

With global travel, intrusion into uncharted habitats, and a growing demand for exotic foods, deadly animal viruses are making the jump into humans.

Somewhere in a remote rural province of China, a peasant trapper captures an exotic animal, unknown in the Western world, and sells it for meat at his local outdoor market. A week later an elderly, middle-class woman in Toronto, Canada, dies from pneumonia caused by an acute viral infection. Amazingly, the fates of these two distant strangers are inextricably linked—tied together by that innocuous woodland creature and the virus it carried.

Zoonotic diseases, those transmitted from animals to humans, are not new to the planet. The bubonic plague, rabies and HIV are now entrenched in the worldwide psyche. What is new, however, is the rapid onslaught of “emerging diseases” that scientists are identifying—West Nile virus, monkeypox, SARS—all of which have only recently appeared in the Western Hemisphere and whose origins may be traced to such animals as migratory birds, Gambian rats, civet cats and raccoon dogs.

Pathogen

A close-up photograph of a dead cormorant with its head pressed against the rusty metal bars of a cage. The bird's feathers are light brown and appear somewhat matted. Its long, dark beak is pointed downwards. In the background, other cages and animals, possibly dogs, are visible but out of focus, suggesting a crowded market environment. The lighting is somewhat dim, with some highlights on the bird's head and the cage bars.

Wild animal markets help foster the spread of viruses once confined to remote areas. Here, a dead cormorant awaits a buyer at a market in Guangzhou, capital city of southeast China's Guangdong Province.

Pollution

“The emergence of these diseases is absolutely an ecological issue,” says Dr. Peter Daszak, executive director of the Consortium for Conservation Medicine at Wildlife Trust, New York—a collaborative effort between scientists at Harvard, Johns Hopkins and Tufts universities and the U.S. Geological Survey’s National Wildlife Health Center. “Viruses are rapidly emerging in places where we haven’t seen them before. These viruses have been around a long time, but ecological changes have allowed them to make the jump into humans. By environmental changes I mean human population movement, trade, deforestation, and building roads into remote areas, all of which bring human traffic into the area and viral traffic out of the area. We call it ‘pathogen pollution.’”

Americans are familiar with the hazards caused by overt man-made environmental assaults: A corporation dumps toxic waste into a neighborhood landfill; a camper lights a match to dry underbrush and torches 100,000 acres of virgin timber; an aging oil tanker leaks gallons of slimy, black goop into a pristine bay. But pathogen pollution, which Daszak defines as “the introduction of new disease-causing agents into a ‘naïve’ population,” is far more subtle. Viruses, after all, are submicroscopic structures. All they really need for reproduction is a living cell to serve as a host.

As human populations increase, people are forced to find more places to live, are residing under more crowded conditions, and must search for more sources of food, which motivates hunters to trap and kill different kinds of animals for meat. “Population density is an issue we’ve never dealt with before, and we don’t really know what the implications are,” says Dr. Mark Denison, associate professor of pediatrics and microbiology and immunology at Vanderbilt. “An obvious effect as the population increases is our intrusion into ecological niches. Some of these viruses may exist in a single valley, in a single river, in a single upstream place, in a single species of animal. And they are perfectly adaptive in that small niche.” When those viruses break out of that niche into a wider population, however, scientists face a whole new—and frightening—paradigm.

For years Denison had been working away



A beggar and her child wear surgical masks to protect them from the SARS virus at a foot bridge in Hong Kong.

AP/WIDE WORLD PHOTOS

in his lab, receiving little fanfare as he studied mouse hepatitis virus, which is a model for the study of coronavirus growth and diseases. Then in 2003 the coronavirus took on momentous significance when SARS (severe acute respiratory syndrome) emerged and rapidly spread around the globe, causing severe, often fatal, respiratory distress. SARS ultimately spread to 30 different countries, infecting nearly 8,000 people and killing more than 900.

