

Yellow Fever Comes to America

YELLOW FEVER IS AN ACUTE VIRAL HEMORRHAGIC DISEASE caused by the yellow fever virus. The virus belongs to the flavivirus group, which includes the West Nile and dengue fever viruses. Infection results in a wide spectrum of disease, from mild symptoms to severe illness and death, making the disease difficult to diagnose. Doctors may confuse it with malaria, typhoid, rickettsial diseases, other arthropod-borne viral fevers, viral hepatitis, and even some poisonings.

While some infections will have no symptoms, most people with yellow fever will experience an acute illness normally characterized by fever, muscle pain, backache, headache, shivers, loss of appetite, nausea, and vomiting. Their eyes may be bloodshot and their tongue fuzzy. While in many febrile illnesses a high fever is accompanied by a rapid pulse, in yellow fever, the pulse is often slowed down, a phenomenon called Faget's sign. During the acute phase, which lasts about three days, there is virus circulating in the patient's blood and that person can be a source of infection. In most patients, the illness will not progress beyond these symptoms, and most victims will improve and recover. However, about 15 percent will enter a "period of intoxication"¹ within two to twenty-four hours after the acute phase appears to be resolving. In these patients, fever reappears and jaundice develops along with severe abdominal pain and vomiting. Bleeding can occur from the mouth, nose, eyes, and stomach. Digested blood may appear in the feces or vomit. The Spanish were struck by this feature and named the disease *el vomito negro*. It often heralds death. Kidney function may be affected, ranging from abnormal protein levels in the urine, called albuminuria, to complete kidney failure with no urine production, called anuria. Half of the patients in the toxic phase die within ten to fourteen days after becoming ill.

Yellow fever is an arboviral disease, meaning that it is transmitted to humans by an arthropod vector. Arthropods include insects and ticks. Adult female mosquitoes pick up the virus from infected individuals while

feeding. Males do not feed and cannot carry the disease. Humans and monkeys are generally the only animals that can be infected.

After the mosquito ingests infected blood, the virus is carried to the mosquito's midgut. There it reproduces or replicates in the cells lining the midgut wall. The virus is then released into the mosquito's hemolymph, or blood, and travels to her salivary glands. The virus is now ready for release into the mosquito's next victim. The time needed for the virus to complete this part of its life cycle is about seven to seventeen days and is called "extrinsic incubation." The mosquito cannot transmit the virus until after this time.

The female mosquito can also pass the virus via infected eggs to its offspring. These eggs can lie dormant through dry conditions, hatching when conditions are right. Therefore, the female mosquito and its eggs are the true reservoir of the virus, ensuring transmission from one year to the next.

Today scientists recognize three different transmission cycles for yellow fever: sylvatic or jungle, intermediate, and urban. All three cycles exist in Africa, but in South America, only sylvatic and urban yellow fever occur. Until the 1930s, only the urban cycle was known. Each cycle has its own specific ecology and may involve several different species of *Aedes* and *Haemagogus* mosquitoes.

In jungle yellow fever, monkeys in tropical rain forests are infected by wild mosquitoes that may bite humans entering the forest, resulting in sporadic cases of yellow fever. Intermediate yellow fever occurs in the humid or semihumid savannas of Africa, where small-scale epidemics occur. In this cycle, semidomestic mosquitoes infect both monkey and human hosts in areas where their habitats intersect. Urban yellow fever has historically been the type most associated with the large-scale deadly outbreaks in the United States, the Caribbean, and Central and South America. In this setting, the tiny black-bodied silver-striped domestic mosquito, *Aedes aegypti*, which prefers to breed in man-made containers, carries the virus from person to person. It also stays close to home, having a flight range of only about a thousand feet.

There is no specific treatment for yellow fever, but several strategies are used to prevent the disease or control an outbreak. The most important and effective is vaccination. Also important, especially in urban settings, but perhaps less effective over the long term, is mosquito control.

