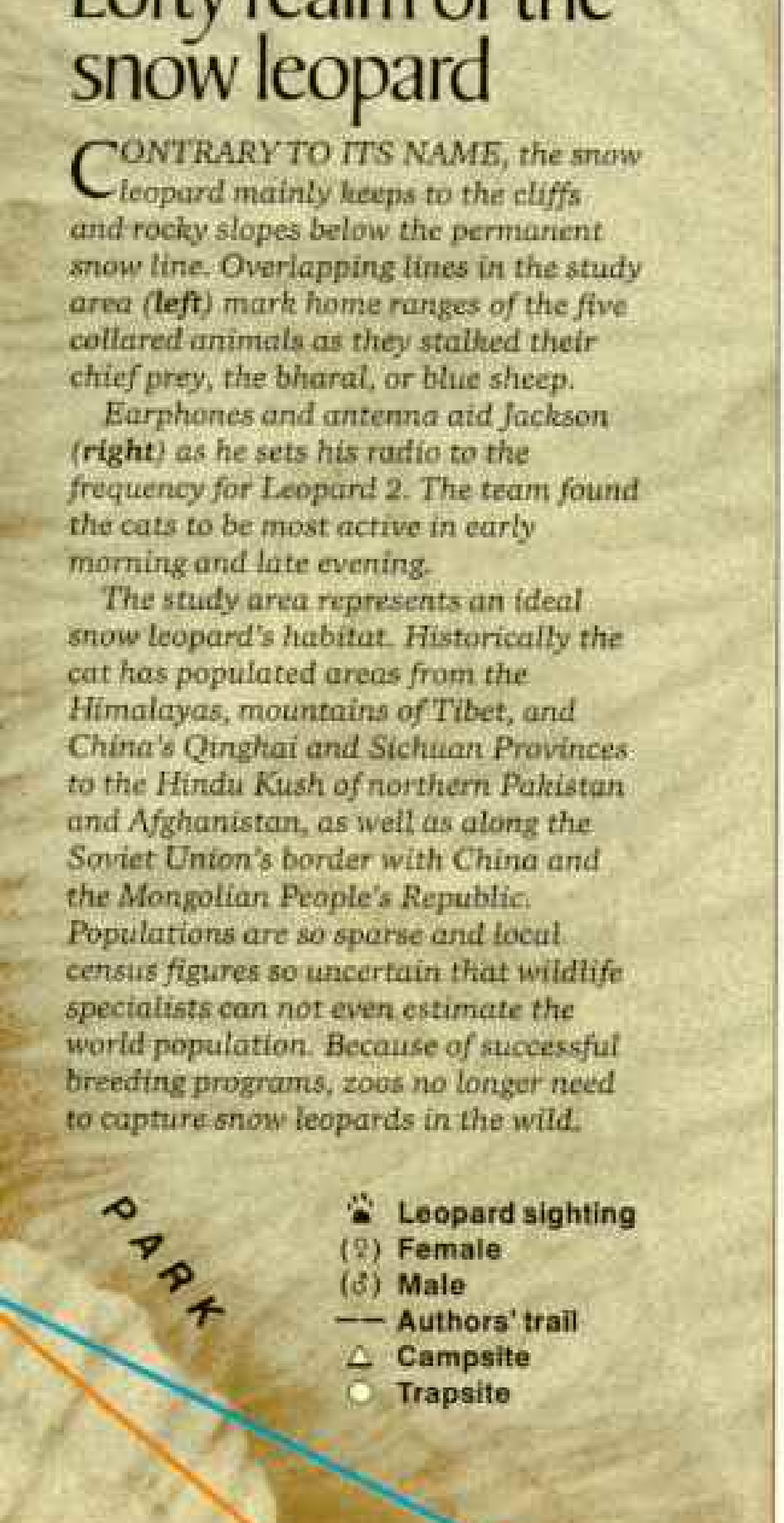
BURMA

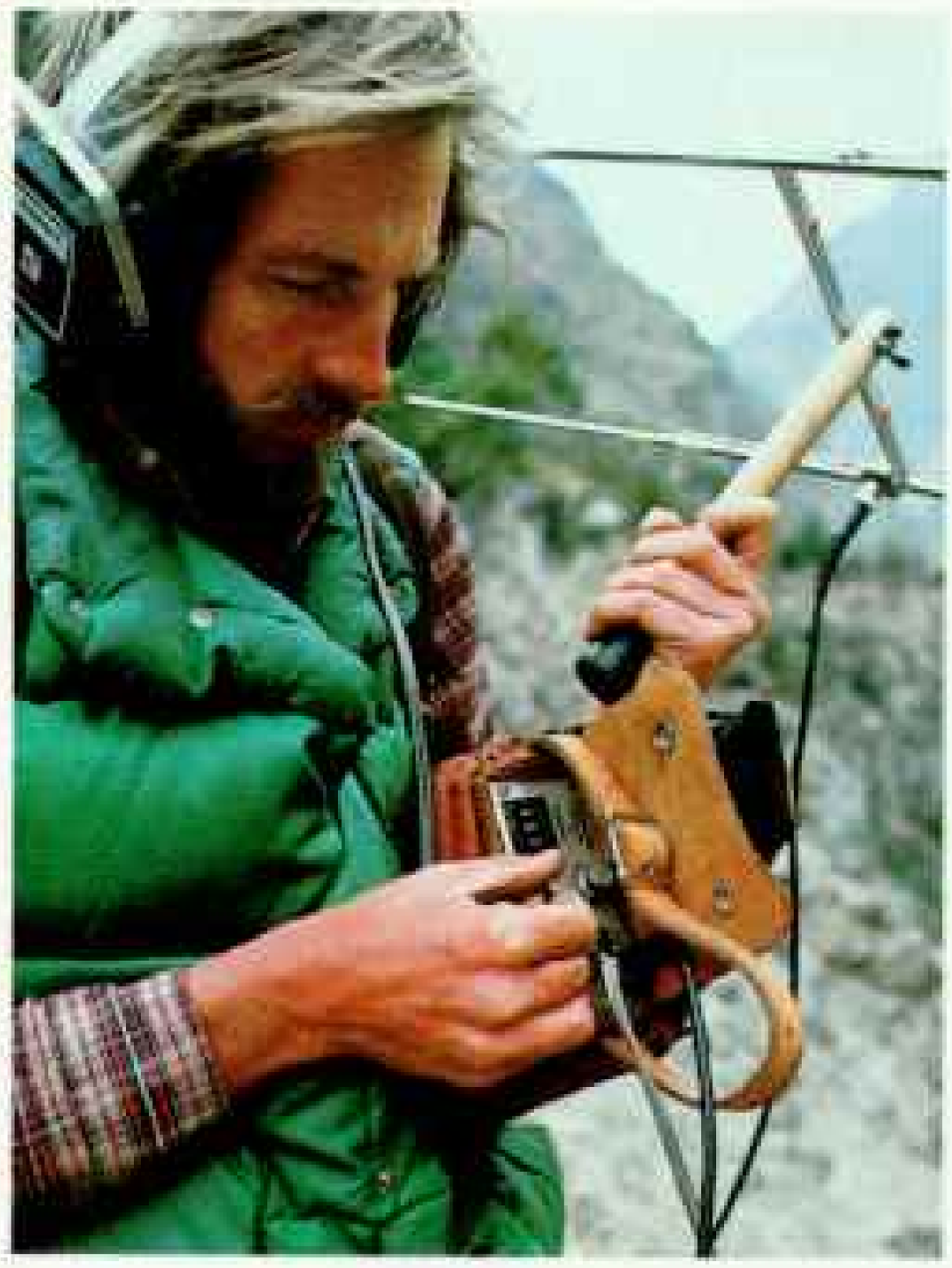
Lofty realm of the snow leopard

*CONTRARY TO ITS NAME, the snow leopard mainly keeps to the cliffs and rocky slopes below the permanent snow line. Overlapping lines in the study area (**left**) mark home ranges of the five collared animals as they stalked their chief prey, the bharal, or blue sheep.*

*Earphones and antenna aid Jackson (**right**) as he sets his radio to the frequency for Leopard 2. The team found the cats to be most active in early morning and late evening.*

The study area represents an ideal snow leopard's habitat. Historically the cat has populated areas from the Himalayas, mountains of Tibet, and China's Qinghai and Sichuan Provinces to the Hindu Kush of northern Pakistan and Afghanistan, as well as along the Soviet Union's border with China and the Mongolian People's Republic. Populations are so sparse and local census figures so uncertain that wildlife specialists can not even estimate the world population. Because of successful breeding programs, zoos no longer need to capture snow leopards in the wild.





was in heat. Spraying boulders along the bluff above camp, she alerted other cats to her condition. In June her activity pattern and reduced range indicated she had given birth. She made only quick hunting forays from the den: The need to nurse her young was as strong as her need to hunt for herself.

I was highly tempted to climb up there, to see if I could find the den and sneak a look inside. But that might have caused her to move or abandon the cubs, which are completely helpless during their first six weeks of life. Unavoidable commitments precluded our staying another month. We left reluctantly, hoping that when we returned the following autumn we could recontact 4, who would then be traveling with her babies.

It took several months after we returned in November to confirm that she had two cubs. And at that, confirmation was only in the form of tracks in the snow. Each time her signal came in loud and clear, we would search intently. One would think three cats together might be easy to spot—but no.

As we radiotracked her and the two growing cubs, it became evident that she was again utilizing her entire range. The cubs must have quickly developed the climbing skills to enable them to follow their mother wherever she chose to go. The cubs began to exhibit marking behavior at about nine

months; on the Pine Camp trail I found scrapes made by one or both of them.

But what we really wanted to see was the cats themselves. Snow leopards in the Langu are most active in early morning, late afternoon, and evening, but are not averse to traveling during the heat of the day. They are constantly on the move, daily seeking a new resting site—unless on a kill, which may keep them occupied as long as a week.

Their ability to subdue prey is remarkable. A subadult, weighing perhaps 45 or 50 pounds, killed a fully grown male sheep weighing at least 120 pounds. Tracks down a grassy slope showed us how it had dashed about 50 yards, caught the sheep, and then rode him another 160 yards before managing to kill him. Tufts of fur—sheep and leopard—clung to bushes along their path.

NO CAPTURE of any leopard has gone exactly to script. Each cat responds differently to immobilization, but the sedation period is always brief, and we must work quickly to collar the animal and obtain its vital statistics.

One or two recaptures are desirable to check the cat's condition and if necessary replace its collar, which has a 24-month battery life. Once a cat has been trapped, it

Mammoth paws *and thickly muscled shoulders of Leopard 3, a subadult male* ***(left)****, illustrate the snow leopard's superb adaptation to a life of scaling steep slopes. Under sedation, the cat remains calm while Jackson makes a final check of the radio collar* ***(below)*** *before release.*

Minutes later the groggy cat's initial attempt to leap away ends in a spill ***(bottom)****. Not all encounters went so smoothly. After collaring Leopard 2, Jackson was seriously bitten on the right hand. The wound required a trip to Kathmandu for treatment. Jackson lost a month of working time but suffered no permanent damage.*

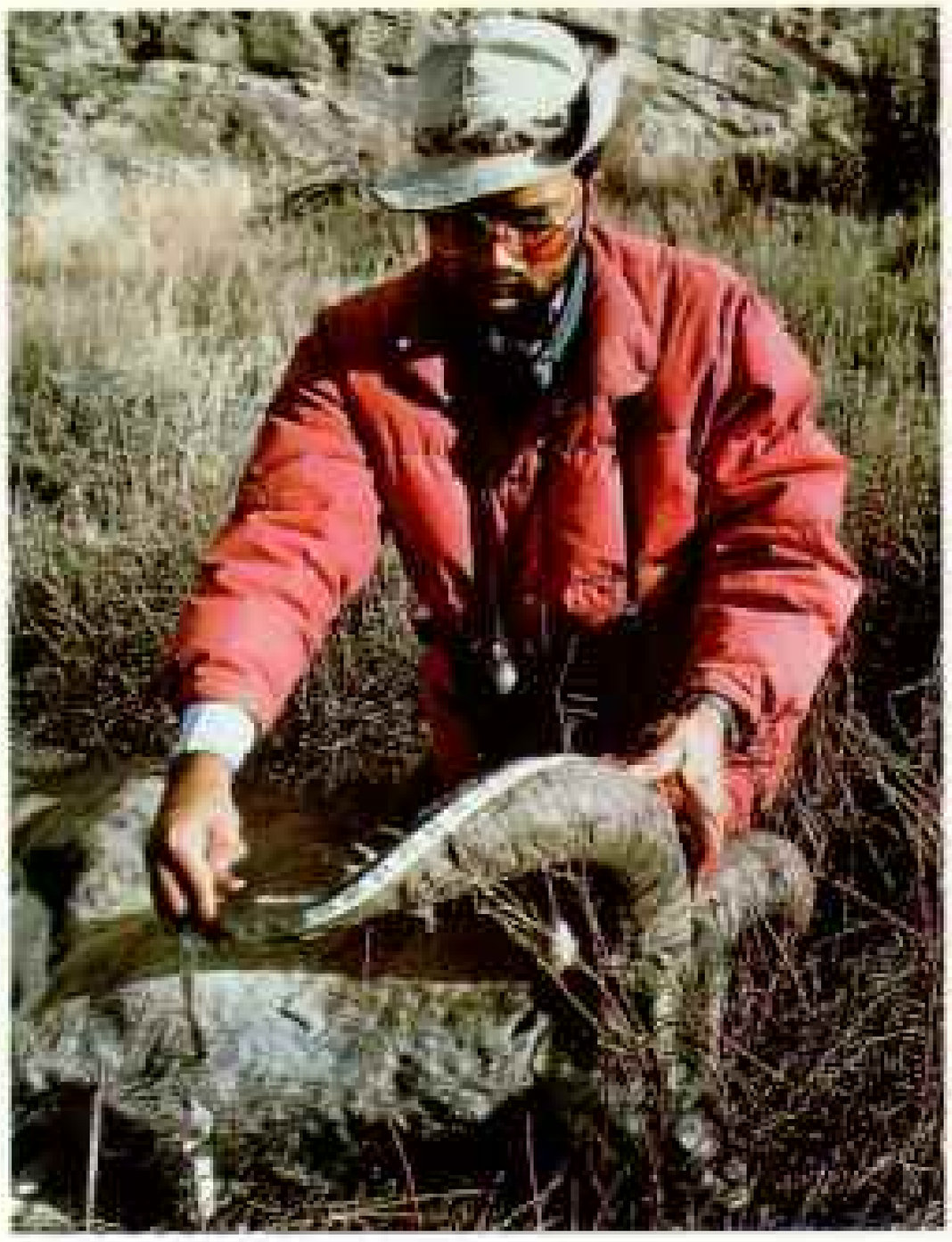
normally continues to use the area and follow the same trail, avoiding its previous trap site by simply walking around it. But Leopard 2 became notorious for his inability to avoid capture. He was caught five times.

