THIS MONTH: CLOSE ENCOUNTER WITH A NEW COMET

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OMNI

MAY 1990

ROBO-BUGS AND THE WORLD'S SMALLEST MACHINES

THE KILLING FIELDS: SETTING THE STAGE FOR FUTURE EPIDEMICS

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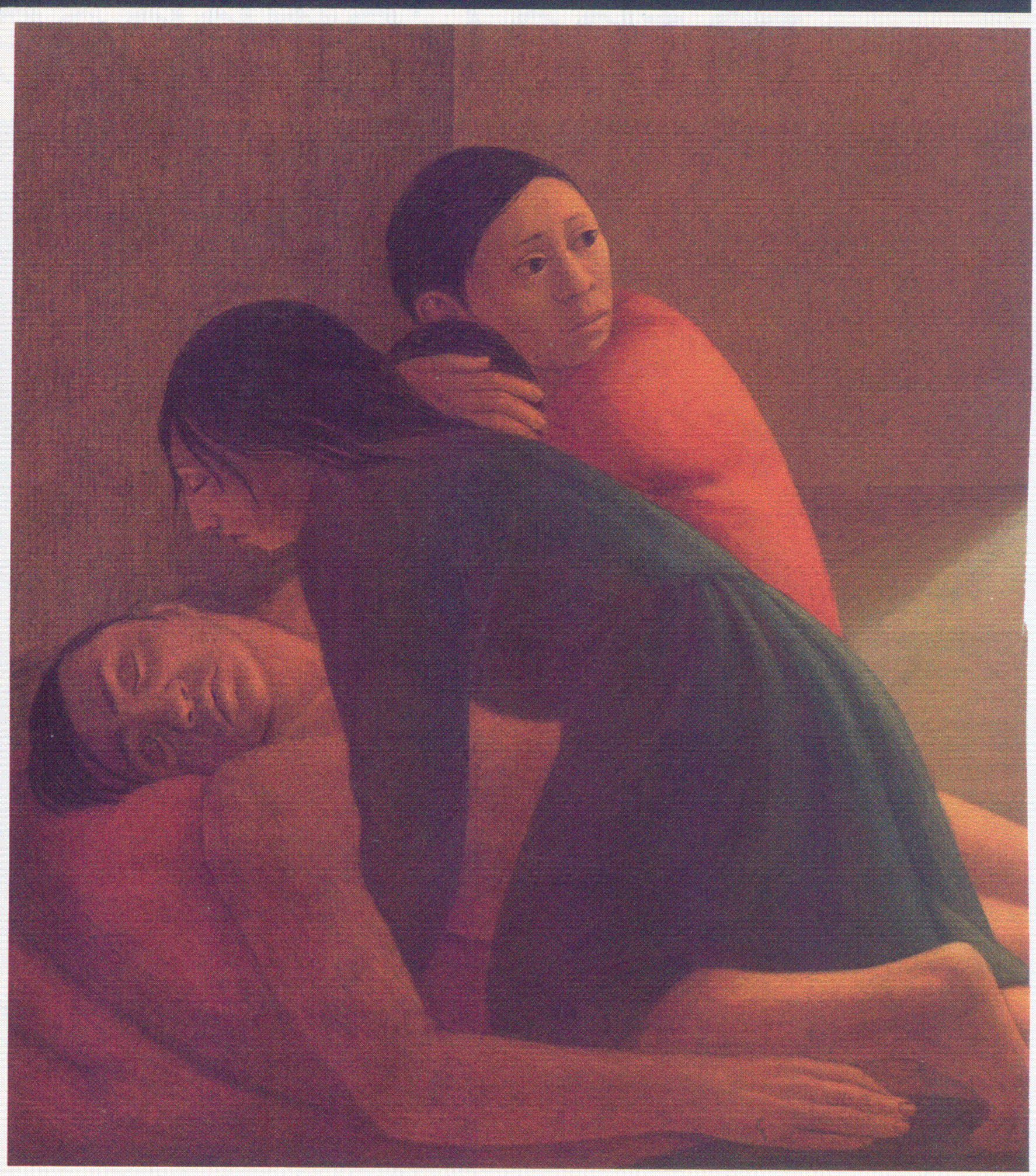
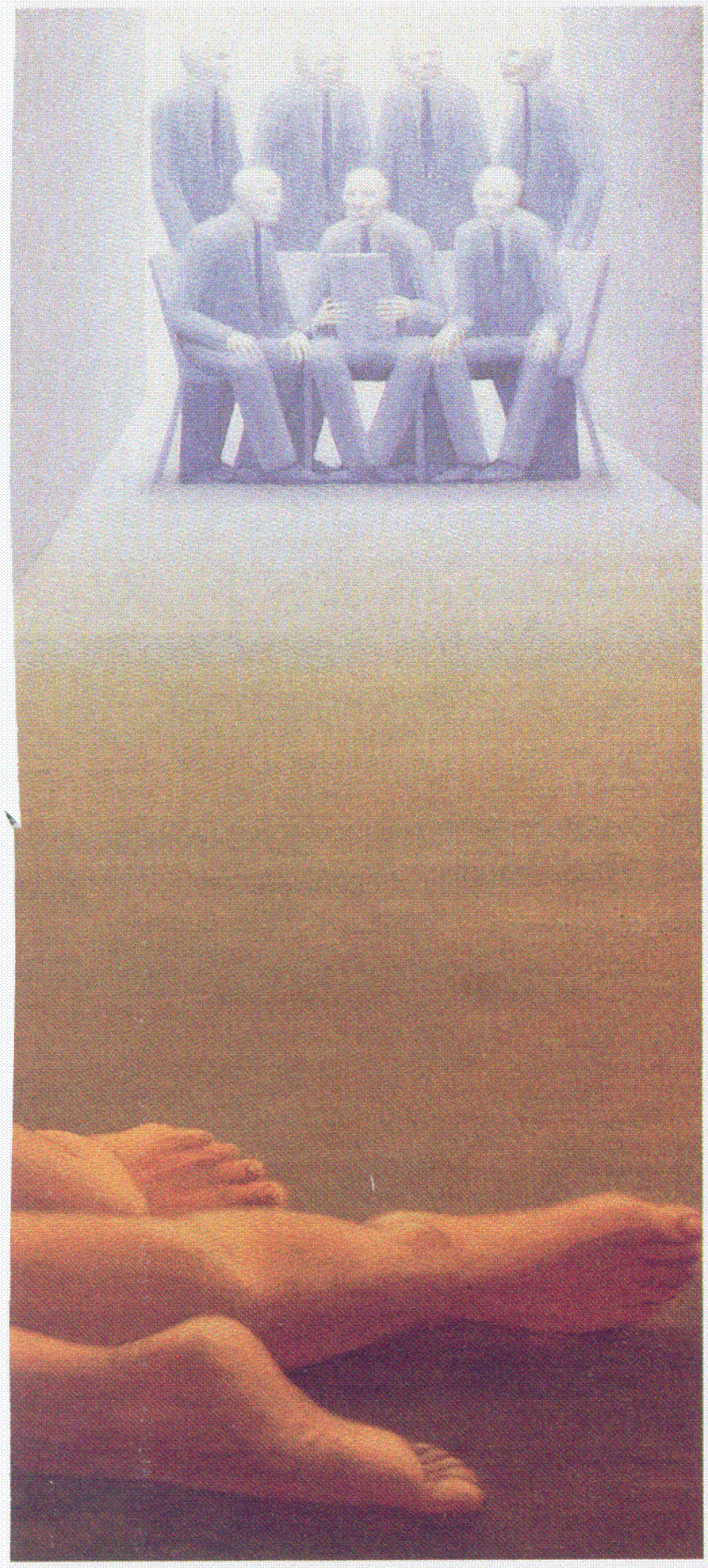