Since the 1960s and early '70s, Denison says, coronaviruses have been known to exist in cats, dogs, turkeys, cattle, pigs, chickens, mice and rats. While the original animal host for SARS remains unknown, scientists do

know that last year’s outbreak began in China’s Guangdong Province, where it is common practice for trappers to sell live forest animals to local meat merchants and exotic pet traders. There the sellers often stack cages of exotic animals one on top of the other or put them together in cages. In the wild, these animals normally would never cross habitats or come in close contact with each other.

Searching for the source of the outbreak, scientists discovered the SARS virus in civet cats, raccoon dogs and ferret badgers, and in the people who had handled them. “These animals may just be an intermediate vector for SARS,” says Denison. “Or they were just bystanders that happened to be in cage num-

ber three from the top, and whatever was at the top was dropping the virus all over everything below.”

In any case, once the virus began to spread into humans, the result was calamitous. In a normal pandemic, or worldwide spread of disease, the number of cases typically increases exponentially—two to four, four to eight, 100 to 10,000, etc. With SARS, however, because it is spread by coughing and fecal-oral transmission, and because it requires intimate contact or close proximity to the infected person, five patients were responsible for exposing hundreds of others to the disease, including health-care workers caring for them. SARS also has an incubation period of seven to 14 days. Some of the SARS carriers hopped on planes and traveled to other countries, spreading the disease to Hong Kong, Canada, Taiwan and Singapore, before the World Health Organization (WHO) stepped in and imposed quarantines and other barriers to its spread.

“Because public-health intervention measures were put into place, instead of seeing 100 cases going to 10,000, you saw 100 cases going to 140 to 165 to 170 to 190 and then stalling,” Denison says. “What happened with SARS is unprecedented in public-health medicine. It’s a virus with an incredibly high degree of potential for worldwide spread, and it had the most organized global health response ever. Likely, these efforts avoided a pandemic.”

The aggressive surveillance and intervention coordinated by WHO was difficult for Chinese governmental officials to accept and they were not initially cooperative, says Dr. William Schaffner, chairman of the Department of Preventive Medicine at Vanderbilt and an expert in international public health response. He explains that within the Chinese culture, it is inappropriate to speak to outsiders about such matters as improper food handling, unsanitary living condi-

tions and inadequate health practices, which catalyzed SARS’ rapid transmission in that country. Only by overriding those cultural concerns was WHO able to throw up barricades—quarantining anyone exposed to SARS, ceasing air travel into and out of infected areas, and handing out face masks to protect against airborne viral particles—that stopped the pandemic in its tracks.

“We must contrast the international response to SARS with what happened when AIDS came on the scene in the 1980s,” says Schaffner. “The world has changed a lot since then. We’re still dealing with the difficulty of addressing AIDS, which involves sexuality—a public health issue that is fraught with difficulty. In the U.S. we’re still not responding optimally to AIDS. We live in a country where it’s difficult to speak openly about sexuality in a public health context, especially if the sexuality is outside standard moral strictures, such as with homosexuality.”

Because AIDS now has such a firm foothold in both industrial and developing nations, researchers can use it as a benchmark for studying the consequence of humans imposing themselves upon fragile ecosystems and the movement of zoonotic viruses around the globe. The ancestry of HIV, the virus that causes AIDS, can be traced to cross-species transmission in west central Africa. According to the journal *Science*, carnivorous chimpanzees preyed on monkeys infected with SIV (simian immunodeficiency virus). Over time the virus recombined in the chimps and evolved into HIV (human immunodeficiency virus), which doesn’t make chimpanzees sick. African hunters captured and butchered the infected chimpanzees for bush meat, and through blood-to-blood contact the deadly HIV virus was inserted into the human population.