We had begun to wonder if he didn't perhaps *like* his encounters with humans—until his fourth capture, when events made it clear that he was not happy to see us. He took his revenge in a way I will never forget.

In previous captures he had remained relatively docile while the drug was injected. This time he was uncooperative, making every attempt to avoid the needle. We gave him the normal dose of drug, but he did not respond the usual way. He became only lightly sedated—immobile for the moment—probably long enough for us to replace his collar, which was old and battered. I was reluctant to give another injection, as it would significantly prolong his recovery and possibly create risks to his welfare.

Working at top speed, we figured we could send him on his way in ten minutes. As I tightened the new collar, a low growl confirmed the need to hurry—we must move him quickly away from the bluff's edge so he would take off safely upslope.

I took the forequarters, Gary the hind. Less than a yard from the shade of a juniper tree where we were headed, the leopard lurched—too quickly for me to react before



Victim of age, *a bharal judged to be at least 13 years old is measured by researcher Karan B. Shah* **(above)**. *A lecturer from Kathmandu's Tribhuvan University, Shah worked in tandem with Jackson on his own study of snow leopard prey.*

Later, the study team's cook **(right)**, *who weighs but 110 pounds, hauled the 125-pound sheep to base camp and prepared it for dinner. Unlike sleek animals such as deer, which depend on speed for their survival, bharal have powerful, stocky bodies well adapted to jumping and climbing.*

his jaws clamped tightly upon my hand.

At once, Leopard 2, Gary, and I let go of one another, and the leopard crawled behind the juniper, a few feet upslope, still groggy and unsteady. I had a serious wound: deep punctures and a bloody gash between two fingers, knuckle and bone exposed.

We had bandages, painkillers, and antibiotics, but we could not assess tendon damage or the risk of deep infection. Only two weeks into our field season, I would have to walk out to get medical attention. In the dead of winter it would be a month's round trip, if we were not delayed by storms.

Taking only bare necessities, Darla and I, with our camp assistant, Karma, set off the next morning. Eight days of hard walking got us to Jumla, in spite of a storm that dumped two feet of snow on the trail over Ghurchi Lekh. In Jumla we were advised to fly on to Kathmandu, for although my hand was in good shape, all things considered, only in Kathmandu were there facilities for surgery, if necessary, and rabies vaccine.

We were directed down narrow, winding streets in Kathmandu, among small shops and family homes, to an excellent Nepalese surgeon who laid to rest my anxieties about permanent damage to my hand and pronounced me fit after a week's observation. Our friends in Kathmandu took delight in making me a most reluctant celebrity—"Oh, I want you to meet Rodney Jackson. He's been bitten by a snow leopard!"

RADIOTRACKING highly mobile, solitary leopards in the Langu's awesome terrain requires that we work between base camp, three permanent high tracking camps, and several temporary camps along the main river course.

The leopard radio, to our surprise, was quickly dismissed by Dolphu villagers during the first field session. Expecting, I guess, to hear a growl, or the munching of teeth on bharal bone, one young fellow exclaimed, *"Tok-tok-tok-tok. Sabu chhaina!"*—Beep-beep-beep-beep. That's no leopard!

Dolphu villagers, like many Himalayan people, believe that snow leopards drink only their prey's blood, leaving the meat. This belief is likely inspired when a leopard is scared off, before it can eat a fresh kill, by an early-rising villager, who finds his cow or goat dead with telltale toothmarks in its throat. But such encounters are rare.

With no villages or livestock grazing along most of its 35-mile length, the Langu Gorge and its side canyons provide ideal sanctuary for snow leopards and their prey. In Nepal's less rugged high mountain areas, however, snow leopards face poor odds. In areas where much of the wild prey has been forced out by livestock grazing or killed by hunters, leopards typically venture into villages in search of a meal. Verbal and written accounts tell of the snow leopard—unaggressive, in fact docile toward humans—being stoned to death by villagers.

Considering the relative scarcity of prey, the home ranges of our collared cats are proving remarkably small, averaging about 12 square miles. But this figure does not take into account the surface area within the rugged topography. While there is considerable range overlap, each leopard has preferred areas to which it frequently returns between bouts of often extensive travel.

Some sites are favored by all the cats, but occupancy is staggered so that they are usually at least a mile apart. Given the abundance of leopards in the core study area and their propensity for using common travel corridors, they seem quite successful at avoiding one another.

KARAN B. SHAH, a lecturer from Tribhuvan University, Kathmandu, has the demanding task of gathering information on the leopards' prey—herds of bharal *(Pseudois nayaur)* and Himalayan tahr *(Hemitragus jemlahicus)* that roam the gorge. His effort is concentrated on bharal, for although significant numbers of the goat-like tahr occur along the Langu's moister and more forested south side, they are scarce in the core study area.

During the winter we often see small herds of bharal within a hundred yards of base camp. Constantly alert, the sheep sound the alarm—a high-pitched *chir-r-rit, chir-r-rit*—for no apparent reason. The herd then bolts for the nearest protective cliff, leaping effortlessly across hair-raising chasms and onto the smallest of ledges.

Snow leopards, well aware of the defensive tactics used by bharal, spend a good deal of their time padding quietly up and

Prized pelt *of the snow leopard has long lured poachers into a lucrative trade fed by human vanity. Now the market is waning because of public laws and private sentiment against the killing of endangered species.*

*The chain of commerce often began with three-foot-long sharpened bamboo spears (**right**) tipped with a concoction made from the poisonous monkshood plant. Placed at 45-degree angles along ledges, the spears impaled cats leaping down to follow a trail. So lethal was the poison that even a superficial wound could kill.*

*In a Nepalese village a hunter offered a pelt for sale in 1977 (**bottom left**), several years after an international convention restricted trade of snow leopard pelts. Jackson bought the pelt for only ten dollars and presented it to Nepalese officials as proof of the poaching violation—action that brought police to investigate. The pelt apparently was taken from a leopard whose skinned carcass (**left**) Jackson discovered abandoned near a riverbed. Poaching for pelts has since declined and is no longer considered a major threat to the species' survival.*

Yet coats are still sold, even on the open market. In contrast to the paltry sum Jackson paid for the skin, a pelt in good condition can bring several hundred dollars when sold in the city. From there, the price climbs quickly as it passes to middlemen, coat makers, and dealers.

*A couple from Arkansas paid $1,058 at a government tourist store in China for this snow leopard coat (**right**), seized at the Seattle airport and here inspected by Helen Freeman of Seattle's Woodland Park Zoo. U. S. Fish and Wildlife Service inspector Bill Schaff stored the coat with other contraband made from protected species.*

Schaff said the buyers professed both innocence and ignorance, saying they had been misinformed about the coat's identity. Dr. Freeman, who heads the International Snow Leopard Trust, a group working to protect the species, said the garment was made from three snow leopard pelts. To create a coat of the highest quality, a furrier would select the best parts of as many as a dozen pelts. Such a coat could command upwards of $60,000 on the black market.

MATTHEW NEIL MEYER (RIGHT)

down narrow cliff ledges that tower above the Langu and its tributary gorges. They zigzag along ridgelines, which afford both cover and a view of the immediate terrain, and through gullies, hoping to surprise the ever alert bharal.

As the crow flies, leopards may travel only half a mile in a day, but in fact, taking the topography and their circuitous route into account, they cover much more ground. Were it not for the beautiful and evocative sound of the words "snow leopard," I would be tempted to consider "crag leopard" a more apt description. For one thing, leopard prey is usually found below the permanent snow line. But snow leopards have been known to cross 18,000-foot passes on occasion or meander across high glaciers as they move between major valleys.

At 14,475 feet Tillisha Cave shelters the highest of our tracking camps. In two miles we gain 5,000 feet—a six-hour hike. Though leopard sign is not easily found in the alpine grassland around the cave, the cats visit regularly, and some of our most exciting moments have occurred near Tillisha Cave.

Working from the cave in late spring, I found myself near the summit of Tillisha Mountain, a place of jumbled boulders, ice, and snow. It was cold, windy, and difficult to write down my notes. Male 2's fresh pugmarks led down a snowbound slope, meandering between massive boulders toward ocher bluffs.

Climbing the mountain's steep east ridge with receiver and antenna, I located him in the grass and rock moraine 1,500 feet below. He had spent the night traveling hard from the precipitous western cliffs of Tillisha Mountain up a long ridge to the round peak. There, at about 17,000 feet, he had traversed half a mile of frozen rock and snow, looked down into the remote and frigid alpine basin that provides the headwaters of Tillisha Stream, climbed several huge boulders, then headed downslope for areas more likely to yield bharal.

Clouds moved in to swirl about the peak, engulfing me and the views. Cold, shivering, yet immensely satisfied with the day's work, I headed down to the shelter of the cave, companionship, a cup of tea.

Months later, as Gary and I scanned the same slopes above Tillisha Stream, I spotted Leopard 4 sauntering along the mountainside—and behind her were two big cubs. They romped and chased one another, rolling and tumbling down the steep slope. They stalked imaginary sheep. They leapt and charged like kittens instead of year-olds! We watched for 20 minutes, until it got too dark to see. They were too far away and there wasn't enough light to photograph, so we indulged ourselves completely, absorbing the event for which we'd waited so long.

Poor 4! We wondered how she ever fed those two rambunctious cubs. They must bungle half her attempts at hunting. In fact such play is probably very important for the cubs' serious work of learning to hunt for themselves. By the age of two, they will face the task of establishing their own range.

SINCE 1973 His Majesty's Government Department of National Parks and Wildlife Conservation has created six mountain parks and reserves, a remarkable effort for a country of only 54,362 square miles. Our study area occupies the far northwest of 1,370-square-mile Shey-Phoksundo National Park.

But simply setting aside parkland is not enough, for villages are a fact of life in Nepal's parks. They must be managed so that man and wildlife can coexist harmoniously. Also, with populations of snow leopards increasingly fragmented, buffer zones must be created to allow movement between separate enclaves. Otherwise, inbreeding may diminish the species' chance for adapting to long-term environmental change. To meet this challenge, Nepal has created the King Mahendra Trust for Nature Conservation. Its goal is to strike a balance between nature conservation and human needs.

How many snow leopards are left beyond the Langu Gorge? No one knows. Except for Tibet and China's Sichuan and Qinghai Provinces, what little prime habitat remains is near international boundaries, which often makes study impossible. With international cooperation, urgently needed surveys can be carried out and necessary steps taken to protect this rare cat throughout its range.

Without *Panthera uncia* the high mountains of Asia would be like the African plains without lions, reduced in vitality and appeal. For now, the snow leopard is a living

symbol of encouragement—a sensitive indicator of a healthy mountain environment.

The children of Dolphu and Wangri are learning that the *sabu*—snow leopard—is worth more to them alive than as a pelt for barter. As they come of age and take their places in village concerns, they could become the most effective guardians of their national treasure, keeping the snow leopards of the Langu a safe distance from the edge of extinction. □

With a last look back, *Leopard 2 prepares to steal away, following the attachment of a collar. Threatened by the loss of habitat, the world snow leopard population also faces reduction of prey species by hunters and death at the hands of herdsmen protecting stock. Unless man stubbornly insists on protective measures, he may someday find his hopes for a glimpse of this great cat to be in vain.*

A MAN-MADE SUN ***rose over Bikini Atoll on March 1, 1954. Seen here from 50 miles away, the 15-megaton hydrogen blast called Bravo ranks as the largest U. S. test, a thousand times greater than the atom bomb dropped on Hiroshima in 1945.***

U. S. AIR FORCE/DEFENSE NUCLEAR AGENCY

A Way of Life Lost

BIKINI

By WILLIAM S. ELLIS
NATIONAL GEOGRAPHIC SENIOR WRITER

Photographs by JAMES P. BLAIR
NATIONAL GEOGRAPHIC PHOTOGRAPHER

The year was 1946. World War II had just ended in a flash of atomic fury that even the bomb's inventors didn't fully understand. For further tests, the American military chose a remote island cluster in the Pacific called Bikini Atoll. Its inhabitants agreed to vacate their homes, assured that they could return when the tests were over. Today, 40 years and 23 nuclear explosions later, the Bikinians are still waiting, on a cramped, isolated island 500 miles from home. For as instruments on Bikini show (*below*), their atoll is still dangerously radioactive.