ARTICLE

THE KILLING FIELDS: LATTER-DAY PLAGUES

AIDS may be just the beginning. Experts fear a rash of worldwide epidemics

BY KATHLEEN McAULIFFE

"An entire hospital has been wiped out and we still don't know what's behind the outbreak. Can you find out for us?"

It was not the sort of phone call Karl Johnson relishes, but as a world-renowned expert on tropical infections at the U.S. Centers for Disease Control (CDC), he stoically bid farewell to his wife and boarded the next plane for Central Africa. There, near the fetid banks of the Ebola River in northwestern Zaire, a horrible fever had sprung seemingly from nowhere. The year was 1976, and as Johnson arrived with an international team of investigators, fleeing villagers were being turned back at gunpoint by government authorities ordered to quarantine the entire province. None of the community would go near the bush hospital where the outbreak began. So the party of foreigners—with only surgical gowns, gloves, and face masks for protection—set off in jeeps to visit the sick in scattered villages.

"For two to three weeks, we really held our breath," says Johnson, who now works at National Biosys-

PAINTINGS BY GEORGE TOOKER

tems, Inc., in Rockville, Maryland. "We saw very rapidly that the disease had an eighty to ninety percent fatality and we had no idea how it was being transmitted." Compounding their fears, members of the team—all of whom had volunteered for the mission—kept getting splattered with blood while collecting medical samples. Meanwhile the villagers were unwittingly inviting death by participating in funerary rites that involved intimate contact with the deceased.

To Johnson's relief, the tribal chiefs awoke to the gravity of the threat, banned this ritual, and reinstituted stringent disease control practices used since antiquity in Africa to thwart the ravages of smallpox. The infected were isolated in a hut, where their only contact with the outside world was through food and water slipped under the door. "If they walked out," says Johnson, "fine. If not, the hut was set on fire."

