

A Virus from the Nile

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It probably happened in August. Beyond that, no one can say when the tiny brown wisp settled upon Enrico Gabrielli's body. The sixty-year-old cherished summer evenings among the red geraniums and purple cosmos in his garden, in the Italian neighborhood of Whitestone in Queens, New York—and never more so than in the summer of 1999. In July the temperature broke ninety-five degrees for eleven straight days—the hottest month ever recorded in the city.

On Wednesday, August 11, the gray-haired Gabrielli returned from his job at a mannequin factory in Elizabeth, New Jersey, and complained of fever and chills. His wife, Caterina, suspecting the flu, handed him two aspirin tablets and sent him to bed. He shivered and sweated throughout the night.

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By the time Gabrielli was admitted to the intensive care unit of Flushing Hospital Medical Center the next day, he was feverish, disoriented, and unable to move. His strength rapidly faded. He began having trouble breathing and was put on a ventilator. A few days later, as he lay beneath dozens of get-well cards taped above the bed, Gabrielli opened his eyes and spoke. His 104-degree fever had broken. He had lost more than twenty pounds, which made his once-full face gaunt. Over the next few weeks he grew stronger, though he still could not walk on his own and relied on a catheter to urinate. Although he now walked with a cane, the life-threatening phase of his mysterious illness had passed, and Enrico Gabrielli, the first known victim of West Nile virus in the Western Hemisphere, had lived to tell about it.

On August 15, four days after Gabrielli began experiencing symptoms, an eighty-year-old man who lived a few blocks from the Gabriellis fell ill. Most evenings that summer, he and his eighty-two-year-old wife had sat outside their home, talking to each other and to passing neighbors. The annoying whine of jets passing overhead from nearby John F. Kennedy International Airport and LaGuardia Airport was a part of life. So was the sweet maritime scent of brine from the nearby marshes. Gray herons, egrets, gulls, and other shorebirds frequently passed over the neighborhood, making the skies above Queens a living diorama on the history of flight, ranging from the ultra-sophisticated structure of herons to crudely shaped modern aircraft. Aside from a manageable heart condition, the former World War II sergeant had been

active and healthy. His wife believes that the mosquito bit him one August evening as he relaxed outside in his armchair.

Many houses in the neighborhood lacked air-conditioning. Evenings outside, always a favorite summer pastime in northern Queens, were a necessity that year. April, May, and June had been the driest stretch in more than a hundred years. Newspapers carried headlines about the drought and the heat, which killed more than a hundred people from the Midwest to the East Coast.

“Is something new and different going on with the weather?” asked science writer William K. Stevens in the *New York Times*. The article said that the heat wave was part of a fifty-year trend toward hotter summers in the region and that heat waves and droughts could become more frequent. Meteorologists attributed the drought to the naturally shifting warm-cold cycle of surface temperatures in the Pacific Ocean linked to El Niño and La Niña years, while climate scientists suspected that the increasing severity of shifts in the recent past has been caused by global warming.

The drought made misery for humans, but it benefited one of the most common biting insects in Queens. The northern house mosquito, *Culex pipiens*, often thrives during droughts. After getting a blood meal, a female mosquito deposits eggs in wastewater, which is laced with organic nutrients. Because of the drought, the city sewers had not been flushed by rain in months, creating the organically rich standing water the egg-laden females preferred. When the

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mosquito eggs hatched, the dry heat aboveground tended to confine the emerging insects to the humid sewers. On August 5, the first rain in weeks fell on Queens, helping to liberate the blood-seeking wisps from their subterranean lairs. At dusk they fanned across the borough.

Although they naturally prefer birds, the mosquitoes bite humans and other mammals as well. There are actually two beneficiaries of their blood meals: the mosquitoes themselves and any viruses they might harbor—West Nile virus in this case. The virus needs a living being—a host—within which to replicate. Each time the mosquito bites a bird, the virus within the mosquito has an opportunity to move into a new host. Without such living incubation chambers, or reservoirs—and a means of traveling to new ones—a virus would quickly die out because its life within any particular animal may be brief. By using a mosquito as a vector, the virus can quickly spread and become established in millions of birds through a process appropriately known as amplification. It is a diabolically effective system. Mosquitoes also pass the virus to people, where it can replicate in the brain. That was the case with Gabrielli and his elderly neighbor.