Although the HIV virus is thought to have moved from nonhuman primates into humans around the beginning of the 20th century, it

remained relatively obscure and localized in remote regions of the jungle until African nations started to become urbanized. “The epidemic really came to light because of plane travel,” says Dr. Richard D’Aquila, Vanderbilt’s director of infectious diseases and director of the Vanderbilt/Meharry Center for AIDS Research. “One of the first cases of outbreak of the disease in North America has been traced to an airline steward.”

Unlike SARS, HIV is very difficult to transmit, requiring blood-to-blood contact or contact with genital fluids. Unfortunately, HIV is what Richard Preston terms a “hypermutable,” surreptitiously changing its character as it passes through various populations. D’Aquila concedes that HIV is extremely adaptable. “It adapts to the environment within an individual and also to the environment within a whole population,” he says. “That environment includes several threats and pressures to HIV—the immune system, which tries to recognize and contain it, and the drugs we use to combat it. It randomly makes mutations, and from this pool of mutations those that are most fit to grow in a particular environment become dominant. So the minute there’s something new, like a new drug, there will be an advantage for the rare mutant with resistance to the drug.”

HIV uses other strategies for self-preservation, as well. It is most virulent and most easily transmitted in the first few weeks after infection—usually long before the carrier has any symptoms. In fact, says D’Aquila, the symptoms of HIV are related to whatever opportunistic infection or malignancy patients have acquired as the virus weakens their immune systems—which can take up to 10 years or more.

“The most common way people get diagnosed is coincidentally,” he says. They have a routine physical or see a doctor for some other problem and discover they’re HIV-positive,

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even though they may be asymptomatic. “The reason HIV is spread is because it’s flying under the radar. You can’t detect it unless there is enough suspicion to look for it.”

The virus thrives in its human host for years, escaping through blood and genital secretions, becoming more resilient against each new blitzkrieg. For years a diagnosis of HIV meant certain death. But in the 1990s, researchers discovered that some drugs that had been developed for the war on cancer were actually more effective against retroviruses, and in combination against HIV in particular. Suddenly, HIV patients were living longer and had a better quality of life.

With these new drugs, HIV is now being contained in people seeking treatment in developed countries. However, these medical advances have also led to cavalier attitudes about the disease. The reigning generation of sexually active young adults doesn’t remem-

ber the scourge of AIDS in the 1980s and often doesn’t feel inclined to take precautions. Public health officials are reporting a rise in sexually transmitted diseases, which suggests people are not using condoms as conscientiously as they once were. Alarming, the virus seems to be developing resistance to the new armament of drugs.

D’Aquila says, “Across the Western world, [in patients] where HIV-fighting drugs have been used for the first time, roughly 10 percent of people who’ve never been treated will have a drug-resistant virus. And although we can’t prove this in every case, that means they were infected with a drug-resistant strain. So HIV is adapting. Obviously, if this continues, patients who are infected in the future might not derive benefit from any of the current drugs.”

Complacency is a demon that public health officials battle every day. West Nile virus, caused by bites from mosquitoes that feed on infected migratory birds, was first reported two years ago in New York City. Once the virus subsided there, people in other parts of the country ignored warnings to lather up with

to see the spread of this infection.”

Although everyone who is infected doesn’t become sick, West Nile can lead to a fatal encephalitis or meningitis, usually among the elderly. Last year more than 4,000 people became infected and nearly 300 died. According to the Centers for Disease Control and Prevention (CDC), the virus has also infected horses, cats, bats, chipmunks, skunks, squirrels and domestic rabbits.

Human carelessness is also the reason monkeypox jumped from African mammals to native American mammals to American citizens in 2003. A less dangerous cousin of the smallpox virus, monkeypox appeared in the West when a giant Gambian rat was housed with prairie dogs in a pet shop. The Gambian rat infected the prairie dogs, which were later sold in 15 states. The outbreak was stymied when the CDC blocked exotic pet traders from bringing Gambian rats into the United States.