Several hundred deaths later, the disease vanished as mysteriously as it had appeared. The researchers eventually determined that it was a blood-borne viral infection—unprecedented in medical history—precipitated at the hospital by the use of a few unsterilized syringes to administer hundreds of injections, and possibly spread by sex with infected individuals.

Such an outbreak would be unthinkable at a modern, well-equipped hospital in the United States or Europe. But that hasn't stopped Johnson from pondering alternative outcomes—frightening "what if" scenarios—that haunt him like a recurrent nightmare more than a decade later. "What would we have done if the virus was spread by cough droplets in the air?" he asks. "If that were the case, there's no doubt in my mind that Ebola fever could have qualified as the Andromeda strain and we'd all have died."

Such a disaster may not be as remote as commonly thought. As Nobel laureate Joshua Lederberg of Rockefeller University warns in a leading medical journal: "Most people today are grossly overoptimistic with respect to the means we have available to forfend global epidemics comparable with the Black Death of the fourteenth century or on a lesser scale the influenza of 1918, which took a toll of millions of lives."

In a span of less than 15 years, the United States alone has been stricken by a wave of new infections. Toxic shock syndrome, Legionnaires' disease, AIDS, Lyme disease—all have emerged from obscurity to become household names. And while no one has a crystal ball, infectious disease experts fear an escalation of new—and possibly more deadly—epidemics in the future. Indeed, some candidates already loom on distant horizons—isolated in tiny geographical pockets. Others—notably an insect-borne infection that can be fatal to children—are rapidly encroaching on American territory.

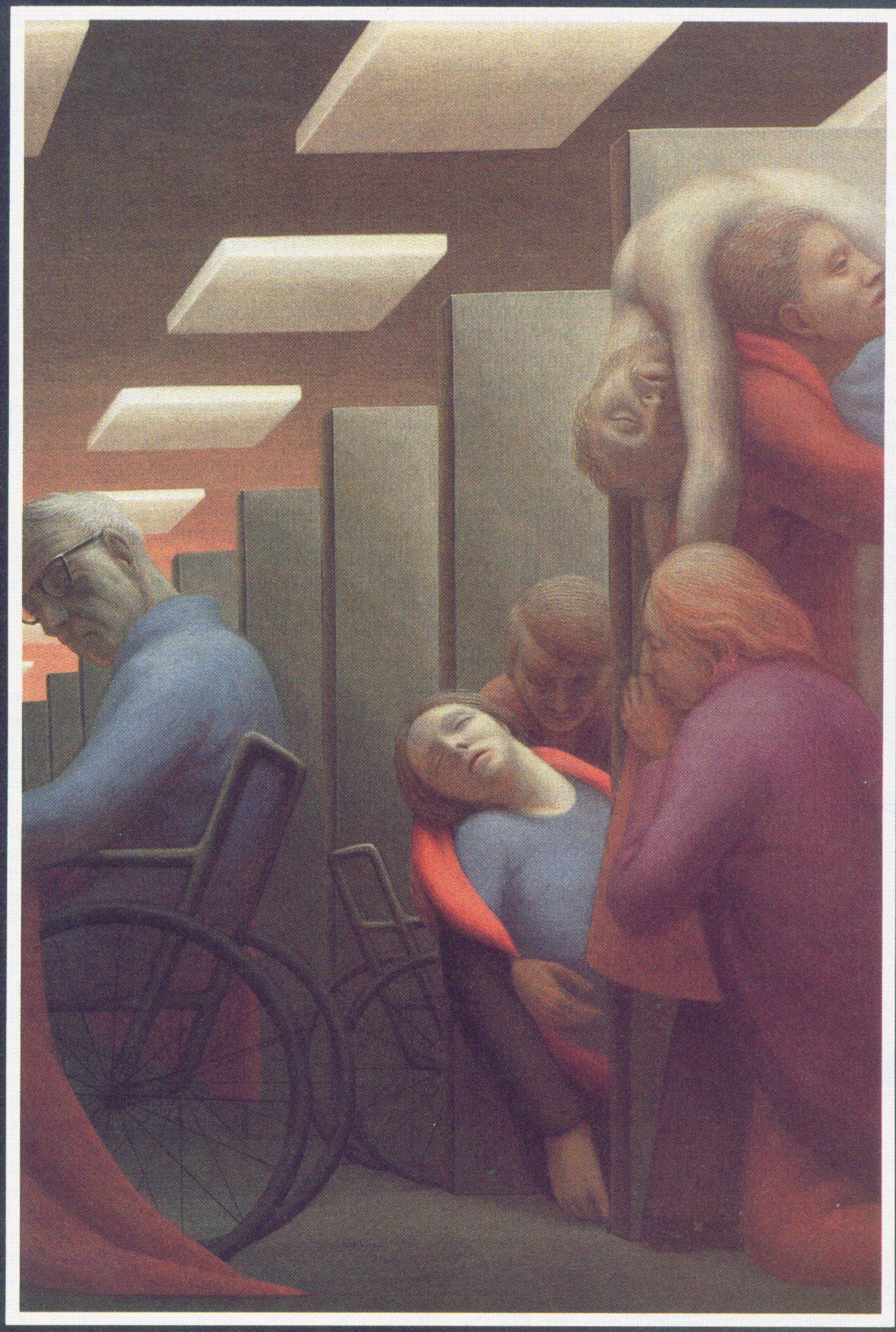
Why the explosion of pestilence? If these were the Dark Ages rather than the Space Age, we would undoubtedly wonder if God was punishing us for our sins. To be sure, changing mores associated with sex and drug use have contributed to the spread of highly lethal diseases—AIDS being a leading example. But many other global forces have also conspired against us.