THIS PAGE FOLDS OUT

THEY SANG when they left, and now that they were back, they sang again.

Sitting on the beach at night, they raised their strong, good voices until the harmony carried out over the black waters of the lagoon. They sang of love, a song about the fragrance in the morning lingering from the night before. They sang too of a spirit lost at sea, waiting to be caught up in a great current and to be borne to everlasting peace.

Nearly 40 years had passed since that Sunday in 1946 when Commodore Ben Wyatt of the United States Navy met with them after church services to say that their island was needed for a project that would benefit mankind. He implied that an authority higher than any on earth would be pleased if they decided to cooperate.

Being both a devout and benevolent people (and not without awe over America's military power), they announced this decision, through their chief, Juda: "If the United States government and the scientists of the world want to use our island and atoll for furthering development, which with God's blessing will result in kindness and benefit to all mankind, my people will be pleased to go elsewhere." All 161 members of the 11 families were transported to another place aboard a Navy LST. They took with them the thatch from their 26 houses, along with the dismantled church and community hall.

Less than six months later, on July 1, 1946, a B-29 bomber known to its crew as *Dave's Dream* appeared over the lagoon, and from its belly there fell an instrument, hurtling toward one of some 93 unmanned target vessels at a speed of 300 miles an hour. At 34 seconds after nine o'clock in the morning the device exploded at an altitude of about 500 feet. For a wrathful moment then, it seemed as if the sun had risen for a second time that morning.

And then the world came to know about this island and its atoll, a place in the western Pacific called Bikini.

The testing of nuclear weapons in the Pacific by the United States had begun. In the next 12 years, more than 60 explosions would follow, most of them in the lagoon of Enewetak (Eniwetok) Atoll in the Marshall Islands. Of the 23 set off at Bikini, there was one called Bravo, the most powerful bomb ever detonated by this country. The combined power of all the weapons fired in all the wars of history would fall short of that released by Bravo over the 242 square miles of the Bikini lagoon. When the testing ended—when the tens of thousands of servicemen, technicians, and scientists had all left, when the ships of the target fleet had either sunk, sailed, or been towed away, when the shock waves stood the waters of the lagoon on end for the last time—Bikini island was still there with its coconut palms and pandanus trees, a testimonial, seemingly, to survivability in nuclear action.

BUT THE ISLAND and some of the 22 others in the atoll were not the same then and are not the same now. Radioactive material remains in the soil, and after two score years the people of Bikini have not been able to return to their home to live. Rather, they remain on a small, isolated island some 500 miles away, an island without a lagoon, a mere dot of land of 230 acres standing naked to the sea. Its name is Kili, the place where they live, and the old men and women there remember a way of life that is now lost.

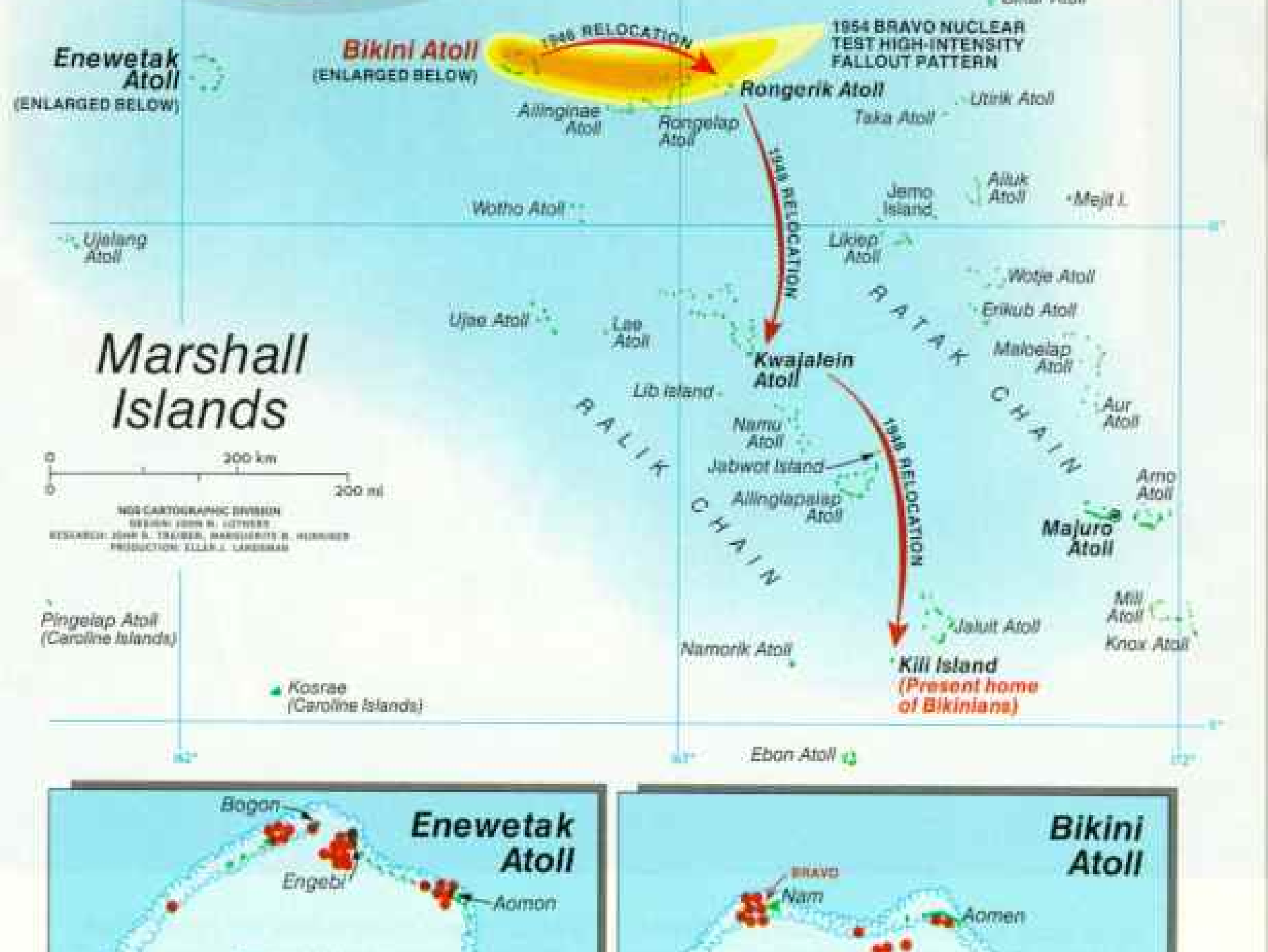
Kili, like Bikini and Enewetak, is part of the Marshall Islands group of Micronesia, taken from Japan in World War II and administered by the United States as a United Nations trusteeship. Divided into two chains, the Ratak ("sunrise") on the east and the western-facing Ralik ("sunset"), the 34 atolls and single islands of the Marshalls lie 2,400 miles southwest of Hawaii.

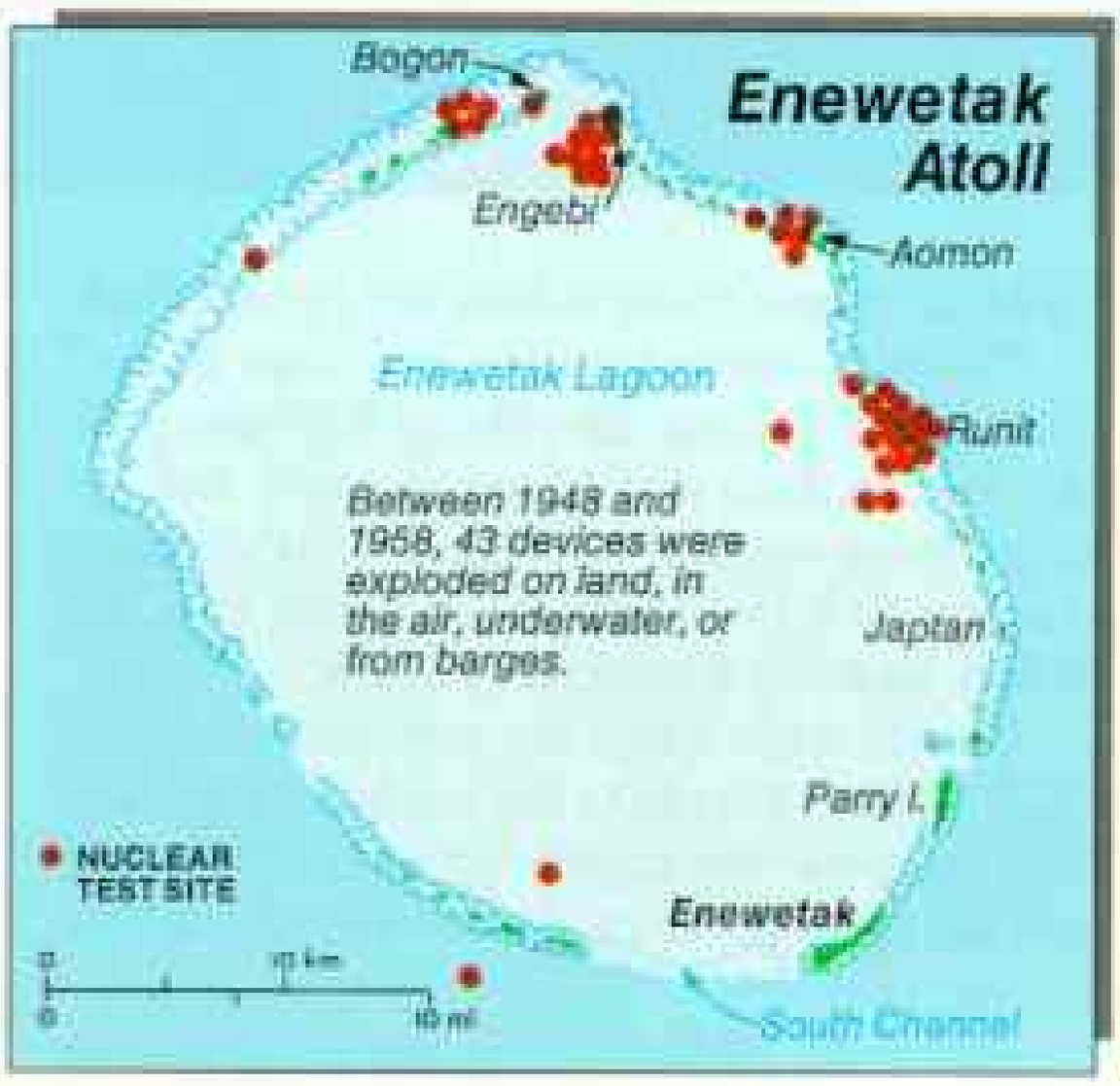
For the most part these are not Pacific islands in the Gauguinesque sense of flowery bliss. These atolls, coral reefs built up on the slopes of sunken volcanoes, barely rise above the water. Many of them are like flagstones in a path, trodden by violent winds and waves, some under recurrent drought, others lush from almost daily rainfall.

Once, the Bikinians were expert sailors, taking their outrigger canoes across many miles of water to visit other islands in the atoll. They fished and gathered turtle eggs. Their other foods were coconuts and arrowroot. With the disruption in their lives, they became landbound, and their seafaring

Route of the nuclear nomads

IT WAS A TEMPORARY MOVE, or so the people of Bikini thought in 1946, when they left for uninhabited Rongerik Atoll. Within two years they were starving; many local fish were poisonous and coconuts scarce. Evacuated to a U. S. naval base on Kwajalein, they were moved eight months later to Kili, where about half their numbers remain. The rest are scattered throughout the Marshall Islands. Enewetak (Eniwetok) Atoll, also used for testing, was partly resettled in 1980 after radioactive soil and debris were removed. Bikinians hope such a plan may one day end their 40-year odyssey.





skills died as the old men died. As wards of the U. S. government, they now receive food from the Department of Agriculture, such as peaches soaked in heavy syrup. Diabetes is a major concern among the Bikinians, and such food only adds to the problem.

They also suffer from despair, and so their comments to outsiders are weighted with complaints. But there is never rancor in what the Bikinians say, no confrontational protest. Their culture does not permit that.

"They promised us we could go back," said Sorry Jelang, an elderly Bikinian, "so all we can do is stay here and wait. But we need more money, more food. You tell them to give us a big bank. Look at my hair, all white now; on Bikini, only black."

On the days when the airplane comes to Kili, banking lazily to the left before threading the eye of the needle between palms and the sea to set down on the runway of crushed

U. S. AIR FORCE/DEFENSE NUCLEAR AGENCY

*"**For the good of mankind,**" Bikinians left home to make way for the Able and Baker atomic tests; American negotiators found the missionary-educated Bikinians especially open to religious appeals. Here an advance construction party of U. S. Navy Seabees and Bikinians loads supplies onto a landing craft for the trip to Rongerik.*

coral, there is a stir of excitement among the Bikinians. Except for the radio and periodic visits by a government supply ship, it is their only link with the rest of the world. It also brings them new stocks of Fanta grape soda.