Ebola is one of the most terrifying of all viral afflictions, and scientists still haven’t identified the animal that serves as its intermediary reservoir before it passes into humans. On the other hand, says Denison, Ebola is more easily contained than some epidemics because the symptoms are so severe—patients bleed from the eyes, ears, nose and mouth. That makes the outbreak easily recognizable, and infected areas can be quarantined as the virus quickly “burns through” the affected population.

Aside from the sheer morbidity, the cost of these zoonotic diseases has been astronomical. In the two decades since the discovery of AIDS, more than 42 million people have become infected with HIV and 28 million have died, devastating entire cultural populations, particularly in Africa.

In many cases the spread of these microbes originates in food sources. Mad-cow disease, which causes severe

wasting of the brain in people who have eaten infected beef, originated when ranchers fed slaughterhouse waste products to cattle. Eighty people died from the illness and hundreds of thousands to millions of cattle were disposed



Aminata Niang, a mother of 10, slips a condom over a soda bottle in front of a room of Muslim women on the outskirts of Dakar, Senegal. This gathering in an impoverished neighborhood is part of a far-reaching campaign that has helped Senegal avoid the worst of the AIDS epidemic gripping Africa.

AP/WIDE WORLD PHOTOS

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“Those of us in public health knew West Nile virus wouldn’t be a one-shot deal,” Schaffner recalls. “It was now in the bird and mosquito populations, and we knew we were going

of, at a multibillion-dollar cost. Likewise, in order to contain the 1997 outbreak of the Hong Kong “chicken” flu, which killed six people, more than a million chickens, ducks and other edible fowl were slaughtered. To prevent the 1999 spread of Nipah virus, transmitted by fruit bats into swine, more than a million pigs were destroyed in Malaysia. The travel ban imposed after the SARS pandemic cost billions of dollars to Canada and numerous Asian countries. In fact, *USA Today* has reported that infectious diseases have cost world economies more than \$100 billion since 1990. SARS alone may have cost world economies more than \$80 billion.

“There have been many cases in the past where some change in food-production practices has allowed pathogens to emerge,” says Daszak of the Consortium for Conservation Medicine. “Chronic wasting disease involves a microbe similar to the one that causes mad-cow disease and is moving rapidly across the United States in wild deer populations. We think captive and ranched deer in the West are involved in the process. So don’t think we’re immune here in the States. We have some unusual food production habits, too. And as we intrude more and more into unknown ecosystems, we’re going to see more and more of these diseases emerge.”

Acknowledging the devastation caused by these furtive submicroscopic agents, the National Institutes of Health have established a new consortium to study microbes that could be used in a bioterrorist attack. Vanderbilt University Medical Center has been selected as one of the participating institutions, and Denison will serve as a co-principal investigator and member of a steering committee. The consortium will investigate known transmissible threats such as anthrax and smallpox, as well as potential and emerging diseases.

Schaffner, who is also serving on various governmental committees, says, “The specter of bioterrorism has lent a new sense of urgency and anxiety to those of us in preventive medicine. It has illustrated to us that we in the United States have permitted much of our public-health infrastructure to erode over the years. We’re now trying to rebuild that, and it’s coming along—in fits and starts.”

Vanderbilt Hospital has a large rotating

supply of drugs to combat anthrax so that, if necessary, starter doses could be administered to a large number of people exposed to the disease. Schaffner says a major concern is designing a method of response that addresses any given problem without inundating the delivery system. “We have a project with the CDC that prepares us to enhance the health-care system but not overwhelm it. We need to be able to respond to the earliest alert, but not be so burdened with background noise that our response becomes ineffectual.”

Prevention has become the resounding theme, whether the threat is a bioterrorist or a naturally occurring one. Denison is part of a group of researchers developing various types of SARS vaccines. Although there is no evidence at the moment of live, ongoing SARS, he believes a vaccine might be vital for containing future outbreaks. “We don’t know if the virus is being maintained in human populations at a lower level and if the coming of other pathogens, such as influenza, will create an environment that will favor its reemergence as a more severe disease. You can’t really make the determination that a virus is gone from the human population for at least five years, and more like 10 to 20 years,” he says. “If it reemerges as a pandemic or as an endemic or epidemic disease with high mortality and high morbidity, then we’ll need to move quickly.”