With air travel becoming increasingly affordable, infectious agents that would have been confined to one corner of the world just a few decades ago are now jumping across continents at near-supersonic speeds. This places modern man at a historical crossroads—much like New World inhabitants at the dawn of the Age of Discovery—that makes us uniquely vulnerable to novel plagues. As William McNeill, a retired professor of history at the University of Chicago and author of *Plagues and Peoples,* points out, "Cortés did not conquer the Aztecs—it was the smallpox that the Spaniards brought with them." Whenever an unexposed population comes into contact with a new, lethal infectious agent, the death toll is notoriously high, leaving only a tiny subgroup of survivors composed largely of resistant individuals. Just 130 years after the conquistadores arrived in central Mexico, up to 90 percent of the indigenous population had perished from smallpox and other European diseases—a frightening reminder of the threat posed by today's globe-trotting microbes.

IT'S BIZARRE: A DISEASE NEVER SEEN BEFORE STRIKES WITH THE SAME VENGEANCE, IN THE SAME SEASON, 600 MILES APART.

Our encroachment on rain forests and other wilderness areas is also bringing humans into direct contact for the first time with potentially dangerous pathogens harbored by wild animals. In the U.S. Northeast, for example, new housing developments infringing on natural deer habitats have been implicated in the explosion of Lyme disease—a debilitating arthritic condition transmitted by a deer-borne tick.

Just as ominous, a favorite breeding ground of microorganisms—the steamy tropics—now sustains the densest human population ever. Of particular concern is the unprecedented emer-



gence of "mega-cities" of 5 million or more people in developing parts of the tropics, where malnutrition and poor sanitation give microbes a further edge. Says McNeill, "Swelling numbers at the top of the food chain constitute a magnificent feeding ground for microbes."

Adding to this peril, the United States and other nations are withdrawing support for infectious disease surveillance around the world. Such biological "listening posts" are critical for detecting epidemics early on—especially in primitive cultures at high risk for emerging plagues.

Before beating a fast retreat to civilization, however, be forewarned that technology is no safeguard against the rising tide of infection—and may even increase our chances of succumbing. Ironically, inventions designed to ease our lives can sometimes backfire, providing microbes with more lethal routes of entry into the body. Consider *Staphylococcus epidermidis*, a bacterium long viewed as harmless, which is now a leading cause of infection in intensive care units. Tough new strains that don't respond to antibiotics routinely find their way into patients' veins through intravenous tubes and sometimes even colonize artificial-heart valves. "It's a terrible problem and can be fatal for patients who are very ill to begin with," says Claire Broome, chief of the CDC's special pathogens branch.

The bacterium that killed 29 people who attended a 1976 American Legion convention in Philadelphia may also have gained a technological boost. Recent outbreaks of the disease have been traced to faulty ventilating systems, which permit the pathogen to proliferate. This is not to imply—public perceptions to the contrary—that the bacterium sprang out of thin air. After isolating the culprit at the convention, the CDC found similar samples in its vaults that came from people presumed to have died from pneumonia. "In the past," says Broome, "Legionnaires' probably occurred and was mistaken for viral pneumonia."

Likewise, toxic shock syndrome owes its notoriety to a more absorbent tampon introduced by Rely in 1980. Before then, according to CDC epidemiologist Benjamin Schwartz, the bacterial infection probably struck infrequently—and hence was likely mistaken for scarlet fever, which has similar symptoms.

As AIDS and Ebola fever clearly demonstrate, however, some diseases are true originals, emerging unheralded in man. As such, they pose a formidable challenge to medical science—and tracing their evolution involves detective work of the highest order. Although there are often more clues than answers, high on the suspect list are pathogens that appear to have jumped from an animal to a human host.

An intriguing example from the past: The oldest documented case of syphilis has been tentatively traced to a bear that lived 11,500 years ago in what is now Indiana. That is more than 5,000 years before there is clear-cut historical evidence of the first outbreak in man. The bear's bones, uncovered in 1987, had holes and other signs of the venereal disease—a possibility further supported by an antibody test. Although more studies of both human and animal remains could alter the picture, researchers now speculate that a bear bite, or contact with a contaminated carcass, could have unleashed the scourge of syphilis upon mankind.