Some four hundred years after the first cases of the disease were described in Mexico and the Caribbean, the mystery surrounding the origin of yellow fever remains unsolved. Among the many theories of its origin is one that claims the yellow fever virus existed in the rain forests of the New World but needed the African *Aedes aegypti* mosquito to carry it to humans. The consensus among virologists and disease ecologists, however, is that both the disease and the *Aedes aegypti* mosquito arrived in the Western Hemisphere from Africa as a consequence of the early slave trade. Molecular biology may end the debate. The case for an African origin of the disease is supported by recent work in the evolutionary genetics of the yellow fever virus. There is more genetic variation in the African strains than in the South American strains, pointing to a longer evolutionary history for the virus in Africa. Therefore, Africa is most likely yellow fever's ancestral home.

There is little or no question that the mosquito has its roots in Africa. On that continent, there are many mosquito species closely related to *A. aegypti*. As with the virus, this suggests a common evolutionary path. In the Western Hemisphere, this particular mosquito has no close relatives, making it likely that it was recently introduced. In Africa, *Aedes* was primarily a forest-dwelling pest that bred in water-filled tree holes. Over time, it adapted itself to life in close proximity to human habitats and became domesticated. By the middle of the twentieth century, it was found in many of the world's tropical and subtropical regions and even made its way into the more temperate zones of North America, North Africa, and the Middle East. Since that time, aggressive mosquito control efforts, especially in the Western Hemisphere, have greatly reduced its range.

Whether it was the vector and disease or the vector alone that was brought from Africa, there is no debate on how they came to meet in the Americas—trade. In much the same way that the global economy of the twenty-first century facilitates the movement of diseases like SARS or West Nile around the world, the opening of trade routes in an earlier time resulted in the movement of disease. Yellow fever was not the only disease on the move. Spanish conquistadors brought measles and smallpox to the Inca and Mayan societies and the Carib Indians. In turn, the Spanish probably took home syphilis. Most likely it was the trafficking in human cargo that delivered yellow fever to the Americas.

Infectious diseases love social upheaval. War, mass migrations of people, changes in climate, and other events that alter human ecology often create incubators for illness. The American Revolution and a continent-wide smallpox epidemic were joined in time and place. The 1918 influenza pandemic that took 20 million lives worldwide began at the tail end of World War I. HIV/AIDS took advantage of changing sexual mores. Yellow fever was born of the mating of slavery and sugar.

At the midpoint of the 1600s, significant changes came to Caribbean agriculture and the labor pool that supported it. Until this time, indentured servants from Europe mainly worked the small farms that dominated colonial West Indian agriculture. These laborers exchanged three to five years of their lives for passage to the Americas; some voluntarily, some at the point of a sword. But the indentured labor pool was shrinking, and many of these workers, it was discovered, were not up to the backbreaking work and hardships of tropical farming. A new source of cheap labor was needed.

The Spanish-Portuguese monopoly on the African slave trade that had been in place since the early 1500s was also coming to an end. Dutch, British, and French slavers were increasingly taking over the trade—sometimes by force. The Dutch were among the most aggressive and seized Spanish-controlled slave ports on the west coast of Africa. With more players in the trade, the number of slaves transported to the Americas dramatically increased.

The typical slave ship of the time may have been similar to a Dutch flute: a small three-masted wooden ship with two decks, top and below. The crew of about twenty would sail from Europe to slave-trading outposts such as Benin and Old Calabar on Africa's west coast. There, ship and crew plied coastal Africa for many months, cutting their best deals for slaves who were hunted down and sold by other Africans and Islamic traders. Before departing, the ships loaded up on provisions. Sweet potatoes and other native African fare were put up for the journey across the Atlantic. These foods were for the slaves. Many captains had learned that a European diet, especially one of dried meats and hardtack, could not sustain their human cargo. Too much of their high-priced inventory was lost to dysentery and other digestive disorders during a crossing without native foods.

Water was also essential for the trip. Casks of water were loaded in Africa for the three-month journey. It can be assumed that a few days out

of port, wigglers, or mosquito larvae, danced just below the surface of the water. Several days later, the mature mosquitoes would have emerged. Slaves and crews provided the blood meals female mosquitoes needed to produce eggs. The sated females returned to the water casks and cisterns to lay their eggs. During the voyage across the Middle Passage, as the Africa to America journey was called, the mosquitoes could pass through several generations.