In July of last year the plane—then the *only* operational one of the Marshall Islands airline—left Kili with the mayor of the community and members of the council among the passengers. The destination: Bikini.

They were returning not to stay but to be shown what the government is doing to make the island habitable. Most of them were elders who had spent their early years as fishermen and boatbuilders, and they were the ones for whom the departure from Bikini in 1946 was most painful.

"Bikini not long now." Lore Kessibuki looked out of the window, down to where the Pacific lay sunstruck and still. We had stopped at Kwajalein, the largest island in the largest coral atoll in the world, and were glad to be gone from there, for it is a place where outsiders are not made to feel welcome. Kwajalein Atoll is where missiles land after being fired from Vandenberg Air Force Base, some 4,800 miles away in California. They are seldom far off target as they slam into the lagoon or the sea nearby, unnerving fish and bird, and prompting one person on the plane to observe, "I have no doubt that in the event of a war, the United States can knock the hell out of Kwajalein."

THERE IS no landing strip on Bikini, so we put down on Eneu, in the southeast corner of the atoll. No one lives on the 304 acres of Eneu, and the runway dates from the nuclear testing period.

Tomaki Juda, the mayor and son of the late Chief Juda, may have been the one who caught the first fish from the boat taking the delegation from Eneu to Bikini. It was a 45-pound yellowfin tuna, taken on a handline with only a few strands of burlap for a lure. Unfished for many years, Bikini lagoon gave generously that day of its tuna and other fish, all free now of radioactivity. The 17 vessels in the target fleet that sank during the testing act as convention halls for marine life, including sharks in menacing numbers.

Lore Kessibuki was among the first onto the beach. He is an old man, but he stood there with his back straight and his head tilted upward, like a visionary at a time of revelation, and said, in a whisper, "Bikini,

Bikini." He was finally home, if only for a few days.

THERE is one radioactive substance almost totally responsible for preventing Bikinians from living on their island. It is called cesium 137. Established in the soil, it contaminates the groundwater and food crops. That is not to say that a person eating a coconut from a tree on Bikini is going to die or even become ill. But a steady diet of locally grown foods could result in serious health problems.

That was the case during a ten-year period starting in 1968 when President Lyndon B. Johnson declared Bikini to be safe. By 1971 some Bikinians had returned, but by 1978 they were found to have ingested more cesium than was considered acceptable. Once again the island was evacuated.

Cesium 137 has a half-life of 30 years, meaning that after 30 years its strength is reduced by half. And then in another 30 years, it is again reduced by half (by contrast, plutonium 239 has a half-life of 24,360 years). By such calculations it will take another 80 to 90 years before the cesium on Bikini has been reduced to acceptable levels. However, there may be quicker ways of cleaning the island, and in the forefront of those seeking them is Dr. William L. Robison of the Lawrence Livermore National Laboratory in Livermore, California.

"It took us years of work just to get a data base so we could make radiological assessments of Bikini," Robison said. "Now we are looking at possible remedial measures, such as blocking the uptake of cesium into the food crops, or reducing the radioactivity by removing some of the soil."

It is possible to do the first, Robison believes, by applying fertilizer rich in potassium to the ground at Bikini. The second measure would require scraping off the top 12 inches of soil to reduce the cesium hazard. Clearly, the use of fertilizer would be less expensive and less destructive. To take 12 inches off Bikini's 560 acres could cost as much as 80 million dollars and destroy 25,000 trees and all the beneficial organic matter now in the soil. Finally, disposal of the "hot" material would present a problem.

U. S. AIR FORCE (ABOVE); U. S. NAVY/NATIONAL ARCHIVES

***Ringside seats** for the "bomb" were a hot ticket in 1951, when military and civilian VIPs (**above**) watched from the officers club on Enewetak, just 12.5 miles from ground zero. Naïveté was the order of the day during the 1946 tests, when radioactive target ships were boarded within hours of a blast, and men assigned to scrub down the decks (**below**) routinely ate on board.*

For those reasons scientists hope that the soil will not be removed but rather that fertilizer will be applied. Whatever the cost, it would be a pittance compared with the billions of dollars spent to test the weapons.

"There is no question that we owe them rent, and we owe them renovation," said Dr. Henry I. Kohn, professor emeritus of radiation biology at Harvard Medical School. "I feel the United States owes it to Bikini's people to return their atoll as close as possible to its original condition."

Kohn is chairman of the Bikini Atoll Rehabilitation Committee (BARC), a group of scientists appointed by Congress to make recommendations on how to make Bikini livable again. He was among those who visited the island last summer, when the Bikinians were there.

BIKINI WAS SELECTED as the test site because it is isolated from sea and air routes, and because the winds in the atoll blow in predictable directions, thereby controlling the drift of radioactive clouds. But once the winds shifted at the time of a test shot, and because of that the Bikinians remain nomads after 40 years.

Bravo was the first test of a deliverable hydrogen bomb, a surface shot detonated in 1954. It was an explosion of about 15 megatons, or 15 million tons of TNT (the bomb exploded over Hiroshima had a force of 15,000 tons of TNT), making it the most powerful weapon ever activated by the United States. A freight train carrying Bravo's equivalent in TNT would span the North American Continent.

The errant winds showered radioactive pulverized coral and other material over a vast area—perhaps as much as 50,000 square miles. Those caught in the fallout included some 250 Marshallese from the islands of Rongelap and Utirik; 28 weather station personnel on Rongerik; and 23 crewmen of a Japanese fishing vessel, the *Daigo Fukuryu Maru (Lucky Dragon No. 5)*, one of whom died of radiation exposure. To this day the tragedy of Bravo haunts the U. S. government and its victims.

Had it not been for the power of the explosion and the shift in winds from northward to eastward, Robison would not be kneeling down in the dirt of Bikini 31 years later,

U. S. AIR FORCE/DEFENSE NUCLEAR AGENCY (FACING PAGE); BROOKHAVEN NATIONAL LABORATORY

"Bikini snow"*—bits of radioactive ash and coral—showered Rongelap Atoll when winds shifted during the Bravo test in 1954. Curious natives played in it, even tasted it, and many—like Iroji Kebenli (**facing page**)—suffered burns. He recovered, but three out of four children under ten later developed thyroid tumors. Lekoj Anjain (**top**) had his thyroid removed, free of charge, by New York's Brookhaven National Laboratory in 1968. He died in 1972 (**above**) of radiation-induced leukemia.*

examining vegetables and other crops being grown in an experimental garden. In one place the hot soil had been removed, and in another, fertilizer had been spread on the ground. Robison rose and squinted in the bright sunlight as he explained to the mayor and members of the Bikini council that samples would be tested for cesium content.

"It may be that we can get rid of some of the cesium by flushing salt water through the soil," he told them. "We are experimenting with that." The Bikinians listened and said nothing.

Also present were Dr. Frank L. Peterson of the University of Hawaii, a hydrogeologist; Dr. Earl L. Stone, adjunct professor of soil science at the University of Florida; and Dr. Arthur S. Kubo, a nuclear and civil engineer at BDM Corporation in McLean, Virginia, all members of BARC and all active in working to decontaminate the island.

The scientists share a deep concern for the welfare of the Bikinians, but past deceptions, contradictions, and confusion have left the people with an eroded sense of trust.

"We don't really understand these experiments," said Kilon Bauno, at last. "The only thing we understand is that you poisoned our island and that I am old, with not too many years to live. So all we say is get us off of Kili and give us lots of money so we can live comfortably until Bikini is safe."

Lest the scientists take offense, another Bikinian added: "It's true that we do not understand your work, but we do know that you Americans are very smart."

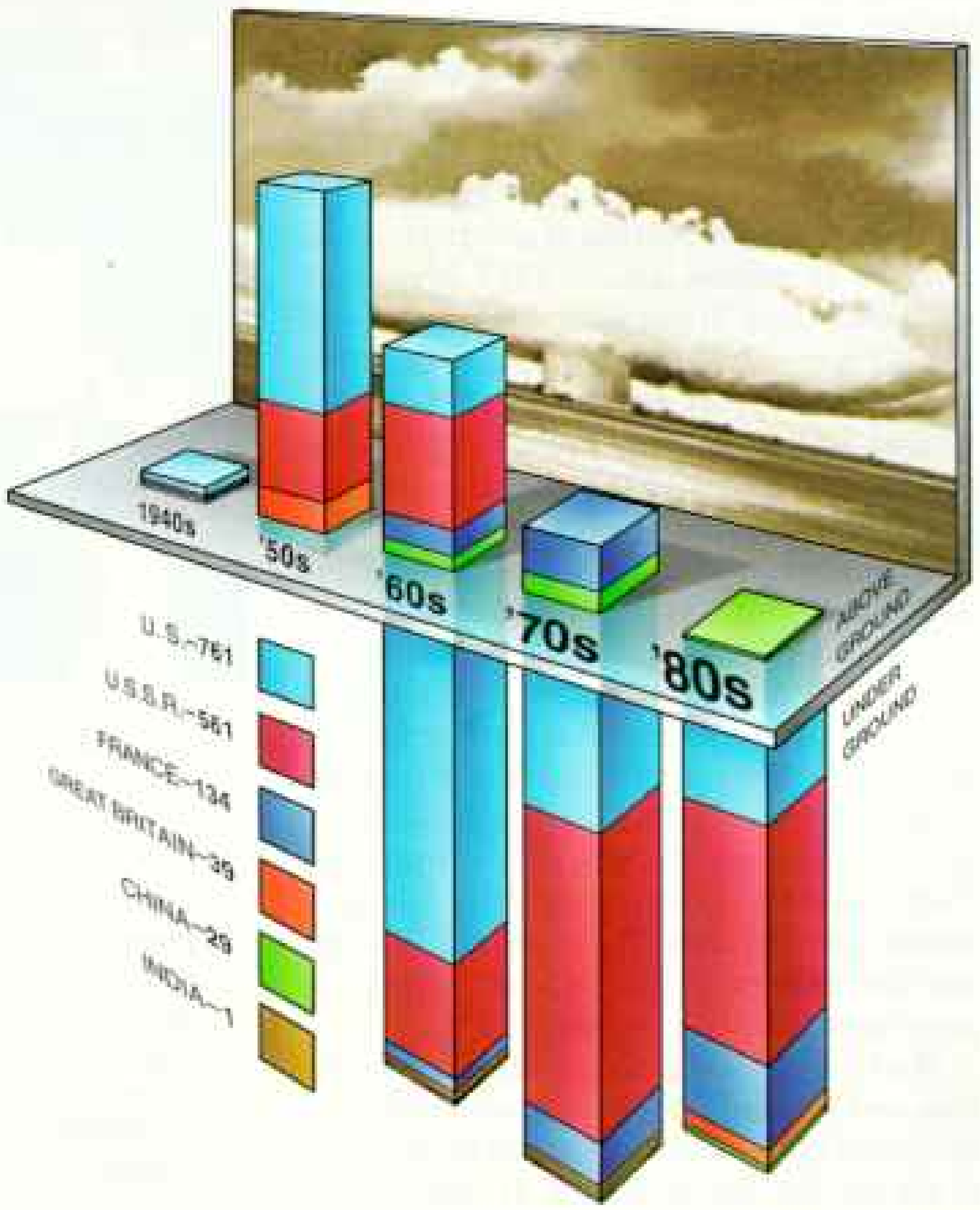
ON ANOTHER DAY we traveled by boat across the lagoon, over the place where the U.S.S. *Saratoga* lies on the bottom, her flight deck only a hundred feet below the surface. The honored carrier went down during the second shot of the testing, settling upright on her keel, her planes still arrayed on the hangar deck.

Then we sailed over the mile-wide Bravo

Nuclear scoreboard

THE ATOMIC CLUB *had one member—the United States—when testing began in 1945. The Soviet Union made its debut in 1949. Since then four more players have joined the group, which through 1985 conducted 1,525 known tests.*

Fallout from intensive atmospheric testing during the 1950s and early '60s peaked in 1963, when it added some 7 percent to the dose of radiation we receive naturally. The increase today stands at less than one percent, thanks in part to the 1963 Limited Test Ban Treaty signed by the U. S., U.S.S.R., and Great Britain that began the era of underground testing.



NATIONAL GEOGRAPHIC ART DIVISION
DATA SOURCE: STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE

National Geographic, June 1986

crater, still clearly defined beneath the water. Nearby were old reinforced concrete bunkers in which automatic cameras recorded the infernal turmoil of atoms gone berserk—the steamy, dirty clouds rising tens of thousands of feet in the air, the waves of heat and sound and motion breaking across the atoll, the complete destruction of an island, its beaches and birds and trees all gone to vapor and dust.

As we passed the islands in the north of the atoll, sounding the ship's whistle to send the terns and petrels rising from the trees, the Bikinians spoke among themselves of the times they sailed here. "If we started out before the sun came up, we'd be here by midmorning," one said. They knew the owner of each parcel of land on each island, for nothing is more important to a Bikinian than land. In their culture a man without land is denied his dignity, his very reason for being.

The Bikinians are a people with no written history. It is not certain where they originated, although the Marshall Islands atoll of Wotje is often cited as their ancestral home. Regarded as inferior by the Germans and Japanese, who controlled the islands at different times until the end of World War II, Bikinians came to hold themselves in low esteem. Even among other Micronesians they were considered backward, doltish.