In a similar vein, a primate is now suspected of having played a key role in the eruption of AIDS. The evidence: Large numbers of seemingly healthy African green monkeys living in the wild carry antibodies against a closely related virus. "Possibly facilitating viral transmission from animal to man," says Gerald Myers of Los Alamos National Laboratory in New Mexico, "there was a sharp rise in the exportation of monkeys from Africa into the United States in the Sixties for medical research."

The origin of Ebola fever is more perplexing. While Johnson struggled to stamp out the epidemic in Zaire, an identical disease broke out in another rural hospital in the southern Sudan—600 miles away. Initially, it was assumed that the same virus had caused both epidemics. But to everyone's shock, laboratory analysis later revealed that two distinct—though related—strains of viruses were involved. "It's a bizarre biological coincidence," says Johnson. "A disease never before encountered in recorded time strikes with the same vengeance, in the same season, six hundred miles apart. It almost makes you think that some environmental factors were just right for this family of viruses to explode on the scene."

The plot thickens. Last January a Swedish tourist returning from a vacation in Kenya mysteriously contracted another related virus—and, after hovering at the edge of death for two weeks, appears (as of this writing) to be recovering in the intensive care unit of a hospital south of Stockholm. Only a month earlier, Ebola fever made an even odder appearance, this time striking monkeys imported into the United States from the Philippines. This makes Johnson wonder whether a primate is a key link in the propagation of the disease in Africa. But, as he cautions, an exhaustive search for infected animals in the vicinity of the stricken villages turned up negative. "Frankly, we're scratching our heads about this," he says. "Ebola fever is as lethal to monkeys as it is to man, and you'd

CONTINUED ON PAGE 94

"Break it up!"

KILLING FIELDS

CONTINUED FROM PAGE 54

normally expect the animal that harbors this virus in nature to be resistant to it."

The evolution of a new disease agent cannot always be traced to a microbe expanding its range of target hosts, however. Sometimes the precipitating event may be an internal transformation—a genetic mutation that turns a once-benign microorganism into a powerful foe. It appears to be just such a fluke that brought tragedy to a small Brazilian town in 1984. Ten children were rushed to an emergency ward after developing a high temperature and huge purple blotches on their skin—a syndrome that came to be known as Brazilian purpuric fever. As doctors puzzled over how to treat their strange symptoms, all of the youngsters perished. A second outbreak in 1986, involving 14 more children, eventually yielded an important clue: Many of the victims of Brazilian purpuric fever had earlier suffered from conjunctivitis, a bacterial infection that causes symptoms no more serious than runny eyes. But in this Brazilian town, says CDC epidemiologist Bradley Perkins, it looks as though the bacterium "underwent a genetic change that made it more virulent."

Viruses are a still more prolific source of new mutants in nature. That, coupled with the fact that they are impervious to antibiotics, makes them a daunting threat to public health. We have slain the tiger and speared the mighty whale, but we are still at the mercy of the world's smallest creatures. As Rockefeller's Lederberg proclaimed at a conference last year in Washington, DC, on emerging viruses, they are "our only real competitors for dominion of the planet.... We shall have to be very nimble indeed to keep up with them."

Unlike bacteria and the cells of higher organisms, many viruses lack "proofreading" mechanisms for correcting genetic errors during replication. Since their sheer numbers are staggering—many billions of times the entire human population could easily fit inside a test tube with a good source of bacteria for food—genetic copying mistakes are commonplace. According to recent estimates by John J. Holland, a virologist at the University of California at San Diego, viral mutations occur in about 1 in 10,000 replications—a figure much higher than previously suspected and a full six orders of magnitude greater than occurs in human cells.

To be sure, most of these mutations are deleterious—and even when the organism is rendered more potent, it must still contend with immune cells in the body. But there is always the risk that a rare mutant will be able to crush the host's defense system. Such gangbusters typically go on a killing spree until they have virtually exhausted their food supply.

That is exactly what happened in a Pennsylvania chicken farm in 1983. A mild avian flu that normally infects the chickens' lungs suddenly turned killer and attacked their brains. Every chicken died, and the virus spread to three states before it was finally brought under control. To do so, the U.S. Department of Agriculture spent $70 million and eradicated 17 million chickens, burying them in a mass grave. "The virus nearly wiped chickens off U.S. menus," says Robert Webster, a virologist at St. Jude's Children's Research Hospital in Memphis. "It was that serious."

Remarkably, a single point mutation wrought all this mayhem—and there's no ruling out a repeat episode. A close relative of the mutant germ is now broadly disseminated in the wild duck population, where it coexists in their guts and is excreted into the water. "Several hundred million chickens are just waiting to be infected," says Webster. And he's not just worried about a cheap source of protein evaporating. The situation of the chickens, he warns, "is very similar to humans who live in urban environments. What if this occurred to us? We can't dig trenches and bury everyone [suspected of being infected]."