Between the time they left Africa and the time they docked in Pernambuco, Guadeloupe, or Barbados, a ship's crew was likely reduced by 20 percent, almost entirely by sickness. The extent to which yellow fever contributed to this mortality rate will never be known; such things were kept "conveniently dark."² The death rate among the ship's human cargo, due to disease, suicide, and murder, was about the same in this period. It is very likely that only the mosquito population had increased on the crossing.

Slaves and mosquitoes disembarked into the New World. Slave labor was desperately needed to work the new large plantations that were displacing the smaller family farms. In Barbados in the mid-1600s, the ten-acre plot worked by a family and a few indentured servants was disappearing, replaced by large plantations averaging three hundred acres; some stretched over a thousand acres. As the plantations grew, the number of property holders fell from over 11,000 to under 800. The demand for a huge slave labor force also grew, and the slavers were ready to comply. Barbados had 5,600 black slaves in 1645, up from near zero a few years earlier. By 1667, there were more than 82,000 Africans working the island's plantations.

Many of the shifts in land use and the labor force were the result of a major change in West Indian agriculture. Europe and the European colonies to the north had developed a sweet tooth. Where cotton and tobacco were once grown, the green spiky leaves of sugar cane now waved in the Caribbean trade winds. Whether it was packed into cones of sugar, turned into molasses, or fermented into rum, demand was high, prices were higher, and the incentive to forsake other crops in favor of cane was even higher.

While the slaves went to work in the fields and plantation homes of the Caribbean, *Aedes aegypti* mosquitoes, now freed from their water casks, went in search of blood meals. And while blood was essential for laying eggs, it was not required for sustenance. Sugar water, now abundant on the islands, could sustain them quite well until they happened on a warm-blooded mammalian feast.

Sporadic cases of yellow fever probably occurred for many years before the virus and the vector were sufficiently established to cause a devastating epidemic. Historians have reported several disease outbreaks before 1648 as yellow fever. Among those were an epidemic that ravaged Christopher Columbus's troops and the Carib Indians they engaged at the 1495 battle of Vega Real in Hispaniola. Much later, in 1643, an illness dubbed the *Coup de Barre* struck Guadeloupe. Four years later, a mysterious illness visited Bridgetown, Barbados. Both this outbreak and *Coup de Barre* have been called the first reports of yellow fever. It is uncertain whether any of these were yellow fever.

The Vega Real outbreak is too poorly documented for us to know its cause. The *Coup de Barre*, described by the French priest Pere Dupertre and named for the extreme muscle pains that accompanied it, was unlikely to be yellow fever. It was similar to a previously known disease and had too low a death rate for yellow fever. While conditions may have been right for yellow fever on Barbados in 1647, not enough is known about the outbreak to name it. Whatever it was, it was devastating. Writing to Governor Winthrop of New England, a correspondent described "an absolute plague, very infectious and destroying."³ In the writer's parish, twenty people were buried in one week, and in many weeks during the epidemic there were fifteen or sixteen burials.

The first relatively certain occurrence of yellow fever was in the Spanish stronghold on the Yucatan in 1648. Writing in his *Historia de Yucathan*, Lopez de Cogolludo noted that conditions that year were ripe for a great calamity. In March, one of the signs of impending disaster was the arrival of a fog so dense that for several days the sun appeared eclipsed. For the old Mayan Indians the fog was "a sign of great mortality of people in this land, and for our sins." The first cases of the mystery illness appeared in Campeche in June. Cogolludo said the city was "totally laid waste." The *peste*, as he called it, continued throughout the summer. The Spanish established roadblocks around Campeche in an effort to confine the contagion. But the disease spread. There was little confidence in the authorities' ability to halt the sickness. After all, many reasoned, what good were human barriers if their Lord God did not protect the city? Moving from Campeche, its apparent place of origin, to Merida, the *peste* appeared to jump over the villages between as if carried directly from one city to the other. A resident of Merida, where the epidemic hit in August, wrote in a letter,

“With such quickness it came on great and little, rich and poor, that in less than eight days almost the whole city was sick at one time and many of the citizens of highest name and authority died.”⁴