They withdrew among themselves but retained a tenuous link to an outside *iroij lablab*, or paramount chief. Only with the arrival of missionaries in the early part of this century did they accept the teachings of others. They became staunch Christians.

NO ONE understands all of this better than 44-year-old Ralph Waltz from Menominee Falls, Wisconsin, who came to Micronesia with the Peace Corps and stayed on to marry a Bikinian and settle on Majuro, the capital of the Marshalls. For a time Waltz lived on Kili and came to know the hunger that gripped the people in their exile, when the arrival of supplies was delayed by heavy seas and a shortage of ships and by indifference on the part of the Trust Territory administration.

"I was lying in bed at four in the morning," he told me, "and I was still awake. You can't sleep when you're hungry. I heard a breadfruit fall to the ground from a tree just behind my house. I jumped up from my mat and ran to the tree, but the breadfruit was gone. Someone had beaten me to it."

He went on to recall the time that he and four Bikinians set out offshore in a small boat to fish. "If we hadn't been so hungry, we wouldn't have risked the trip in that boat," he said. "The motor gave out, and two of the Bikinians went into the water to swim to shore for help. They never made it. They were eaten by sharks."

NATIONAL GEOGRAPHIC PHOTOGRAPHER DAVID ALAN HARVEY

Luck ran out *for the Lucky Dragon when Bravo's gritty fallout covered the Japanese fishing boat and its 23-man crew, causing one death and many illnesses. Crew member Matashichi Oishi* ***(above)*** *sits on the renovated Dragon with his own model; both are part of a Tokyo memorial to the tragedy.*

Unlike the Bikinians, Waltz shows flashes of anger about their plight. This anger has served them well, for he is employed by the council as its liaison officer.

Even more of a counterpoint to the timidity of the Bikinians is the voice and untiring work of Jonathan M. Weisgall, a Washington, D. C., attorney who shepherds their lawsuits for compensation through the courts, who appears before congressional committees on their behalf. Weisgall, too, is driven in no small measure by the steam of outrage.

"In addition to all else," he said, sitting in his Washington office amid a clutter of research material on Bikini, "the social impact on the people has been tremendous. They have lost virtually all their fishing and sailing skills."

STILL, they try: There was the mayor, Tomaki Juda, standing in the surf off Nam, the largest island on the northwest rim of the atoll, grinning and waving a spear from which flapped a small rabbitfish. They used to fish that way. On Kili they use a hook and line, sometimes floating on coconuts placed under their armpits, their heads down, moving silently, stalking the catch.

It was a jewel-like day, that time on Nam.

GORDON W. TROBLE, UNIVERSITY OF HAWAII (ABOVE); U. S. NAVY/NATIONAL ARCHIVES

The nuclear lagoon *of Bikini holds the World War II carrier U.S.S. Saratoga* ***(above)****, one of many vessels purposely targeted to test damage. Saratoga sank during test Baker, a 1946 underwater blast that raised 100-foot waves and shot water from the lagoon more than a mile high. Radioactivity showed up in a surgeonfish* ***(right)*** *that had eaten contaminated algae.*

Pieces of red coral glistened in the sand, while giant turtles slumbered in the lee. The beach was heavy with flotsam, mostly Japanese Suntory whisky bottles (not a message from a castaway in the lot) and mangled flip-flop sandals. There are no dwellings, no people living on Nam, and being there in the harsh sunlight, numbed by the solitude, gives cause to wonder if this isn't the loneliest place on earth.

Nam covers 115 acres. It used to be larger, but Bravo carried away a piece of it and the island of Bokonejen to its west. The nearby island of Bokbata was also blown away in a later explosion.

"That island was a pantry for us," said Lore Kessibuki, speaking of Nam. "We'd sail there and stay two or three days, and then we'd go home with turtle eggs and birds and other things." Even now, going back to Bikini, there was a 300-pound turtle on its back in a skiff being towed by our vessel. Someone suggested that the Bikinians release the turtle, but the past had reached out to touch them, and they liked the feel. The turtle, they insisted, would go with them to Kili when they returned.

THERE would be one more day on Bikini—time enough for Lore Kessibuki to visit the graves of two of his sons. "They got a fever and died," he told me as he looked down at the mounds overgrown with brush. There were markers on the graves, chiseled out of coral.

Lore is the poet, the lyricist of the community. The evening before they were to go back to Kili, he sat in the old schoolhouse being used as a dormitory and said to the scientists: "The thing I want to do is thank you for the work you're doing on this island, the ways you are looking for to get rid of the poison in the ground. All the things you are doing are amazing to me. Just a little while ago I saw a beautiful cloud in the sky. I saw that with my eyes. With my mind I see America being thousands and thousands of miles ahead of all others scientifically. I see too that Bikini people added to America's advancements in science by giving up their island, and so there should be an understanding between Americans and our people. Well, I just wanted to say that."

He and some other council members then went outside to the beach, and, sitting there by a fire fed with driftwood, they sang their songs of love and sorrow.

So they left the next morning. It is likely that Lore and some of the other elders will never see the island again. At the same time most young Bikinians show little sincere interest in going there. It may be, therefore, that even if the cesium is removed, Bikini will remain abandoned.

Those who were born after the 1946 evacuation of the island have grown attuned to a world broader than the traditional social order of their parents. And, as wards of the U. S. government since birth, they have become addicted to welfare. They are fed and housed, and their illnesses are tended to, more or less. There is no turning back now to fishing and gathering for the Bikinians. It is too late. They *like* Spam.

IT HAD RAINED for four hours on Kili, buckshot rain pinging on the metal roofs, and the water lay in chalk-colored pools from one end of the mile-long island to the other. All around, the sea swells beat against the shore. Here and there pigs rooted in garbage thrown on the ground while chickens performed in their interminable fandango of walking and pecking, walking and pecking. Generators fed power to the houses in noisy, fitful surges.

And everywhere there were children; the birthrate on Kili must be among the highest in the world. They have few toys so they squat in the sand and juggle pebbles. They walk with their mothers to the beach and watch as soiled diapers are discarded in the surf. Then they play in the water, imagining themselves as sharks and ships and madcap monsters risen from the deep.

Shem Jamore, Toshiro Jelang, and Uraki Jibas stood together in a doorway and waved to the driver of a pickup truck passing by. There are six pickups on Kili, and for a fare of a quarter a Bikinian can climb into the back and be driven around the island. It is a fine way to catch a breeze on a hot day, especially racing down the airstrip.

"Right here, where we are, is downtown Kili," Toshiro said, laughing. "At that end is Chinatown, and on the other end is the high-rent district."

There are no Chinese on Kili, and there is

Off-limits forever *for habitation is Runit* ***(below)****, where 111,000 cubic yards of radioactive soil and debris scraped from islands in Enewetak Atoll lie entombed in a bomb crater beneath an 18-inch-thick concrete dome. The effort earned Enewetak a clean bill of health, but medic Kunio Joseph* ***(above)*** *says fearful islanders think "maybe 'they' put radiation in the ocean, and that is why there is always sickness here."*

no rent, high or low. Toshiro had meant to mock the suffocating confines of the island and the sameness of the 75 or so houses made of plywood and metal. There is also an elementary school, a church, and a restaurant that may or may not be open on any given day to serve chicken and rice—hardly ever anything other than chicken and rice. The sale of alcohol is banned on the island, although soda pop is available through a process laced with mystery and intrigue.

"You want a soft drink?" Toshiro asked. "It is very expensive. Seventy-five cents. And it may take some time." After half an hour the drink appeared, but not before furtive consultations behind a water cistern. The reason for this was never made clear.

Toshiro and his friends Shem and Uraki are all too young to have been born on Bikini. They know little, if anything, about sailing an outrigger canoe or tending coconut palm trees. Ask them where they would like to live and they will answer, as one, Maui, in Hawaii.

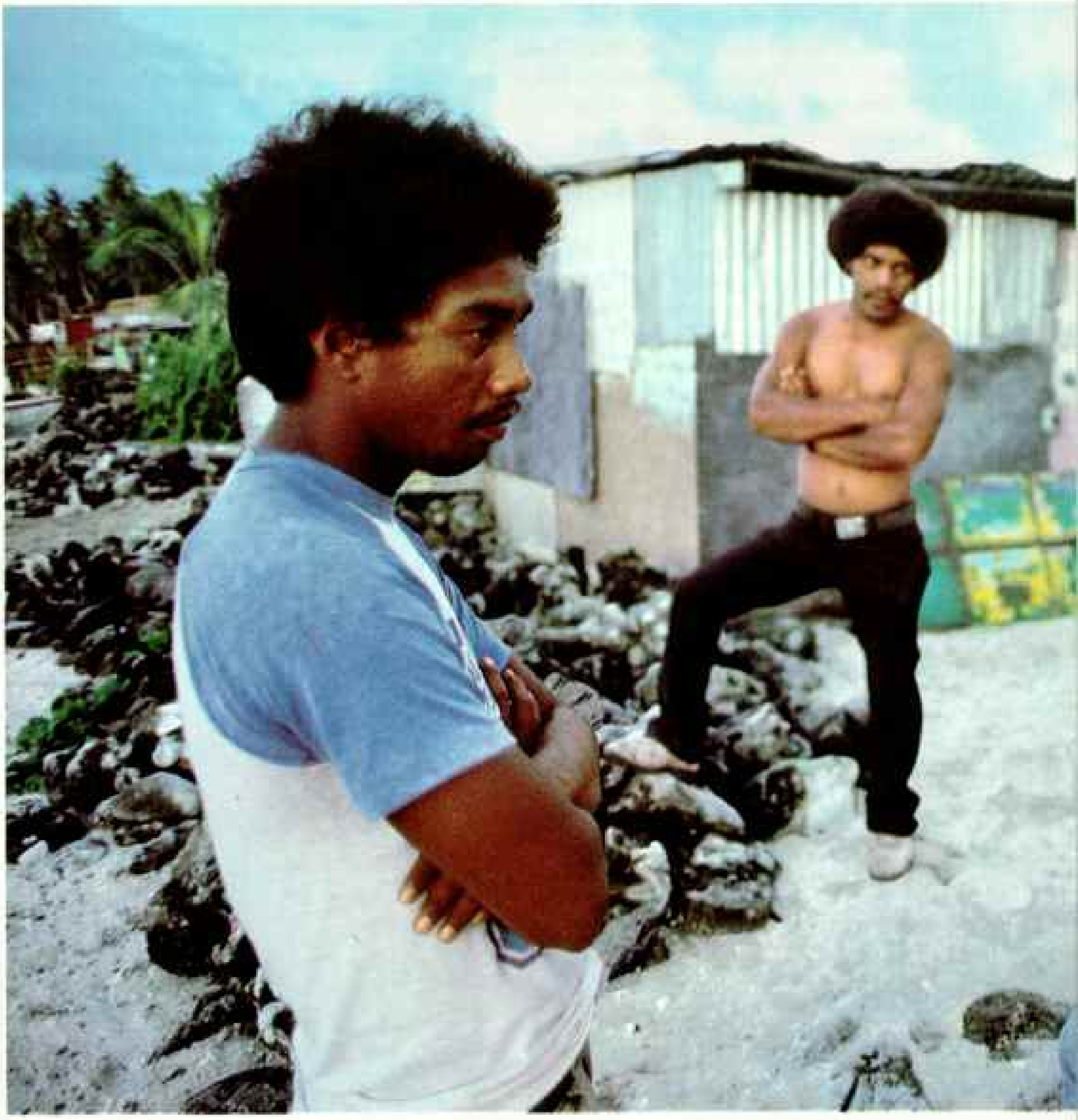
Maui is the first choice for a homesite among most Bikinians. Many say they want to live there until Bikini is ready, but after that intimate exposure to the outside world would they want to return to the island?

SOMETHING ELSE: An agreement with the United States, through which the Bikinians received 20.6 million dollars for resettlement, stipulated that they must find a place to live within the Marshall Islands. Also, it has been made clear by a citizens group on Maui that the people would not be welcome there.

There has been other financial compensation in addition to the resettlement fund to ease the many hurts, but nothing like the 450 million dollars they are seeking in a lawsuit as payment by the U. S. for taking and damaging their atoll. This action was scheduled to go to trial last October, but it has been delayed because of a major development in the status of Micronesia as a trust territory.