Actually, an evolving strain of the influenza virus may be the least of our worries. What might happen, for example, if the already lethal AIDS virus were to undergo further genetic change? Could this formidable opponent become a more efficient multiplier, one day enabling it to populate the bloodstream in sufficient quantities for an insect to transmit it? Or could the virus grow more readily in the skin, intestines, lungs, or mouth—paving the way for transmission by casual contact, ingestion, or inhalation? At the Washington conference on emerging viruses, even Nobel laureates clashed in their assessment of these risks.

One of them, Howard M. Temin of the University of Wisconsin, remained skeptical. Sure, he acknowledges, a mutation could permit the virus to grow more efficiently in other tissues—such as the respiratory tract. But if that were the case, he argues, the pathogen would have to alter its external coat so much that it would lose the capacity to infect immune cells. "So it would no longer cause AIDS," says Temin. "It might be just another cold virus."

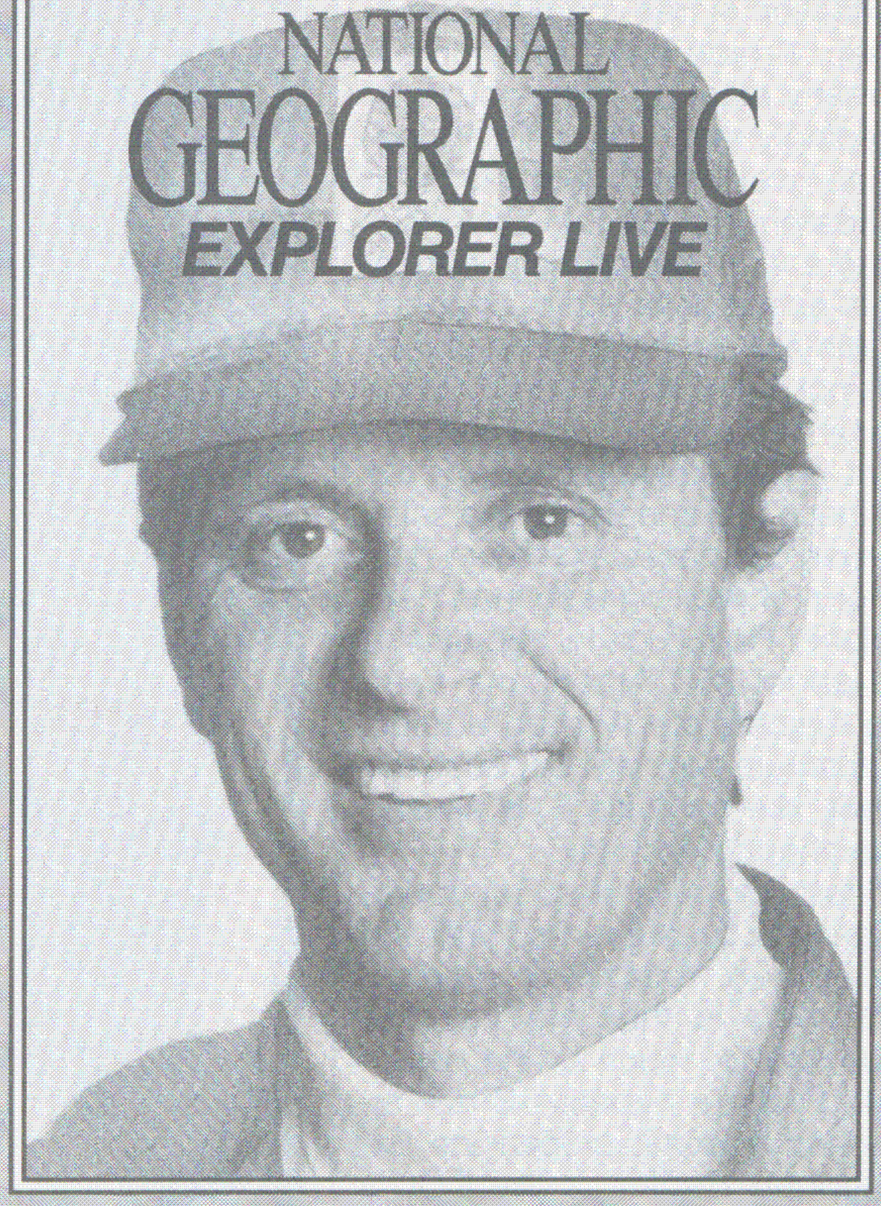
Lederberg, on the other hand, was not so sanguine. "There will be surprises," he says, "because our fertile imagination does not begin to match all the tricks that nature can play."

Doctors tracking the spread of a novel human disease agent called a viroid

would undoubtedly share Lederberg's awe at nature's inventiveness. Smaller than any known virus, this odd entity lacks a protein coat, being little more than a collection of free-roaming genetic material. Viroids have been implicated in many plant diseases, but they are exceedingly rare in the animal kingdom. Or so everyone thought until an Italian researcher in the late Seventies discovered a viroidlike particle in man. Referred to as the delta viroid, or agent, it is the ultimate parasite: To replicate, it requires not only a human cell but one infected by hepatitis B virus (whose outer coat provides protection for the viroid). If these two conditions are satisfied, the viroid can cause a far more devastating form of liver disease than hepatitis B alone. Called delta hepatitis, it now kills about 850 Americans each year. The majority are IV drug addicts and their intimate partners because the delta agent, like hepatitis B, is spread by needle sharing and sex.