Accounts describing the spread and symptoms of the disease leave little doubt that it was yellow fever. Indians fell ill a few days after arriving in the city of Merida. Initially, only friars who left their cloisters to care for the sick became ill. But soon cases of the *peste* appeared in the cloisters seventeen to twenty days after the first friars fell ill. This timing is in keeping with the now known time needed for the virus to reproduce in the infected mosquito, the extrinsic incubation, and for symptoms to develop in people. Henry Rose Carter, who discovered and described the extrinsic incubation period, wrote in his exhaustive 1931 *History of the Origin of Yellow Fever*, published after his death, that the known epidemiology of yellow fever dovetails so perfectly with that reported from the Yucatan “as to almost compel of the diagnosis of it or some other host-borne disease.”⁵

Cogolludo’s recounting of the malady’s symptoms almost certainly confirms it as yellow fever. Victims of the *peste* were “taken with a very severe and intense pain in the head and of all the bones of the body, so violent that it appeared to dislocate them or to squeeze them as a press.”⁶ Many but not all of the sick progressed to a “vehement fever” often accompanied by delirium. The truly unfortunate began vomiting “putrefied blood and of these very few remained alive.”⁷ Those who worsened often died on the fifth day. Except for dying two or more days earlier than most yellow fever patients today, the descriptions of the *peste* symptoms offered by Cogolludo mirror what is now known of the disease.

Who or what brought the disease to the Yucatan is not known. Contemporary writers have noted that there was a lot of pirate activity in the Caribbean that year. Perhaps increased shipping traffic and encounters between ships for pillaging helped transport the virus or the vector to Campeche. The Mayan Indians had their own theories, as reported by Cogolludo: “The malady was a judgment of God, since they were sick only in the [Spanish] cities and towns.”⁸ But the disease raged in the Yucatan for two years, and eventually even the Indian pueblos couldn’t escape the scourge. Attributing the disease to the wrath of God, however, remained a consistent feature of yellow fever epidemics for the next two hundred and fifty years.

The French colonies of St. Kitts and Guadeloupe also suffered a *peste* in the summer of 1648. One-third of St. Kitts’s population perished within

eighteen months. A mysterious disease visiting Guadeloupe that summer was unlike 1635's *Coup de Barre* but epidemiologically and clinically similar to yellow fever. Residents claimed the French ship *La Boeuf* brought it to the island in late July. The ship's crew was sick and dying when it arrived at the capital of Basse Terre. Soon after it docked, Father R. P. Aramand de la Paix boarded the ship to hear the crew's confessions and to administer the Church's sacraments to the afflicted. He took ill while aboard the *La Boeuf* and died on August 4.

The disease soon struck Cuba. From 1511, when Velasquez brought three hundred settlers to Cuba from Santo Domingo and permanently established a Spanish presence on the island, until about 1620, there was no record of any significant disease outbreaks in the colony. Starting in 1620, residents of the island and ship crews calling at its ports began experiencing malignant fevers. Dr. Carlos Finlay, Cuba's pioneering yellow fever researcher in the late nineteenth century, believed these were outbreaks of yellow fever, but too little is known about them to draw that conclusion.

A virulent and horrible disease that struck Cuba in 1649, though the year has also been given as 1648, was almost certainly yellow fever. In Havana, a third of the city's residents died between May and October. If the 1649 date is correct, it is likely that the disease was introduced from the Spanish colony at the Yucatan. Yellow fever was present on the island until 1655. It then either disappeared completely or remained at such a low level as to be almost unnoticeable until infected prisoners from Vera Cruz who arrived to build Cabañas reintroduced it in 1751. It remained endemic on Cuba until 1901.

Throughout most of the Caribbean during much of the late 1600s and early 1700s, yellow fever was a sporadic visitor. Still, it may have been the best defender of the Caribbean against European colonists. During this time, it devoured British and French military expeditions. In 1665, a British squadron, noted to be in good health, seized St. Lucia. A garrison of fifteen hundred troops placed on the island was quickly reduced to eighty-nine by a virulent epidemic of yellow fever. Similar stories of ill-fated military missions were common.

Along with immigrants to the Caribbean, newly arrived soldiers and sailors were among those who suffered the most. Yellow fever became known as a "fever of acclimation." If newcomers survived three years without dying of it, chances were that something else would have to kill them.

Not known at the time was that once infected, a person is immune for life. A constant influx of emigrants from Europe or North America was needed to keep yellow fever alive in the Caribbean. These newcomers were immunologically naive; never having been exposed to yellow fever, they lacked the antibodies needed to protect against infection.