On Saturday, August 12, a week after the half-inch downpour, the elderly neighbor came in from mowing the front lawn and complained of extreme fatigue. “It was the first time he’d ever complained,” his wife said. He wouldn’t eat. He vomited and went to bed. The next morning, his wife expected him to be up as usual by four or five o’clock, banging around the kitchen and making coffee. Instead, he could

barely open his eyes. When he slid his arm over her waist, she noticed that his hand was hot. “Somehow he couldn’t move right,” she remarked. She canceled plans to visit their daughter, who instead came to Queens that afternoon. When she arrived, she saw that her usually neatly dressed father had tucked in only half his shirt. He was laboring to speak in single syllables, and later in the day he collapsed in a chair. An ambulance drove him to Flushing Hospital, where doctors were able to revive him. He was admitted to the intensive care unit, only a few beds from where Enrico Gabrielli lay, but his liver and kidneys began to fail and he suffered a heart attack. Soon thereafter, he died. The former soldier was buried on Long Island—the second known victim and the first fatality of the mysterious disease.

By August 23, three more patients with neurological symptoms had been admitted to Flushing Hospital. Deborah S. Asnis, a staff physician and infectious disease specialist, telephoned the New York City Department of Health and Mental Hygiene to report the unusual cluster of illnesses. After discovering that nearby hospitals had admitted another five patients with similar symptoms, the health department contacted the Centers for Disease Control and Prevention. The next day, an official from the CDC’s Epidemic Intelligence Service flew to Queens to interview surviving patients, comb medical records, and visit the homes of the afflicted in an attempt to identify the disease and determine how it spread.

By early September the CDC had come up with the supposed answer. The mayor of New York City held a news

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conference in Queens to announce that a disease known as St. Louis encephalitis, caused by a mosquito-borne virus, was responsible for the human deaths. St. Louis encephalitis, named for the city where, in 1933, it was first identified, had never before been seen in New York City. This was a public health emergency, and Mayor Rudolph Giuliani promised to “do everything we can to wipe out the mosquito population.”

New York City’s Office of Emergency Management set up a command post at 138th Street and 11th Avenue, near the Gabriellis’ house. The city mobilized eleven spray trucks, five helicopters, and an airplane to douse the city with pesticides. Police officers cruised neighborhoods, warning residents over loudspeakers to remain inside with their windows closed. An advertising campaign called “Mosquito-Proof New York City” was launched.

New York City had last seen a mosquito-borne disease during a yellow fever outbreak in the early 1800s. Most modern New Yorkers could not grasp the idea of a common mosquito injecting people with a potentially fatal virus. A resident of a neighborhood adjacent to Whitestone also worried about the mental health of her children, who had developed a paralyzing phobia of flying insects. “If they see a fly,” she said, “they think that they are going to die.”

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Months before the first human death, hundreds of crows had begun dying in Queens. Some had been found within

blocks of Flushing Hospital. One woman found a disoriented crow hobbling in her garden. At Bayside Animal Clinic, veterinarian John Charos treated more than fifty ill crows. Half of them ultimately died. A security guard at Fort Totten, a 163-acre government property in Queens, found dead crows all over the base and likened it to “a plague.” Crows and other birds were also dying in the Bronx, across the bay from Queens. Near 198th Street and Briggs Avenue, a passerby happened upon four dead pigeons. Forty dead crows were found near the Bronx Zoo, where a captive cormorant, three Chilean flamingos, a pheasant, and a bald eagle also died.

Many people blamed the rash of bird deaths on the drought. Ward Stone, pathologist at the New York State Department of Health in Albany, said it was the worst die-off of crows in thirty years. According to the drought theory, the heat had driven earthworms, insects, and other sources of food deeper into the ground. As the crows dug, they encountered persistent toxins, such as DDT, that had contaminated the soil a half-century earlier, when the pesticide was commonly used.