The good news is that all these deaths can now be prevented with the newly developed hepatitis B vaccine. The bad news is that the vaccine comes too late for much of the developing world, where hepatitis B has already reached epidemic proportions. Explains Stephen Hadler of the CDC's immunology branch, "Hepatitis B can be transmitted through festering skin wounds. So wherever people sleep several to a bed—as happens in poor communities around the globe—the virus is commonplace." More than 200 million people worldwide are estimated to be chronic carriers of the hepatitis B virus—and thus under grave threat from the delta agent. Indeed, delta hepatitis has recently caused devastating outbreaks in South America and is beginning to make inroads into Asia's vast population. "Over there it could do major damage," says Hadler, "but here it's likely to remain mostly in IV drug users."

Also insidiously spreading among IV drug users in the United States is a virus that was once largely confined to southwestern Japan and the Caribbean. Called HTLVI, it causes a rare, highly lethal type of lymphoma and, less frequently, a degenerative nerve disease that resembles multiple sclerosis. Adding to concerns, it has a mysterious cousin, HTLVII, which is also spreading among addicts—but so far without causing any illness. Although needle sharing is the most common route of propagation for these viruses, they can be transmitted by sex, blood transfusions, and from mother to baby through breast milk. Depending upon the part of the United States, 2 to 40 percent of IV drug users carry HTLVI or HTLVII. Long-term studies in Japan, however, indicate that less than 5 percent of infected individuals will actually develop disease symptoms.



Even so, the American Red Cross isn't taking any chances with the nation's blood supply. In December 1988 it began screening for the two viruses. "With so many uncertainties surrounding their health effects," says CDC epidemiologist Rima Khabbaz, "it's hard to know how to counsel infected people who are sexually active or who want to have children."

The behavior of rodents rather than humans is primarily responsible for yet another viral plague that has quietly infiltrated this country. Called Seoul virus, it causes an acute disease of the kidneys in Asia. The pathogen is believed to have been brought to our shores by adventurous vermin that climbed aboard ships carrying goods from South Korea and is now harbored by rats and mice in Philadelphia, Houston, New Orleans, and Baltimore. The rodents themselves are unaffected by the virus, but humans who inhale dust contaminated by their urine or feces may not fare as well.

At Johns Hopkins Hospital in Baltimore, tests showed that 15 out of 1,148 patients with acute kidney failure had been infected by the Seoul virus. In addition to chronic renal problems, they often suffered from hypertension and strokes. None had traveled outside the United States, ruling out the possibility of exposure to the virus overseas.

"This is a very suggestive finding," says James Childs of the Johns Hopkins University School of Hygiene and Public Health. As he points out, hypertension and strokes are much more common among inner-city residents—particularly blacks—than among rural inhabitants of the same race. He suspects that rat infestations in urban settings could be one reason why. "I don't mean to imply that the Seoul virus is the predominant or only cause of hypertension in inner-city blacks," says Childs, "but it's an intriguing link that we certainly want to explore further." If the association holds up, he predicts city health departments will make the eradication of rats a top priority.

Or one would hope. So far the nation's response to the threat of dengue hemorrhagic fever does not inspire much confidence. A viral infection transmitted by insects, dengue has been around in a mild form for centuries in Asia, causing flulike symptoms and aching joints in adults. In the Fifties, however, the virus suddenly became much more virulent—especially in children. Young victims typically break out in a rash and begin bleeding from the nose and ears. Many of them then go into shock and die. More than 600,000 cases of this severe type of dengue were reported in Southeast Asia in 1987, compared with 2,060 in 1967—a 300-fold increase in 20 years.

As if that were not bad enough, one type of mosquito that transmits the disease has been entering America since the early Eighties aboard tires imported from Japan for retreading. The insect's eggs, explains entomologist Bruce Eldridge of the University of California at Davis, hatch in water that collects inside the tires when it rains. This highly successful invader is known as the Asian tiger mosquito and is now found in Texas, Missouri, and everywhere east of the Mississippi. So far it does not appear to be transmitting the deadly dengue virus—at least not within the continental USA. But there are plenty of mosquito carriers throughout the tropics—including Puerto Rico and Mexico, where the hemorrhagic fever attacked more than 30,000 people in 1986. "The disease is literally knocking at our back door," warns Eldridge.

The Asian tiger mosquito is an extremely aggressive biter, and it is difficult to eradicate. On the outskirts of almost every major metropolitan area are tire dumps that stretch for acres. Since pesticides can't penetrate to the inside of the tires, they are of little use in controlling the insect. The obvious solution is to conduct a massive cleanup—but

it is also a costly solution, and so it has been abandoned. "I'm deeply concerned about this," says Eldridge. "If we don't commit the resources today, it could harm us in the long run."