How much of the mortality attributed to yellow fever during its early history really was the result of infection with the yellow fever virus is unknown. Standardized medical nomenclature simply didn't exist, and a variety of names were applied to it. In English-speaking colonies, the name "yellow fever" didn't become routinely associated with the sickness until the mid-1700s. The descriptive *el vomito negro* used by the Spaniards had been in use much longer. The disease had other names. *Mal de Siam* was applied to the disease during a 1690 epidemic in Martinique, where a French man-of-war, the *Oriflamme*, docked after traveling from Siam, known today as Thailand. The ship was believed to have carried the fever. Since yellow fever has never been known to occur in Asia, the sickness more likely came aboard during a port call the ship made in Brazil a few weeks earlier.

Complicating matters, while the symptoms of severe yellow fever are nearly unique to the disease, those in less virulent cases can be shared by other diseases. Milder cases that did not progress much beyond flulike symptoms would have been impossible to diagnose as yellow fever with any certainty. Even today, blood tests and urinalysis for biochemical changes and immunological markers of infection are needed to make a definitive diagnosis.

After the 1690 *Mal de Siam* epidemic, as yellow fever settled into the Caribbean, cases of the disease were being exported along with rum and sugar. In 1693, Boston was the first British North American colony struck by an epidemic. Admiral Joseph Wheeler's fleet, recently arrived from the West Indies, was blamed for the introduction. Charleston and Philadelphia also came under attack. A year later, the admiral lost almost his entire squadron to the scourge while preparing to mount an assault on Martinique.

Over the next hundred years, yellow fever epidemics occasionally struck port cities up and down the East Coast. In 1699, Philadelphia and Charleston were again visited. Both cities lost about 7 percent of their residents: 220 people in Philadelphia and 178 in Charleston. New York City lost 10 percent of its population to yellow fever in 1702. During the century after the first Boston epidemic, major outbreaks were reported in only

fifteen of those years. There were two notable periods, however, when the disease made back-to-back annual visits. Starting in 1737, eastern seaports suffered through seven consecutive yellow fever summers and then were yellow fever-free until 1762. Between 1762 and 1765, yellow fever returned each year to North American cities. It then disappeared for nearly three decades.

During this time, outbreaks in the Caribbean were also sporadically occurring. While a continuous influx of immigrants provided fresh victims throughout the early and mid-1700s, few outbreaks were reported for the twenty years after 1770. Dr. William Wright, a British physician practicing in Jamaica from 1764 to 1777 and 1783 to 1786, claims to have never seen a case. This was also a time of peace in the region, but that was about to change.

In the wake of the 1789 French Revolution, the French colony on the island of St. Domingue (now Hispaniola) was torn by civil war. Whites, powerful landowners, and the lower class *petits blancs* battled one another over independence from France. Meanwhile, the Free Coloreds, a mix of free blacks and mulattos, were fighting for full rights as citizens. Initially, the black slaves watched as these warring factions fought one another.

Taking advantage of the turmoil, thousands of slaves rose up against the island's white society on the night of August 21, 1791. The Haitian revolution on St. Domingue was under way. In the northern provinces of St. Domingue, the slaves butchered their white owners and other whites, torched hundreds of plantations, and forced refugees to flee into Cap François, now Cap Haïtien, and a few other heavily defended strongholds.

A Revolutionary Commission, led by Léger Sonthonax and backed by seven thousand troops, was dispatched from Paris to take control of the island. As malaria and yellow fever decimated his French troops, the Republican leader aligned himself with the Colored militia and imposed a reign of terror on the island's whites, most of whom he believed were monarchists. St. Domingue's whites turned on Sonthonax. In June 1793, to strengthen his position, he offered freedom to all blacks who joined his revolutionary cause. Accepting his offer, a band of black fighters set upon Cap François on June 20. They killed ten thousand mostly white residents. The survivors fled the island. Among the ships heading away from Haiti that summer was the *Mary*. Loaded with refugees, it sailed north for Philadelphia.

The turmoil its passengers left behind continued for another eleven years. St. Domingue was a battleground for French, British, and Spanish troops all maneuvering for control of the once productive and prosperous colony. In addition to the black warriors, the Europeans were confronted by yellow fever. British forces lost one hundred thousand soldiers and sailors—half of them killed; half disabled—to disease in Haiti, with most, it is believed, succumbing to yellow fever.