Tracey McNamara, a veterinarian and head pathologist at the Bronx Zoo, questioned the drought theory. Crows were hardy, adaptable, and resourceful birds, she thought; why would a drought affect them more than other birds? Furthermore, a drought would not have directly affected captive zoo birds, which had all the food and water they needed. The CDC’s diagnosis of St. Louis encephalitis didn’t explain

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the birds' deaths, either, she realized, because birds generally aren't susceptible to St. Louis encephalitis.

McNamara's hunch was that a different—perhaps new—virus was responsible, even though viruses that killed both birds and people were few and far between in North America. One candidate, at least in theory, would be eastern equine encephalitis, or Triple E. This disease, which also attacks the brain, can kill not only birds and people but also horses and individuals of other species. The Triple E virus was known to be especially lethal to emus, ostrich-like birds from Australia. Yet the Bronx Zoo had a number of emus, and they remained healthy even as the other birds died during the mysterious outbreak. This fact alone all but ruled out Triple E as the culprit.

Another observation that weighed in favor of a new virus, McNamara believed, was that all the birds stricken by the disease at the Bronx Zoo were native to the Western Hemisphere. Did this mean that the virus had moved here from another part of the world and was killing only birds whose immune systems were unprepared for this exotic invader?

On September 9, two more flamingos died at the zoo. While taking blood from one of them, McNamara's colleague accidentally stuck herself with a contaminated needle. If the bird and human deaths were related, McNamara realized, the technician's life could be in danger. That day she called the CDC to ask about her colleague's exposure and to suggest that the human deaths and the bird die-offs were related. In doing so, she was discounting St. Louis encephalitis as the cause and thus

challenging the CDC's diagnosis. The latter is not something a veterinarian—or anyone else, for that matter—usually does.

3.

Every autumn, clouds of white storks move over Israel as they migrate from breeding grounds in Europe to wintering grounds in Africa. A more direct flight to Africa would carry them across the Mediterranean Sea, but these heavy birds rely on thermals—currents of air that rise from warming land—to keep them aloft and carry them on their journey, forcing them to avoid large bodies of water, even at the expense of a longer migration route. The summer of 1998—a year before the virus struck in the United States—was the hottest in thirty-five years in Israel. Temperatures along the migration route regularly reached 100 degrees Fahrenheit and occasionally soared to 116 degrees. Winds gusted to thirty miles per hour. Unable to navigate the winds or endure the extreme heat, tens of thousands of the stressed birds that had hatched in Europe landed in Israel.

One flock of 1,200 birds set down at Eilat, in Israel's southern tip, near the Red Sea. Farmers in the region soon began finding dead storks in their fields. Not long afterward, hundreds of domestic geese in villages around the country mysteriously succumbed to an unknown disease. Many of them had neurological abnormalities: they could not stand or keep their balance. Israel's government tested a number of wild storks and the geese, and the brain of a dead goose yielded West Nile virus. Common throughout Africa

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and, more recently, in Europe, the virus had visited Israel in the 1950s and the late 1970s—but not again until the summer of 1998. The young European storks may have re-introduced the virus into Israel, where it then infected domesticated geese. Perhaps under normal conditions, even infected storks would have remained healthy—some birds carry the virus without ill effect—but under the stress of a difficult migration, the storks fell ill. But not, apparently, before spreading the virus to mosquitoes in the area where they landed. The mosquitoes then could have easily infected the goose farms. This drama in Israel was unfolding seven thousand miles away from Queens, and a year before either a person or a bird there would fall ill from the disease.

4.

On September 9, 1999, when McNamara telephoned the CDC's Division of Vector-Borne Infectious Diseases in Fort Collins, Colorado, to express concern about her colleague's accident, her call was transferred to the chief of the Epidemiology and Ecology Section. McNamara asked whether the CDC would test blood samples she had taken from her colleague and the dead birds to see whether the same virus could be isolated from both. It was inappropriate, the official explained, for an institution concerned with human health to test birds' blood; indeed, since the viruses in birds and in people were different, the CDC thought it superfluous even to test the human blood sample. At a loss for what else to do, McNamara sent both samples to the National Veterinary

Services Laboratories (NVSL) in Ames, Iowa. Several days later, an official at the NVSL called McNamara to say that an unusual virus had been isolated from both samples. The lab could not determine exactly what the virus was, beyond the fact that it was a member of the dangerous *Flavivirus* genus. Yet flaviviruses had never been associated with bird fatalities in the United States. Had a new one arrived or an old one mutated?