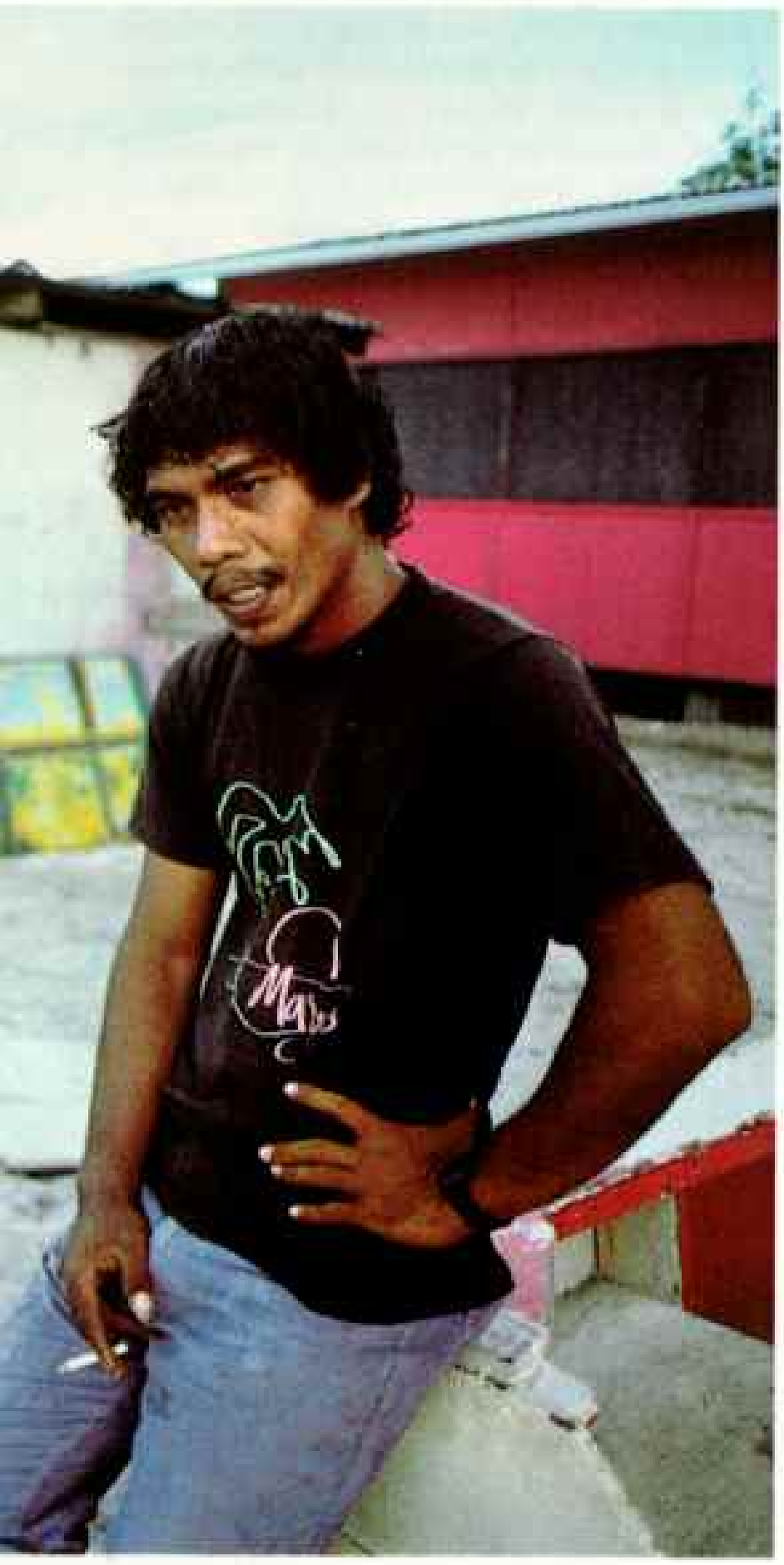
Under recently signed congressional legislation the Marshall Islands, to which Bikini belongs, will become a "freely associated state," independent except for matters of defense. (This same surge toward political autonomy within the Trust Territory will also create the Federated States of Micronesia, the Republic of Palau, and the Commonwealth of the Northern Mariana Islands.)

Time passes slowly *on Kili, the 230-acre island* ***(right)*** *where many Bikinians have lived since 1948. Fed and housed by the U. S. government, even able-bodied young men* ***(below)*** *have little incentive to battle the island's pounding surf for fish. This leaves 650 Bikinians with nothing to do but watch for the supply plane or dream of being somewhere else. "All we can do is stay here and wait . . . wait," says one islander.*



Although most of its islanders favored creation of a new Republic of the Marshall Islands, as it will be called, 89 percent of the Bikinians voted against it. They are reluctant to break their strong tie to the U. S. for fear the welfare will end.

"Without the government food my diet would be something like four crabs and a scoop of rice each day," said Tomaki Juda. "Also, we would not feel comfortable if the Marshallese government was put in charge of our money. There are now many programs beneficial to the Bikini people, but we have concerns that they may not continue under a compact of free association."



While the future of the Bikinians hangs now in a dark limbo, their numbers have grown from the 161 who were taken from the island in 1946 to more than 1,260 today, of whom about half live on Kili. And they pass their days there waiting—the old men with faces like book bags, lumpy and strapped with wrinkles, the young girls with large combs in their black hair, the teenage boys surly with boredom—waiting for their flight from despair. They have reason enough to curse those errant Bravo winds.

Also because of their fallout:

- A man named Gene Curbow seeks redress from the government, claiming his health has suffered. As a weather specialist in the Air Force, he was one of 28 servicemen stationed on the island of Rongerik at the time of the blast. The government paid him $53, the cost of the clothes he had to leave behind. He claims to have received 117 rem of external radiation in two days (200 times the maximum annual dose allowed by federal radiation standards) from those heavy, powdery flakes they called Bikini snow. He had three heart attacks by the time he was 42 and now has three clogged arteries in his body. He attributes all this to Bravo.
- The people of Rongelap, also caught in Bravo's poisonous dust, claim to be plagued with illnesses. They have developed a high number of thyroid tumors, some cancerous. The claim that their women give birth to grossly deformed babies is highly contested. Last year the people were taken by the Greenpeace organization to another island in the Marshalls.
- Roger Ray, a gentle and thoughtful man, struggles against the forces that would have him change his feelings of regret to those of guilt. As a physicist he was present at Bikini for Bravo. Subsequently, as the U. S. Department of Energy program manager for the Marshalls, Ray devoted the last 14 years of his career to exorcising the terrible legacy of the bomb from the lives of the islanders.

There are those who charge that the government, knowing that the winds had shifted, went ahead with the detonation of Bravo with the thought that those caught in the fallout would serve as guinea pigs for the study of the effects of radiation. Roger Ray disputes that, and so does Gene Curbow. "It was incompetence," Curbow told me.

"That's all you can flat outright say about it. If they set me up as a guinea pig, why haven't they been around to check on me?"

The people of Rongelap and Utirik caught in the fallout continue to have their health monitored and their illnesses treated by the Brookhaven National Laboratory of Long Island, New York, working as a subcontractor for the government. Dr. William Adams, who is in charge of the program, contends that there is no medical reason for the people to have left Rongelap last year.

"Obviously, there was fallout over these atolls, and some residual radiation in the soil. But the radiation the people received on Rongelap since they moved back there in 1957 is less than if they had lived in Denver all that time."

Adams and other physicians travel to the islands twice a year to examine and treat the people. There are thyroid problems among the population, he said, and two pituitary tumors have been diagnosed. "A great deal has been made about malignant disease and the radiation exposure," Adams said, "and while I do not want to make light of it at all, there are groups that magnify the horror of what happened, and that has led to such things as this exodus of the Rongelapese from their ancestral homeland."

HAD THE TESTS of 1946 shown the naval fleet to be obsolete, useless as a war machine? Certainly there was nothing for the Navy to cheer about as five ships went to the bottom in just the first shot, while others burned with the hidden fires of radiation. But there were ships that survived, ships that steamed from the scene after taking a battering unequaled in the annals of fury at sea. Decision: too close to call.

There was widespread ignorance about nuclear weapons at the time of the testing. Thus, the errors, the miscalculations, the orders that had sailors scrubbing the woodwork of a ship to remove radiation while the brushes may have worked the poison deeper into the pores. The devices used to monitor radiation were inadequate in many cases; also the men sometimes took off their gloves in contaminated areas, necessitating removal of the outer layer of skin with acid.

Yet, at the time of the first two tests there was not a single recorded death or serious

Paradise lost, *the island of Bikini* ***(below)*** *has what Kili lacks—a sheltered lagoon and plenty of space. Several Bikini families moved back in 1971 after the U. S. pronounced it safe. By 1978 they had ingested, through their diet, unacceptable levels of radioactivity and were re-evacuated. In July 1985 members of the Bikini council returned* ***(above)*** *to observe current decontamination efforts.*

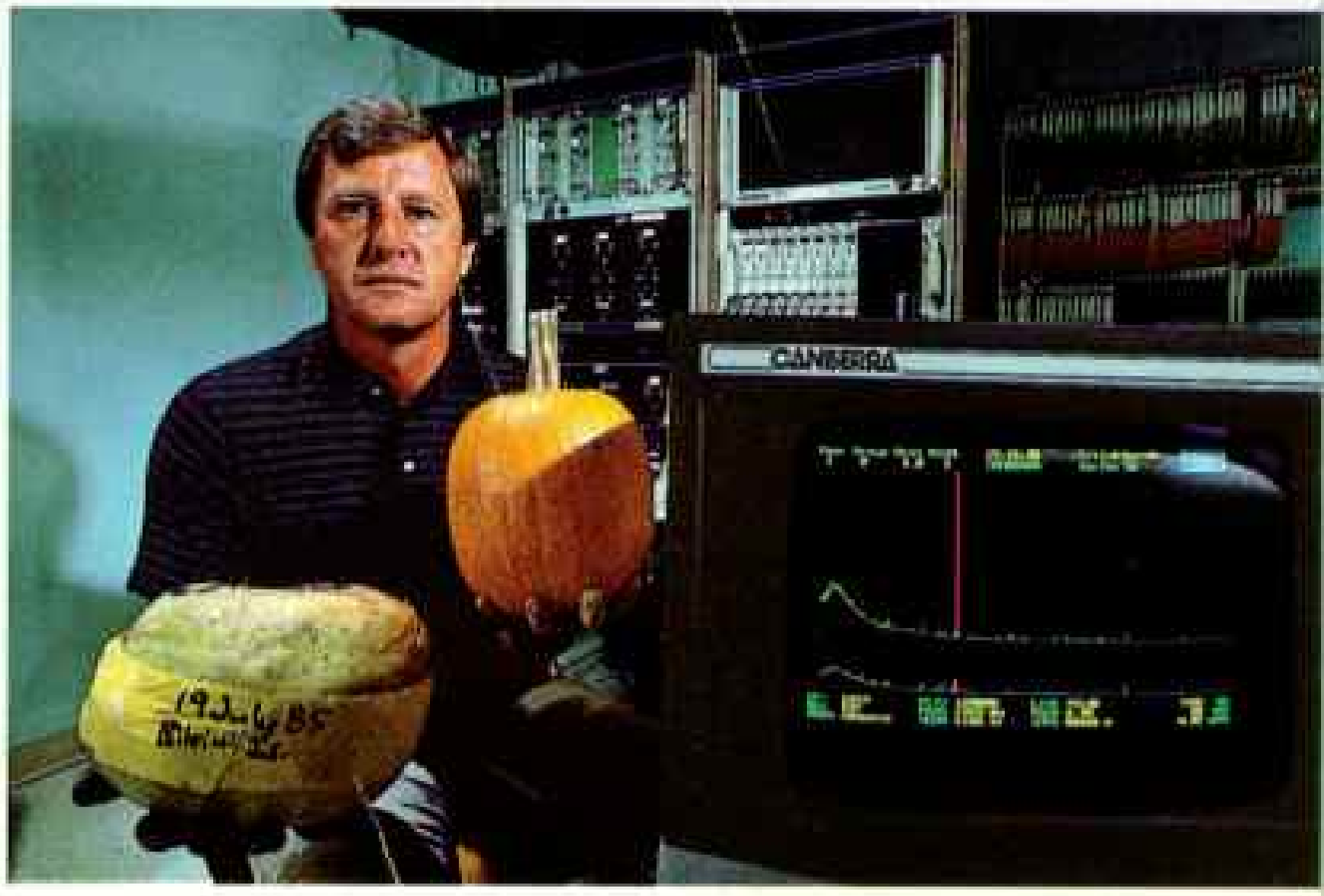
injury due to radiation among the more than 40,000 servicemen and others present at Bikini. The atoll was evacuated; the target ships were unmanned; test personnel were stationed safely upwind.

Still, it was messy.

ON THE EASTERN SIDE of Enewetak Atoll there is a small island called Runit, and on that island there is a massive concrete dome called Cactus Crater, under which lies buried the deadly garbage of radiation (pages 826-7).

The 43 explosions around the lagoon at Enewetak left tons of hot debris and soil. It took three years to clean the atoll, at a cost of 120 million dollars, and the rug under which the dirt has been swept consists of 358 panels of concrete domed over a hole 30 feet deep and 350 feet wide. And still there remain loose on Runit 160 grams of plutonium oxides, a mere thimbleful, but enough of this toxic metal, in its elemental form, to wipe out an entire population.

Kunio Joseph worries about the plutonium, but he worries much more about his empty aspirin bottle. For the past six years he has held the job of medical assistant on



the island of Enewetak. "I have run out of supplies," he said. "I meet the plane every time it comes in, hoping there is something on it for me. I am down to one aspirin."

On Kili, Uraia Jibas complained that he was out of bandages. On a table there were bottles of pills, one of which was marked Worms, another Arthritis, and a third Scabies. Nothing was refrigerated. In all the 68 clinics in the outer islands of the Marshalls, there are fewer than a dozen refrigerators that work.