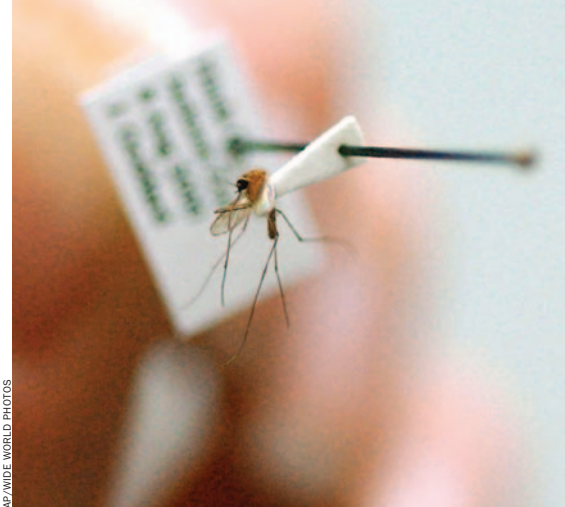
Experts predict the next big peril will likely come from some form of influenza. Influenza genes can easily cross species, mixing with genes of other animal influenza viruses, mutating to create new and deadly ones. In 1918 and 1919, the “Spanish Flu” pandemic killed more than 20 million people worldwide and was, according to *Science*, triggered by the union of genetic sequences of pig and human viruses.

The Consortium for Conservation Medicine is one of several organizations charged with predicting the next emerging viruses and assessing the risks as countries delve deeper into uncharted lands, building roads and setting up business operations in previously untouched habitats.

“Predictive science is not very interesting to funders and policymakers,” admits Daszak. “But we have to think seriously about trade

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The Culex mosquito species is identified as a primary carrier of the West Nile virus in the southern United States.



Some human viral diseases and their animal hosts:

DISEASE	ANIMAL HOST
SARS	Unknown, but found in civet cats, raccoon dogs and ferret badgers
Ebola	Unknown
HIV/AIDS	Monkeys to chimps
West Nile Virus	Migratory birds to mosquitoes
Nipah Virus	Fruit bats to pigs
Monkeypox	Gambian rats to prairie dogs
Hendra Virus	Fruit bats to horses
Hantavirus	Deer mice
Spanish Flu	Pigs
Hong Kong Avian Flu	Chickens, ducks, other edible fowl
Bubonic Plague	Rats
Lassa Fever	Wild rodents

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Without consultation, or much thought, I filled in the blank for career goal as “law.” Shortly thereafter, I received another letter from my draft board, indicating that “law” did not meet the requirements for deferment and that I should prepare myself for induction in the next several weeks.

That letter got my attention. At that time I was moving toward a major in psychology and was very much interested in the therapeutic relationship in clinical psychology. The same would surely be present in medicine. I wrote another letter explaining that I had carefully and seriously reconsidered my earlier decision and had now decided on medicine as my future career. With almost the speed of sound, a third letter arrived from my draft board, ordering me to appear before the full board two days hence.

I took the train home from Nashville to Birmingham, spending the night before the confrontation in my own bed. The next morning my father, J. Wayne Drash, minister of the First Christian Church in downtown Birmingham, dropped me off at the draft board and went on to his office. I don’t remember which of us decided that I should face this ordeal alone.

After 52 years my memories of that morning are understandably somewhat cloudy. I was ushered into a room with the appearance of a small court room. At the front sat eight to 10 draft-board members, all male of course. I was directed to a seat in the “dock.” To my surprise, there were people in the audience, 15 to 25 in number. Who were they, and what were they doing there?