Definitive identification of the dangerous virus would require a secure laboratory to prevent human infection. Only a handful of such facilities existed in the United States. One of these was housed at the US Army Medical Research Institute of Infectious Diseases (USAMRIID), at Fort Detrick, Maryland, the military's main biological warfare laboratory. McNamara happened to have a friend who worked there, and that person agreed to test the samples. A researcher at the New York State Department of Health's laboratory in Albany also agreed to run further tests on the samples forwarded by the NVSL.

Meanwhile, McNamara telephoned John T. Roehrig, chief of the CDC's Arbovirus Diseases Branch, and told him that the NVSL had isolated something that looked very much like a flavivirus. She also pressed her concern that the bird and human deaths were linked—implying that the virus was indeed something new in this part of the world. Confirmation that a flavivirus was killing birds in the United States would be a historic and ominous finding. The CDC's response was still the same: the agency

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insisted that the human and avian deaths were not related and thus there was no logical reason for them to test bird samples. McNamara would have to await the findings from her friend at USAMRIID.

On September 23, the telephone rang in McNamara's Bronx Zoo laboratory. Several senior scientists from the CDC were on the line. Roehrig asked McNamara to ship frozen samples directly to the CDC that night. He said there had been some confusion with the samples the NVSL had sent them earlier. The callers said little else. To McNamara, this spoke volumes.

"Is it okay to be working with the virus here?" she asked in alarm.

Because she wore a mask and gloves and worked under a special ventilated hood, it was probably okay, she was told.

When the conference call ended, McNamara quickly telephoned several friends in the know and learned that the Fort Detrick lab had definitively ruled out three possible candidates for the outbreak: eastern equine encephalitis, western equine encephalitis, and Venezuelan equine encephalitis. The tests further suggested that St. Louis encephalitis, the CDC's original diagnosis, wasn't the cause either. USAMRIID had reported its findings immediately to the CDC and had continued searching for the identity of the mystery virus. Meanwhile, officials at the CDC, finally beginning to grow alarmed, agreed to test the samples McNamara shipped them.

On September 30, 1999, the CDC issued a press release

announcing it had now “made the link between the West Nile–like virus found in birds in New York City and the ongoing human encephalitis outbreak in the area,” thus confirming McNamara’s hypothesis. Geneticists immediately began comparing the New York strain with strains from Africa, Europe, and elsewhere to determine where the New York strain had originated. They soon found that it matched a sample isolated from the brain of the dead goose in Israel, a strain common throughout the Middle East.

West Nile virus was first discovered in the 1930s, when it was isolated from a woman living on the west side of the Nile River in Uganda. Since that time, birds migrating from Africa had spread the virus along their migration routes throughout much of the Middle East and Europe. But there were no bird migration routes from those countries to the East Coast of the United States. How, then, had the virus traveled thousands of miles from the Middle East to the borough of Queens?

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The thousands of Queens residents sitting on their porch stoops and patios the summer of 1999 had no particular reason to realize they lived near one of the greatest crossroads—for both people and birds—the world had ever known. Each month, some 11,000 overseas flights to Kennedy International Airport bring more than 2 million people through Queens. More than 20 million overseas passengers disembark there annually. That does not include the almost

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4,000 horses and thousands of exotic birds, turtles, and fish and other animals that legally pass through JFK every year. Hundreds more animals—perhaps thousands—evade the quarantines and inspections set up to keep out imported diseases. And no one attempts to account for the numerous small six-legged, winged, or tiny crawling stowaways from the aircraft's cabins and pressurized holds and from the bodies of the passengers. If Queens is a cultural melting pot, it is also one gigantic petri dish. In its own way, Queens rivals some of the world's other great interspecies crossroads, such as Guangdong Province in southern China, the epicenter of the SARS outbreak.