For want of a medicine costing 85 cents, a local paper reported, a child on an outer

Radioactivity will linger *on Bikini unless its soil is decontaminated. That's the verdict delivered to the Bikini council by Dr. William L. Robison (**left**), director of the Bikini Atoll project of Lawrence Livermore National Laboratory in California. Foods grown on the island show high levels of radioactive cesium 137 (pink spike on screen, **above**). The contaminated fruit held in Dr. Robison's right hand shows reduced radiation; it was grown in an experimental pumpkin patch (**top**) where the top 15 inches of soil had been removed. High-potassium fertilizer or saltwater irrigation may further block the uptake of radioactivity.*

*"**There are no words** to express my depression," sang Lore Kessibuki (standing, foreground) when he left Bikini 40 years ago. His dream of returning burns brighter during a visit to the atoll, and he believes that those who ruined his home are still his best hope—"It is not impossible for the United States to do anything."*

island died last year. The infant mortality rate in the outer Marshalls is at least three times as high as the United States average. More than 50 percent of the deaths last year were of children under five. Small Styrofoam caskets are neatly stacked on the floor of a store on Majuro, as if on display for a weekend special.

BUT THERE IS NO DEATH on this Sunday morning in Kili. Rather, someone is striking the empty steel oxygen cylinder that hangs from the old breadfruit tree in front of the church, striking it with a length of pipe to produce a sweet but muscled sound, like a requiem for a tsar.

It is the call to church, and soon the Bikinians are sending up their voices to Zion, filling that small hall with a devotion in song. It is then that the outsider comes to know a certain truth about these people, a people at peace with their lives. There is great strength yet in their souls, and only when they sit in those wooden pews, fanning themselves and reaching deep for the pieces of voice that fit together in glorious harmony—only then does the strength come forth.

So on this Sunday morning they are not only singing and worshiping. They are once again sailing their outrigger canoes, and they are fishing and clawing in the sand for turtle eggs. They are fathers smiling as their sons make their first climb to the top of a coconut tree.

It is not the sea that they hear outside, pounding Kili's unprotected shores. It is the ghost of a lost culture calling out to them. □

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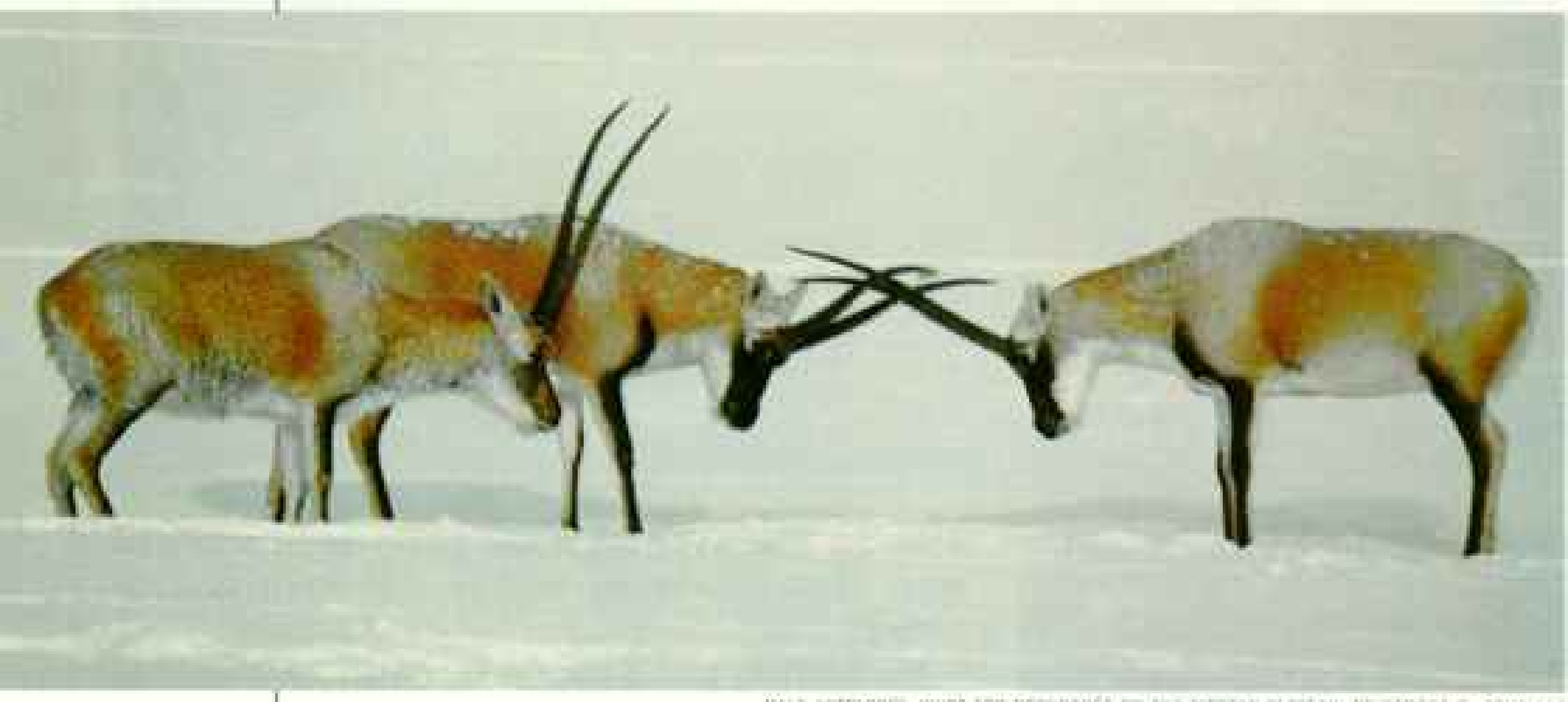
LIKE OLD FRIENDS, institutions can have such enduring and fruitful association that it is only upon reflection that the richness of their intertwined pasts becomes evident. I was reminded of this when George Schaller recently shared with us some of the photographs he has lately taken of the remarkable animals that range the Tibetan Plateau.

Tibetan antelopes, wild asses, white-lipped deer, and gazelles had rarely been seen by Westerners, even in photographs, until George began his work in what he calls a "high-altitude Serengeti" in collaboration with the People's



MALE ANTELOPES JOUST FOR DOMINANCE ON THE TIBETAN PLATEAU, BY GEORGE B. SCHALLER

Republic of China. These animals are now under pressure from hunting and increased competition from domestic grazing stock. On top of that, thousands died of starvation last fall when a rare blizzard covered their normally windblown grazing range with a foot of snow.

George Schaller is director of Wildlife Conservation International, a division of the New York Zoological Society (NYZS). He has been a contributor to this magazine on such topics as lions, snow leopards, and pandas, the last most recently in the March 1986 issue. He has been a recipient of National Geographic Society research grants and is a friend to us and to wildlife worldwide. The association of NGS and NYZS may sound like alphabet soup. It certainly has been mutually warm and nourishing and goes back at least 75 years. (Both of us are approaching our centennials.)

NYZS is best known for its Bronx Zoo and New York Aquarium and, under current General Director William Conway, has been a leader in redefining the concept of zoos' role in the world of wildlife.

When opened in 1899, the Bronx Zoo was much like others—a place to display as many species as could be captured and caged. Yet as early as 1907, NYZS was a leader in conservation by supplying nearly extinct American bison to reestablish wild western herds.

The Bronx Zoo now re-creates habitats where animals live in dignity.

TIBETAN ANIMALS SEARCH FOR FOOD AFTER A BLIZZARD; NYZS DIRECTOR WILLIAM CONWAY MEETS A PANDA IN CHINA; BOTH BY GEORGE B. SCHALLER

Zoos are becoming more like parks and parks like zoos. Most important, wildlife will breed in such settings.

Bill Conway points out: "A very high percentage of all the remaining wildlife is going to be lost. A small percentage of that large percentage can be saved in zoos. We are attempting to pioneer in the development of the zoo as a new, municipally supported and oriented center for international conservation." With some 50 conservation projects in nearly 30 countries, the NYZS is in the forefront of that movement.

It has been more than 50 years since our two societies jointly sponsored William Beebe of the NYZS in his exploration of the deep ocean from a "bathysphere" suspended at the end of thousands of feet of cable. In the 1930s even outer space was better known than that dark world. Beebe's descents may be the most spectacular example of our long cooperation. It has continued in ways large and small, formal and informal. Bill Conway puts it this way: "It has been a long, happy relationship, in which we feel that the Geographic has been an enormous stimulus and help to us, and we think we've been of value to the Geographic." That says it modestly. May it continue; we both have new work to do.

Gilbert H. Grosvenor

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Members Forum

Madrid

Your article on Madrid (February 1986) and Spain's return to democracy brings to mind that, thanks to Gen. Francisco Franco, Spain today is a democracy. If it had not been for him, Spain would have been under a Communist dictatorship. And that is one dictatorship people cannot escape from.

Alfredo M. Pedraza
Coral Gables, Florida

Why call the Franco era a "long night"? The present "day" has brought to Madrid a tremendous increase of pornography, crimes of every sort, drugs in the schools and streets, unemployment, and all sorts of taxation, including income tax.

Clement M. Iglesias
Beaumont, Texas

You gave this charming old city the recognition it has long deserved. El Escorial, the Prado, the Valle de los Caidos, the glorious cathedrals—you have successfully captured the splendor of a magnificent city with a beautiful history.

Heather Linson
Moline, Illinois

To me there is no city in the world like Madrid. In 1937, on the Jarama Front as a soldier in the Abraham Lincoln Brigade, I defended the lifeline running from Valencia to Madrid. This year in October the International Brigades will hold a 50th anniversary reunion in Madrid.

Charles Nusser
New York City

The lack of any map for the city was both noticeable and aggravating.

Gerald Hosenkamp
San Diego, California

You refer to the problems that must face the city and its mayor. One of the gravest is the unexpected terrorist attack. Vice Adm. Cristóbal Colón, pictured on page 173—direct descendant of his namesake—was killed by alleged Basque elements in February.

Emilio Ascaso
Barcelona, Spain

The article deals unfairly with the beautiful monument, the Valley of the Fallen, on pages 170-71, with the implication that the Spanish people dislike it. The basilica is large and peaceful, the cross beautifully situated. The monument is to all who participated in the Spanish Civil War, regardless of nationality or politics. Many lovely structures were designed and built by despots (the Pyramids, for instance).

Col. M. O. Rowland
Stuart, Florida

Tormenting a frustrated and wounded animal until death is greatness? To a matador perhaps. But to people who care for animals, it translates as unabridged horror! In consolation, it is my hope that this photo has brought awareness of the cruelty of this sport.

Wayne Anderson
Markerville, Alberta

Grizzlies

I read with interest "Grizz" (February 1986). As a 37-year resident of Wyoming I have "beat the bush" since nearly old enough to carry a fishing pole and walk at the same time. The "great controversy" surrounding the grizzly bear amuses many a native of this area. If a person doesn't know enough about grizzly country to know that going there entails the risk of being eaten by one, then said person has no business being there in the first place.

Roliand D. Otto
Powell, Wyoming

Congratulations! Your in-depth article brought to light facts known by far too few. Since 1910 our family has lived at the edge of the Selkirk ecosystem, the area where most grizzly sightings have originated. Our Three Mile Creek area is scheduled by the Forest Service to be clear-cut in 1987. So, good-bye grizzlies, good-bye elk, good-bye wolves, good-bye caribou, and good-bye moose. Where are our former "neighbors" to find a new home? Will they end in a zoo, die due to starvation, or be destroyed poaching a farmer's animals?

Lorraine Luhr
Metaline Falls, Washington

Ndebele

I found the article on the Ndebele (February 1986) very enlightening. We often read of riots or shootings in the news magazines, but your article gave real insight into the lives of the individual people involved. I kept being distracted, however, by the pictures and information on the traditional neck and leg rings worn by the women. I felt I had read this before and finally looked back until I found "Burma's Long-necked Women" in June 1979. Is there a connection?

John J. Balaban
Skokie, Illinois

No. Cultural similarities occur throughout the world, sometimes without any evidence of contact or exchange.

Being a deep-rooted white South African with a lot of hope for my country's future, I at once

turned to the Ndebele article. Since the entire world is full of condemnation and negative press toward South Africa, it was pleasing to read an objective, factual, and fairly written account of a region struggling to come to terms with its future.

Dave Burge
Cape Town, South Africa

Why do you not keep yourself with things geographic busy instead of poking your nose in the administration of our government and then giving a wrong view of matters?

S.J.G. Hofmeyr
Pretoria, South Africa

The Ndebele nation has always been left out of big political discussions because their leaders have never been demonstrative enough to keep up with larger black tribes. The government action is to protect the Ndebele heritage. It is naive to think the black nations of South Africa all want to live in one bigger happy home.

Michael Chambers
Barrydale, South Africa

The homelands program was ill conceived, and apartheid never should have been inflicted. Unhappily, however, this article will spur some people to demand sanctions against South Africa, supposedly as a reprisal. All races in southern Af-

rica will be affected. Neighboring countries will be affected due to increased unemployment, curtailed power-expansion programs, loss of customs revenue, reduced imports, exports, and communications, etc. If Western powers are forced to withdraw from South Africa, it will leave a vacuum, and vacuums are usually filled.

Dilys E. Upton
Solano, New Mexico

Banaras

Thank you very much for the article on Banaras (February 1986). Its exquisite photographs brought out the color and beauty of the city and its inhabitants. Too many writers and photojournalists in the past have done a great disservice to India and her Hindu inhabitants by magnifying the ills on the exterior, while totally ignoring the beauty, happiness, serenity, and piety of her soul.