The questioning got under way, and each of the board members took a shot at me, all

suggesting that I was attempting to avoid the draft, which was a criminal offense. Just as I was about to conclude that my next stop would be Korea, a wizened little old man rose in the back of the room and began to speak. Basically, he pointed out that our constitution did not interfere in any way with its citizens changing their mind on any issue. He pointed out that I had changed my mind, something I was perfectly entitled to do. I had chosen to pursue a career in medicine. The draft law was perfectly clear. I could not be drafted until my medical training was complete.

There was a long hushed silence, broken by the chairman who thanked the speaker and agreed that his comments were correct. The meeting was adjourned and that was that—or was it?

Who was the man who stood in my defense? I recognized him immediately. He was Mr. Jim Robins—“Mr. Qinq.” He was a Nashvillian and famous on the Vanderbilt campus. He was a frequent observer at our football practices. I think many of the students knew about him and his contributions to Vanderbilt through campus publications, but I had never met him and had not spoken to him either before or after the Birmingham episode. As I do not recall sharing my draft-board problems with anyone at the time it was happening, I am at a complete loss to explain Mr. Jim’s presence or actions. For me, he has simply been my special angel. I had not discussed this extraordinary event with anyone until plans for returning to Vanderbilt for the 50th Reunion stimulated many long-buried memories.

My last two years at Vanderbilt were exceedingly busy and demanding. I had to make up for the pre-med requirements I had missed

in the first two years, along with completing the heavy science requirements of the last two years. I managed to make Phi Beta Kappa and came in as runner-up for the Rhodes Scholarship from the Southeast region.

I went to the University of Virginia School of Medicine where my interests in children, endocrinology and research began to grow. I was exceedingly fortunate to obtain an internship and residency in pediatrics at the Johns Hopkins Hospital—an indescribably challenging and enhancing experience.

It was at the end of this period in July 1960 that my draft requirement came due. I entered the U.S. Air Force as a captain and was sent directly to Hill Air Force Base, Utah, where I spent the next two years as the base pediatrician. They were so desperate for help that my orders bypassed the usual two-week military orientation for young doctors. I never did learn to salute.

Am I absolutely sure that it was Mr. Jim who came to my rescue in the Birmingham draft-board office 52 years ago? I reluctantly admit that I could have been mistaken. But I am completely sure that my recent Qinq ordination, albeit “in absentia,” has conferred upon me *angel status*. My marching orders are to continue to identify young physicians in training who need support, training, encouragement and direction to reach their goal as caregivers for the next generation.▼

Dr. Allan Drash is a former professor of pediatrics and epidemiology at the University of Pittsburgh, as well as former director of research for the Division of Pediatric Endocrinology, Metabolism, and Diabetes Mellitus at the Children’s Hospital of Pittsburgh. In 1997 he retired to Morehead City, N.C.

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issues and how these animals and animal products are moving around the globe. We need to build relationships between the environmental lobbies and the food-production lobbies. Our focus is pathogen pollution. Our goal is not to block trade, but to work with people doing these trades and make it more economical for them and, at the same time, more healthy for the environment and for the resident population.”

If the transmission of SARS and HIV and other zoonotic diseases has taught us anything, it is that we humans can no longer remain casual observers of the world around us, oblivious to the tenuous symbiosis between the Earth’s plants and animals. Instead we must accept that we are, for better or worse, intimate partners in the life-pulse of the global environment, vulnerable to the tiniest mutations and rebellions that can arise in obscure, seemingly harmless pathogens when others

intrude upon their territory. ▼

Lisa A. DuBois has been a freelance writer since 1985, and over the course of her career has penned stories for newspapers, magazines, radio and video. She has worked as a regular contributor to the now-defunct Nashville Banner daily newspaper, the weekly Nashville Scene and, most recently, the daily Tennessean, among other publications. A native of Greenville, S.C., Lisa resides in Nashville with her husband, Ray, who is on the faculty at Vanderbilt Medical Center.