Kennedy International Airport also lies along the Atlantic Flyway, a major migration route for birds flying between the Americas. In fact, runway 22L juts into the 10,000-acre Jamaica Bay Wildlife Refuge, which is visited every year by millions of birds from Mexico, South America, the Caribbean region, and the far north. Many people forget about the vast network of rivers, wetlands, and shorelines that surrounds New York City. The birds have not.

In spring and early summer, the songs of warblers, vireos, swamp sparrows, goldfinches, and eastern bluebirds arise from the trees and forest patches, and snowy egrets, black-crowned night herons, sandpipers, belted kingfishers, and great blue herons fill the wetlands. The occasional great cormorant, green-winged teal, and red-breasted merganser wander through. In the winter of 1998, a rare sighting of a European widgeon, perhaps from a far-flung Iceland flock,

was made in Queens. Escaped parrots and other tropical birds are also occasionally documented in the borough.

Birds and people are not the only species passing through the region. Monarch butterflies migrate through New York City in autumn, feeding on life-giving milkweed in wayward urban lots and along roadsides. The monarchs are destined for New Jersey's Cape May, where they congregate by the thousands before continuing their patient journeys, on breezes or one wing-stroke at a time, to Mexico.

6.

In late August 1999, when Tropical Storm Floyd dumped nearly five inches of rain on New York City, the historic drought of that year became a memory. By mid-September, when the year's final case of West Nile fever was diagnosed, seven of the fifty-nine people hospitalized with the virus in New York City had died. Enrico Gabrielli, home from rehabilitation for several weeks, walked with a cane.

But a large part of the West Nile virus mystery remained. How had it arrived in the New York region in the first place? Perhaps a person bitten by an infected mosquito in the Middle East had carried the virus to Queens, only to be bitten by another mosquito in New York. Perhaps that mosquito then fled across the parking lot outside the international arrivals terminal and disappeared into the refuge at Jamaica Bay, where it spread the virus to other birds and mosquitoes, many of which could have ended up in the neighborhoods of Whitestone and Flushing. Perhaps an infected mosquito ar-

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rived in an aircraft cabin or cargo hold. Or maybe one of the numerous parrots, parakeets, or lovebirds smuggled through New York each year was infected. It is conceivable that, by some strange anomaly of normal migration, a bird infected with the virus in Europe or in Africa passed the infection to a bird that migrated to Queens. Given the right conditions, a single infected bird could pass the virus to a mosquito. The insect, in turn, could quickly infect other birds, igniting a rapid outbreak of the virus in both birds and people.

As autumn arrived, many birds left the New York region for their wintering grounds. A world away, a new skyful of white storks rode thermals above the hot sands of the Middle East and Israel toward Africa, as they have done since before the time of Abraham. The last wave of monarchs, propelled by the laggard storm winds, departed New York City and environs for forests in Mexico three thousand miles away.

Migrating monarchs, white storks en route to Africa, cooling waters off Peru, winds across Arabia, an empty lawn chair in Queens, and a fresh grave on Long Island. A black-crowned night heron lifted from the waters off Whitestone, circled as if on a designated flight path, and disappeared into the night.

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Many of the birds that left the New York City region in the autumn of 1999 migrated south along the Atlantic Flyway, some fanning into wetlands in South Carolina, Georgia, and

Florida. Although the virus was especially lethal to crows and jays, more than a hundred other species carry the virus. Many of these may have survived an infection, enabling them to carry what remained of it far and wide.

In July 2001, the first confirmed cases of West Nile fever occurred outside the New York–New Jersey metropolitan region when seventy-three-year-old Seymore Carruthers of Madison County, Florida, fell ill. A short time later, a sixty-four-year-old woman, also from Madison County, came down with the disease. “The virus is spreading,” commented Steve Wiersma, chief of Florida’s Bureau of Epidemiology. “We might slow it but we can’t stop it. Nothing can stop it. The ecology is here. The birds are here, and the people are here. Of course, the mosquitoes are here and will always be here.”