Despite abundant evidence that we live in times most favorable to microbes that prey on man, the invention of antibiotics and several vaccines since World War II has lulled many people into a false sense of security. As the Institute of Medicine recently documented, there is now a tremendous shortage of specialists in infectious disease control both in the United States and in developing countries. Owing to budgetary pressures, the National Institutes of Health was forced to close the last of its laboratories for tropical virology in 1973. More recently, an important tropical medicine laboratory in Hawaii shut down, and the U.S. military has scrapped a key surveillance unit for new diseases in Kuala Lumpur, Malaysia. As for the World Health Organization, it has only a handful of people manning its viral disease unit at its headquarters in Geneva and a single regional office for all of Africa. Warns Donald A. Henderson, dean of the Johns Hopkins University School of Hygiene and Public Health, "We are not well structured or staffed on a global level to detect and investigate new diseases."

Like many of his colleagues at the DC conference, Henderson pleaded for greater funding of infectious disease control programs, especially in tropical regions where microbes thrive. For $150 million a year, he estimates, a global consortium could finance 15 tropical medical centers and ten U.S. research facilities, with a remaining $25 million available for special projects.

Given the current budget crunch, however, scientists are skeptical that politicians will be persuaded to cough up even that modest sum. In all likelihood, the early warning detection system will be postponed—until another disaster on the scale of AIDS jolts us into action.

Although dengue is an obvious contender for the title of microbial menace number one, scientists are quick to point out that the threat could come from almost anywhere. Brazilian purpuric fever, for example, has so far accounted for only a few sporadic cases in small, rural towns. But as the CDC's Perkins observes, "If the disease gets to São Paulo, with its population of fourteen million, it could be catastrophic." Even with intensive antibiotic treatment, he reports, the bacterial infection claims the lives of half of its victims.

In this era of fiscal shortsightedness, it is well to recall that germs have far-flung reaches. As Nobel laureate Lederberg stresses, "The microbe that felled one child on a distant continent can reach yours today and seed a global pandemic tomorrow." ∞

COMMUNICATIONS

CONTINUED FROM PAGE 25

speaking countries, and your edition will certainly help to fill in the gap. That's why I'm sure *Omni* magazine will be extremely popular with the Soviet readers.

Wishing you a success on the Soviet market, I want to warn you of some difficulties that you may encounter. One of them is the correct use of the Russian language, which presents lots of traps for foreign learners.

Even those who think that they have mastered Russian to the full extent can find themselves in such a trap. And that's exactly what happened with you (or rather with your linguistic staff) on the very front page of the first issue, circulated in the Soviet Union in September 1989. Your cover persuades:

Выиграйте американские роскошные продукты на сто тысяч долларов.

This sounds alien to the Russian ear, because it contains three incorrect usages of modern Russian. Two of the mistakes can be regarded as not very bad, as they do not hinder understanding (only show that the text was made by a foreigner), but one is rather serious, because it affects sense. I mean the use of the word «продукты». Perhaps your translators were misled by the meaning of the English word *products,* but in Russian, «продукты» (plural of «продукт») has only one meaning, and that is "something one can eat": foodstuffs, food products. That is why the first natural reaction which the title page causes in the Soviet reader is: How on Earth can one eat up so many foodstuffs? The word you should have used instead of «продукты» is certainly «товары» (goods).

I'm not going to tire you with lengthy linguistic analysis because that's not what I'm aiming at. I can only offer you a better Russian variant, which won't sound alien to the Russian readers:

Вы можете выиграть роскошные американские товары на сто тысяч долларов.

While making these comments, I by no means intended to blame your linguistic staff for their inadequate knowledge of Russian. Being a linguist myself and having a special interest in the comparative study of English–Russian word combinations, I know perfectly well how difficult it is to create a flawless text in a foreign language. Please regard this letter as a friendly sign of appreciation of your and Kathy Keeton's attempts to make our life better and a sincere wish of success to *Omni* in the future in the Soviet Union.

It's always better to do things with a little help from one's friends, isn't it? And you've got them in the Soviet Union.

With best regards,
Tatiana Dobrosklonskaya
Doctor of Philology
Moscow State University
Moscow, USSR

For Good Measure

I was quite surprised to find an apparent lack of sense of speed and distance in "Adventure Capital" [February 1990]. You used the term *knots per hour* twice. A knot is a speed of nautical miles per hour. We are also informed that 100 meters is "less than a mile." While true, this is misleading, since 100 meters is less than one tenth of a mile. Someone needs to tighten ship.

John E. Runninger
Rome, NY

Forgive us, we knew knot what we did.
—The editors ∞

Soviet philologist Tatiana Dobrosklonskaya, with children Alexis and Kathy, reading Omni.