S. P. Ankalikar
Tampa, Florida

Queensland

In the January issue you published remarks of the premier of Queensland, who attacked a whole race and poured shame on them. As a former elected senator in my country and as an Aboriginal, I seek to tell your millions of readers our perspective of his views. Sir Joh Bjelke-Petersen talked contemptuously and patronizingly of

whites catering to Queensland Aborigines, thousands of whom are still herded into isolated reserves, where they were rounded up and dumped generations ago when white pastoralists like Bjelke-Petersen wanted to appropriate their lands. Now disease, rejection, and social disintegration daily take a deadly toll and crush the hearts of the living who suffer such thrusts.

Neville Bonner
Ipswich, Queensland

The premier adds insult to injury in his reference to our people who fought with U. S. troops in the Coral Sea Battle area. Aborigines were fully represented by the Torres Strait Light Infantry Battalion as a part of the Australian Infantry Forces.

D. E. Darby
Capalaba, Queensland

Your writer states Premier Bjelke-Petersen has "become a folk hero, winning elections by landslides." In the last election (1983) his party won 38 percent of the vote, which means that more than 60 percent of the people did not vote for him or his party. He only remains in power by virtue of a gerrymander that allows disproportionate representation in rural areas. Joh is a farmer, and the National Party at one time was called the Country Party.

J. C. Thorsborne
Cairns, Queensland

No landslide, and hero only to some. The remarks of the premier so offended Queensland Aboriginal leaders that they have announced the formation of a political group to lobby and possibly field candidates in the next state election.

Challenger

The recent heartbreaking launch of the space shuttle led me to your March 1981 issue with its excellent presentation "When the Space Shuttle Finally Flies." Rick Gore and staff put it all together: see page 332 for details of the external fuel tank.

Carl E. Yazvac
Youngstown, Ohio

Let us dwell on the scientific and technological advances that have benefited our society, and the need to continue our quest for the betterment of all mankind. I recommend a special issue on the positive aspects of our space program.

Dennis K. Feldhaus
Evansville, Indiana

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

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On Assignment

THE SUBJECT WAS LIFE, though not exactly as we know it, when Sweden's ***Lennart Nilsson*** (***below,*** at right), master of photomicroscopy, beamed in on a microcosm for this month's article on the immune system. What Nilsson actually produced, with the help of his longtime friend and collaborator, Jan Lindberg, at left, was a remarkable photographic documentary illustrating the unceasing struggle within the human body to preserve life.

The key to his success was a powerful instrument, the scanning electron microscope (SEM), which uses electrons rather than light waves to produce images of far greater depth of field and resolution than any light microscope. Providing magnifications of from 10 to 100,000 times, the SEM enables Nilsson to pursue his life's work, which is "to show what a wonderful creature is the human being"—right down to the cellular level.

Clinical and forensic pathologist for the Swedish government, Lindberg works at the Karolinska Institute in Stockholm, where he prepares the specimens—cancer cells, viruses, damaged tissue—for Nilsson to photograph. The institute, which awards the Nobel Prize in Medicine and presented Nilsson with an honorary doctorate in 1976, provides Lindberg with a wealth of scientific resources. He obtains samples from the institute's surgical theater and keeps them alive for days under controlled conditions.

During extensive preparation, a specimen is first coated with a fixative solution that "freezes" the sample instantly. Then it is dehydrated and coated with an ultrathin layer of gold to improve its conductivity. In a vacuum chamber at the base of the SEM, the prepared sample is bombarded with electrons, which bounce off the gold coating back to a sensor that converts electrons to electronic signals. These signals are amplified and sent to the SEM's screen, where they form an image. Nilsson studies such images for weeks, even years, viewing one specimen after another and waiting for the elements of a story to emerge.

"Lennart never gives up," says Lindberg of his friend's legendary diligence. "He will respect no hours to get the picture he wants." Of their collaboration he adds, "Lennart is the artist." Their partnership began 20 years ago when they first teamed up for articles on fetal development and heart disease for *Life* magazine. Since then, they have produced a number of highly acclaimed books and films, including a 1984 Emmy winner, "The Miracle of Life."

ASTRID THORÉN

Photographed by Francis Hannecart *Kagu: Genus: Rhynochetos Species: jubatus*
Adult size: Length, 55cm; stands up to a half meter tall Adult weight: 1kg
Habitat: Dense mountain forest on the island of New Caledonia
Surviving number: Estimated at 500—1,000

Wildlife as Canon sees it: A photographic heritage for all generations.

A ground-nester with a spirited courtship dance but limited capability for flight, the kagu comprises a unique genus and family of birds. If disturbed, this shy bird will run away quickly and often stop abruptly, turn, fling out its wings in an attempt to startle the intruder, then resume running. Threatened by habitat loss and preyed upon by dogs, wild pigs and other animals, the helpless kagu faces a very uncertain future.

Nothing could bring back the kagu should it vanish completely. And while photography can record it for posterity, more importantly photography can help save it and the rest of wildlife.

Reserves and parks can help maintain valuable kagu habitat. Captive breeding may one day supplement the wild population. But for the present, information is urgently needed about the kagu. Restricted to inaccessible forests, kagus are almost impossible to observe in the wild, and scientists have to rely on such methods as radio-tracking to obtain the needed data. Not only can photography assist in these efforts, but it can promote a greater understanding of this fascinating bird.

And understanding is perhaps the single most important factor in saving the kagu and all of wildlife.

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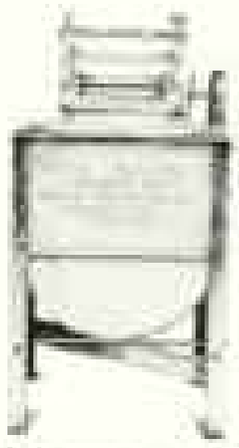

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Guide Dog Foundation For The Blind, Inc.

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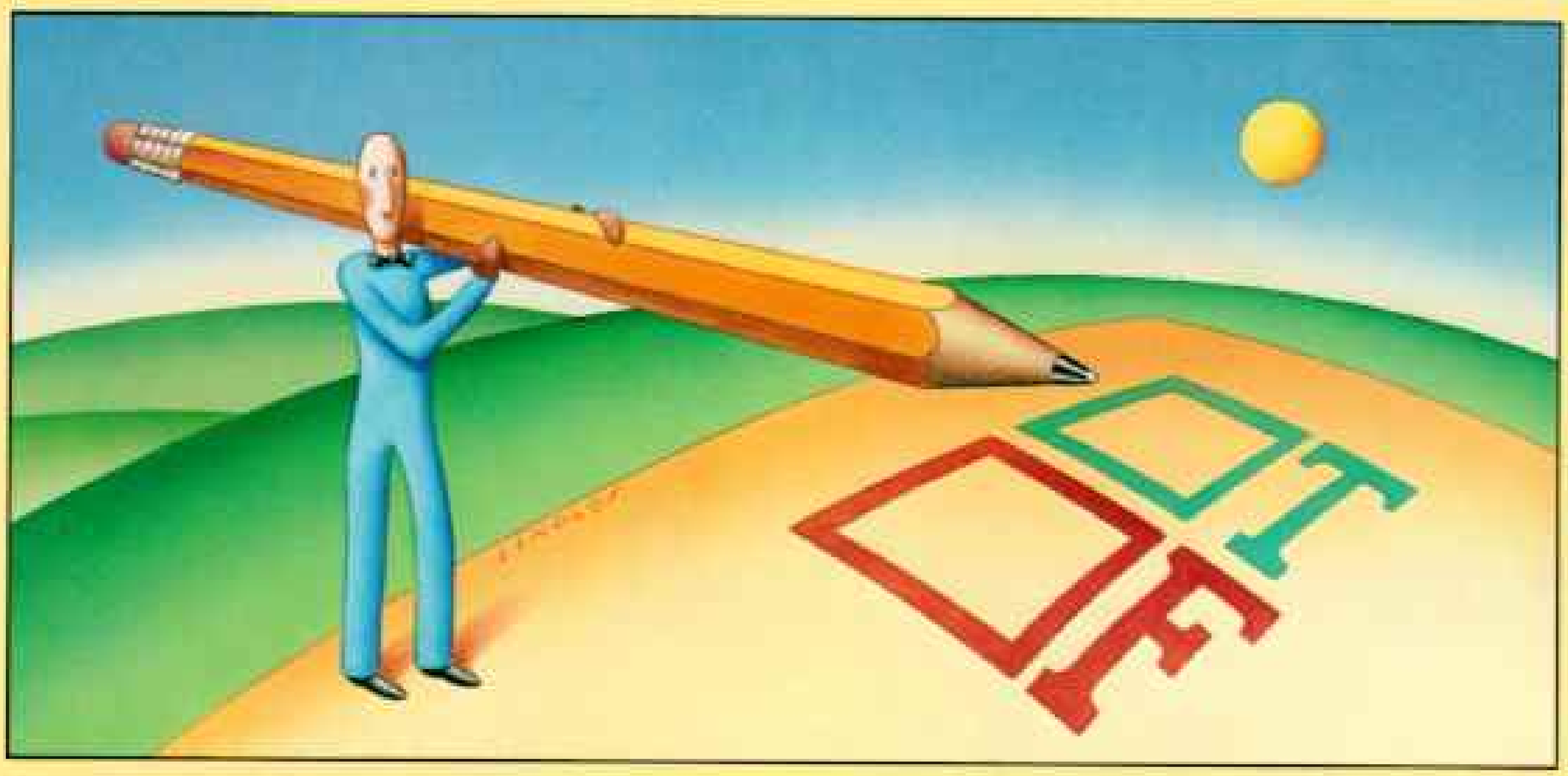


True or False?

America now has 100 operating nuclear power plants.

It's true. The one hundredth plant started producing electricity earlier this year, bringing us all a little closer to real energy independence.

Nuclear energy has quietly become the United States' second leading source of electricity, behind coal. 100 nuclear plants in 32 states now supply us with more electric generating capacity than the whole country had in the early 1950s.

These plants are also reducing the United States' dependence on foreign oil.

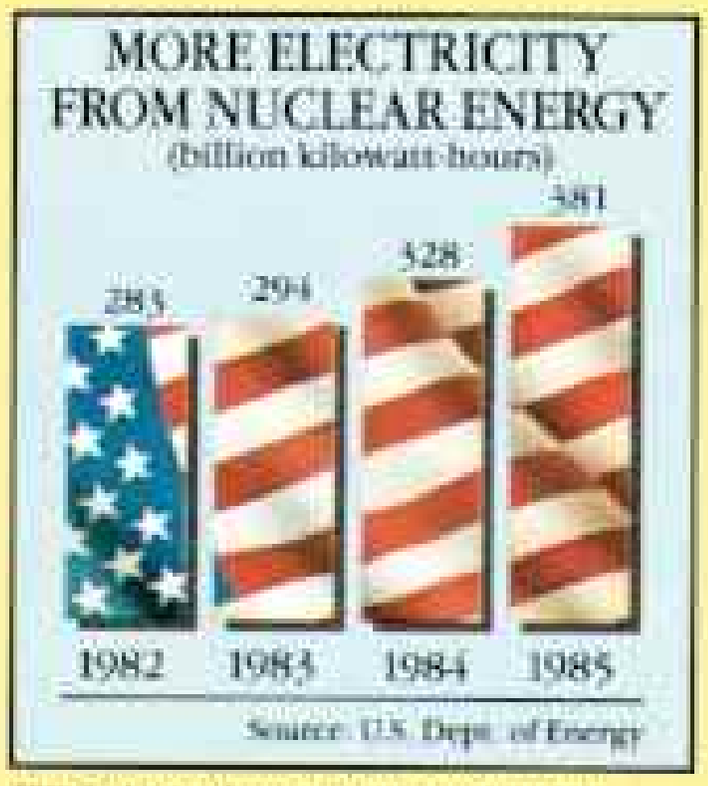
More nuclear energy means less imported oil

Nuclear fuel and the electricity it generates fight foreign energy dependence, because they are economical substitutes for oil. In fact, OPEC admits that nuclear plants have permanently hurt its oil business.

Without nuclear power, U.S. oil imports would be much higher—and so would the price of electricity.

Last year America imported about 5 million barrels of oil every day. That cost us close to a billion dollars *a week*.

All that money leaving the country worsens the trade deficit. And if oil prices keep going down, it will be tempting once again to use more oil and import more. Which will make us even more dependent on other countries' energy.



With 100 plants now operating, nuclear-generated electricity is America's fastest growing major energy source.

Electricity needed for economic growth

When the U.S. economy grows, it creates new jobs and a better standard of living. But that growth requires more and more electricity.

We are an electrified society.

Since the first Arab oil embargo in 1973, America's consumption of electricity has gone *up* by 36% (which closely parallels the economy's 34% growth during the same period).

But the use of non-electric energy—the direct burning of coal, oil, and natural gas—actually went *down* by nearly 13%.

The proven safety of nuclear electricity

It's been over 25 years since America's first commercial nuclear plant started up. Today, with almost 1,000 reactor-years of operating experience in the U.S., the safety record of nuclear power is second to none.

Without fanfare but with much success, it continues to give us electricity for our economy's growth and our country's energy security.

For a free booklet on energy independence, write to the U.S. Committee for Energy Awareness, P.O. Box 1537 (CC14), Ridgely, MD 21681. Please allow 4-6 weeks for delivery.

Information about energy
America can count on

U.S. COMMITTEE FOR ENERGY AWARENESS