Francois Dominique Toussaint-Louverture, the George Washington of Haiti, who led his forces against the French general Victor-Emmanuel LeClerc and his twenty-thousand-man-strong army, was greatly aided in his struggle by yellow fever. One-third of the French troops who landed at Cap François in January 1802 were lost to the malady. Despite his losses, LeClerc forced the surrender of Louverture in May. Yellow fever fought on, and LeClerc knew he could not hold on without reinforcements from Europe.

On May 8, 1802, he wrote to the French minister of marine, "I have at this moment 3,600 men in hospital. I have been losing from 30 to 50 men a day in the colony. . . . To be master of San Domingo, I need 25,000 Europeans under arms."⁹ Many of his generals and their staff were sick, dying, or dead. He ordered a report on the sickness: "According to this report, it seems that this sickness is that sickness which is called Yellow fever or Siamese disease."¹⁰ On October 22, 1802, LeClerc himself succumbed to yellow fever. His replacement, General Rochambeau, arrived to face the disease and the Haitian insurgents. He surrendered what remained of his French army in November 1803. On January 1, 1804, rebel leader General Jean-Jacques Dessalines declared Haitian independence.

The refugees, who had sailed north out of Cap François in 1793 aboard the *Mary* and other ships, left behind the horrors of Haiti's decade-long war of independence. Among the cargoes they carried with them to Philadelphia and other cities was Haiti's great defender, yellow fever.

The devastating Philadelphia epidemic of 1793 ushered in the longest and deadliest string of yellow fever years yet known in North America. While other U.S. cities were stricken, Philadelphia suffered the greatest losses during the tumultuous thirteen-year span of annual yellow fever epidemics that followed. In 1793, 5,000 people, one-tenth of Philadelphia's population, died. After several milder outbreaks in the mid-1790s, the disease again swept away staggering numbers of Philadelphians. In 1797, 1,500 perished, another 3,500 died in 1798, and 1,000 more died in 1799.

The repeatedly high mortality rates were probably the result of a continuous stream of emigrants from elsewhere in the United States and foreign immigrants into the city. The newcomers, both those carrying yellow fever as they fled the ongoing turmoil in the Caribbean and those never exposed to yellow fever, helped ignite and fuel the illness as it burned through Philadelphia and other U.S. cities.

Some blamed the recurring yellow fever epidemics for hindering Philadelphia's growth. Between 1790 and 1800, the city's population increased about 44 percent, from 28,522 to 41,220, but from 1800 to 1810 it grew only by 30 percent, to 53,722. Despite the high mortality rates from disease, European cities seemed to thrive, but the threat of yellow fever was seen as a deterrent to the emergence of the U.S.'s new and emerging metropolises. Thomas Jefferson, no fan of the urban environment, recognized the yearly epidemics as "evil" but saw slowed growth as a bit of good news among the bad. In an 1800 letter to Philadelphia's leading physician, Benjamin Rush, he wrote, "The yellow fever will discourage the growth of great cities in our nation & I view great cities as pestilential to the morals, the health and the liberties of man."¹¹ The Jeffersonian ideal clashed with the view of many that growth and prosperity went hand in hand. City fathers felt they had to control yellow fever and the other diseases then prevalent in their young metropolises if they were to successfully compete for trade and business. The fear of this disease could not be allowed to endanger economic health.

Yet each spring, Americans living in seaport cities came to dread the approaching summer. This seasonal anxiety lasted for over a hundred years, though after the 1820s it was almost entirely confined to southern cities and towns. Throughout the entire nineteenth century, as yellow fever destroyed lives and ruined businesses, residents of these threatened cities struggled with the most basic questions about yellow fever: where did it come from, how could it be prevented, why were some cities stricken and others missed, and why did certain people fall ill and others remain well? Many theories came and went as doctors, especially those in the South, became intimately acquainted with the scourge. No matter what the "theory of the decade" was, city leaders—and before the American Civil War, public health was almost exclusively a local responsibility—relied on two methods in an often fruitless attempt to prevent or control yellow fever.

These were the ancient practice of quarantine and the newer emerging science of sanitation.