The viral plume soon stretched all the way south to Marathon, in the Florida Keys, when a vacationing seventy-three-year-old woman from Sarasota, suffering from confusion, swollen lymph glands, headache, and a high fever, was diagnosed with West Nile fever. She recovered and was released from the hospital several days after being admitted. By the end of 2001, the virus had infected people in ten eastern states, from Massachusetts to Florida, over an area of half a million square miles, and it had been detected in birds across the eastern half of the United States.

No one expected the virus to stop there, not least of all David Rogers, a professor of ecology at Oxford University who had been tracking the virus since its arrival in the New York City area. Working with colleagues from the National

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Aeronautics and Space Administration (NASA), Rogers developed risk maps to predict where the virus was likely to strike next—thus potentially alerting people in the disease path to take precautions. After the Florida outbreak, Rogers began feeding into a computer at Oxford satellite images of ground vegetation, temperature, and other information suggestive of good mosquito habitat. On this data he then superimposed the coordinates of areas in which infected birds had been found. By early 2002, the NASA team had identified Louisiana as a potential trouble spot. True to its prediction, by late summer the epidemic had struck there. Fifty-eight people fell ill. West Nile had also arrived in Mississippi and several nearby states.

The virus struck Louisiana with such fierceness that some speculated it might have mutated into something more virulent than the strain from New York. For one thing, the Louisiana outbreak seemed to be striking a higher percentage of young people than had West Nile outbreaks in the previous three years. During the virus's first two years in the United States, the average age of patients was about sixty-six years; in 2001 it was even higher, seventy. But during the initial 2002 outbreak in the Gulf of Mexico region, the victims' average age was in the upper fifties. Of the fifty-eight cases, twelve of the victims were between forty-five and fifty-nine years of age, and nineteen were younger still. Was the shift in age a coincidence, or had the virus undergone an ominous mutation that gave it the power to overwhelm the relatively healthier immune systems of the young? Time would tell.

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“The peculiarity about West Nile virus,” David Rogers told me, “is that it appears to be supported by at least thirty species of mosquito vectors in the United States and at least eighty species of bird hosts, not to mention some other animals. Normally diseases—even viral ones—have fewer hosts and vectors. Even the relatively close cousins of West Nile virus, such as yellow fever, have far fewer. The greater the number of vectors and hosts, the more likely a disease is to spread within a new continent. In three years West Nile virus in the US has gone from zero to thirty-four states. That’s a record by any standard.”

Rogers pointed out that in 2002 alone there were 4,161 documented cases, with 284 deaths, in forty-four states and the District of Columbia. The Midwest was particularly hard hit, with nearly 2,000 documented cases in just Illinois, Michigan, and Ohio. “This must make West Nile fever one of the most important vector-borne diseases in the entire United States—if not the most important—all within three years of its first appearance in New York,” he said.

“One expects viruses to travel,” Rogers concluded. “They always have, especially when migrating animals are part of the equation. But the rapidity of the spread of West Nile virus is unprecedented. One cannot say exactly where it is going to stop.”

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It didn’t. By the end of 2003, human cases had been reported in all of the lower forty-eight states except for

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Maine, Washington, and Oregon. By 2004 it had invaded Oregon; in 2006 it reached Washington State. In 2012 the first human infection in Maine was documented—a thirty-four-year-old man from Cumberland County. As of April 2013, only Alaska and Hawaii had been spared infection with the virus.

Within a decade of its appearance in the United States, West Nile virus had infected nearly 2 million people, causing illness in 360,000 and encephalitis or meningitis in almost 13,000, and killing more than 1,300. The virus forced the implementation of a costly national blood donor screening program to keep the nation's blood supply safe. In the same way that Lyme disease greatly affected when, where—and if—people hiked or went outdoors in the Northeast, West Nile virus discouraged many people from spending time outdoors during mosquito season in many areas. Like Lyme disease, West Nile virus has changed the way of life for many. And that's just the human toll. The virus has killed millions of birds and cut the populations of some species in half. Some have recovered, but others have not.

The bird-borne virus quickly spread along the Atlantic, Mississippi, Central, and Pacific Flyways to southern Canada, Central and South America, and the Caribbean. Probably assisted by the wild-bird trade (legal or illegal), shipping, and air travel, the virus soon infected large areas of Europe and Africa, as well as Australia. Carried by rodents, bats, cats, dogs, horses, ungulates, and reptiles—not to mention humans—it was never at rest for long. By 2013 it had been

isolated from more than sixty species of mosquitoes and more than three hundred species of birds.

Warmer temperatures, higher humidity, and heavy rain have all increased human infections with West Nile virus, according to recent research. The largest outbreak since 1999 occurred in the summer of 2012, a year of scorching heat and drought and the warmest year ever in the United States, according to the National Oceanic and Atmospheric Administration. In many ways it mirrored what had happened in 1999, when Enrico Gabrielli got infected. But in 2012 an even more dramatic string of temperature records were broken across the United States.

On June 27, Hill City, Kansas, reached a high of 115 degrees; Indianapolis reached 104, and St. Louis, Missouri, 108 degrees. As if a terrible outbreak of West Nile virus weren't enough, the blazing temperatures and weather that year would also bring floods, wildfires, and storms, with record storm surges to the coasts of New Jersey and New York.

In fact, the 2012 outbreak of West Nile virus would go down as the worst since 2003. All forty-eight lower states had infections in birds, people, or mosquitoes. By year's end there had been more than 2,800 infections in people, with half ending up in meningitis or encephalitis. There were 286 deaths.

Hardest hit had been Texas, which alone had more than 1,700 cases and 76 deaths. During the height of the outbreak, the mayor of Dallas declared a state of emergency and tried to stem the epidemic by authorizing the aerial spraying of a pesticide in the city for the first time since 1966.

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Lyle Petersen, director of the CDC's Division of Vector-Borne Infectious Diseases, stated that in the United States and other countries, "hot weather seems to promote West Nile virus outbreaks. And most—many major West Nile virus outbreaks in Europe, in Africa, and now in the United States—have occurred during periods of abnormally hot weather."

Studies have shown that hot weather can increase the chances of infection in several ways. First, the virus spreads more quickly in hot weather than in cooler temperatures. Second, mosquitoes pick up the virus more easily from infected birds in hot weather. Finally, the higher the temperature outside, the more likely the infected mosquito is to pass the virus to a person.

Whatever role temperatures may have played, the American robin, a thrush with the scientific name *Turdus migratorius*, likely played a critical one. Although the robin has long been revered as a symbol of compassion, joy, and good fortune, its days as a symbol of happiness and hope may be numbered. It has become suspect number one in the spread of West Nile virus.

The robin is the favorite host for the feeding of the main mosquitoes that harbor and spread the virus. Despite making up a maximum of 20 percent of the avian communities looked at in a 2011 study, robins were fed on by up to 80 percent of the mosquitoes, earning it the designation of "amplification host." Over the past twenty years, urbanization has helped to increase the yard-loving robin by as much as

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100 percent in some areas. This has led some researchers to conclude that suburbia and one of its proudest symbols—the robin—have likely played right into the hands of West Nile virus.

In fact, both urbanization and climate change are key elements in the emergence of new disease. The recent swine flu pandemic and potentially pandemic circulating bird flus have greatly benefited from domesticated hogs and poultry. Lyme disease increases with forest fragmentation and the increase in human-tolerant species such as mice and deer. The spread of hantavirus increased with the abundance of the mice that carry it. Elsewhere, domestic dogs maintain the transmission of rabies on the Serengeti Plain. Yellow and dengue fever are transmitted by mosquitoes that thrive in populated areas.

With each new or emerging disease, the connections to human activity are becoming better understood. In 2010 the increasing role of humans in fostering diseases such as West Nile virus prompted the CDC to begin offering for the first time direct grants to states and cities to study the health effects of climate change. Currently there are initiatives in seventeen states. Although such actions may help to soften the blow of some new diseases, many others, like West Nile virus, will have established themselves long before we even know they have arrived.