Northern cities acted quickly to contain the suffering caused by their worst yellow fever epidemics. Philadelphia, Baltimore, and New York convened boards of health to manage the repeated invasions. Controversial, but supported by the contagionists, quarantine was one of the most used and perhaps most potent tools available to the boards. Previously it had been applied to halt smallpox and plague, among other diseases, but its use against yellow fever was relatively recent. Ships arriving from yellow fever-infested areas—their crews, cargoes, and passengers—were held on islands or other secluded areas for forty days or more. Infected ships were ordered to fly a yellow flag, giving the disease its common nickname, yellow jack. Overland travelers from suspect cities were also subject to quarantine, as were those living in a city who took ill or had contact with the sick. They were directed to pest houses or camps outside of town.

Pestilence and quarantine have been linked throughout history; both can be traced to early human history. The Bible's Old Testament book of Leviticus laid out the methods for halting the spread of leprosy. In the fourteenth chapter, forty-sixth verse, the Lord tells Moses and Aaron how to manage a leprous person: "He shall live alone, and his dwelling shall be outside the camp."¹² The modern concept of quarantine began to emerge during the great plague of Europe in the fourteenth century. Venice, southern Europe's leading maritime port, established a code of quarantine in 1448. All ships arriving from places where disease was known to exist or was suspected of being prevalent had to anchor outside the harbor for forty days. No cargo or persons could go ashore. A few years later, the seaport created the first lazarettos for the care and treatment of plague victims on a small nearby island. The sick and their families were deported to the pest house and were not allowed to return to their homes until forty days after the disease abated.

The word "quarantine" comes from the Latin *quaranta*, meaning forty. The reason for selecting forty days as the period of confinement is not known. Historians have suggested several theories. Forty days is a recurring number in major biblical events such as the nights and days of rain that Noah and his menagerie endured aboard their ark. It was the time period assigned to Moses's stay on Mt. Sinai, and in Mosaic law it was the

period appointed for cleansing unclean lepers. In the New Testament, Jesus's trial in the wilderness lasted forty days, and it is the number of days of spiritual cleansing in the Christian Lent. The number appeared in Greek medicine, which declared forty critical days for the development of a contagious disease. While forty may be an unnecessarily long confinement for most diseases, including yellow fever, fear and uncertainty demanded a greater rather than lesser period of isolation.

Before the 1793 yellow fever epidemic, Philadelphia used quarantines to prevent the spread of smallpox. A ten-pound fine was levied on anyone harboring a sick person who had been banished to the pest house. In 1774, when a smallpox epidemic swept through the city, a provision was added to the law subjecting any person escaping quarantine to a fifty-pound fine. If unable to pay, the escapee got twenty lashes, well laid-on, upon the bare back. As a nineteenth-century wag noted, this was "a soothing application to the desquamating skin of a small pox convalescent!"¹³

Merchants and businessmen saw quarantine as a costly failure. After all, between 1794 and 1820, the practice failed to prevent eight major East Coast epidemics. Because normal trade was halted, goods were blocked from entering and leaving town, and many believed quarantine was more injurious to a port's commercial interests than were the diseases it was guarding against. As the nineteenth century progressed, even health officials made the decision to establish a quarantine based more on economic rather than on health concerns.

The shipping industry despised quarantine at U.S. ports, and some traders took a cynical view of the reasons behind the practice. In the late 1850s, twenty-two ship captains whose vessels were sitting at quarantine vented their frustrations in the New York *Commercial Advertiser*. They complained that the decisions for sending a ship to quarantine were based on flimsy evidence and were driven less by a need to "preserve the health of New York, but for the benefit of whom it may concern."¹⁴ They then listed those concerned who benefited. The port health officer got \$6.50 a ship. The port warden's fee was \$5.00, and a fumigator got \$6.00 for tossing about a bit of chloride of lime. Others collected fees for services both needed and unneeded. Finally, all dunnage had to be burned at a cost of \$6.00.

Despite the questionable efficacy of quarantine and the high costs associated with it, the practice survived into the twentieth century. Taken together, quarantine and sanitary improvements may have been the reason

yellow fever fled the northern cities and took refuge in the South. Several public health historians credit both these interventions as key elements in the demise of yellow fever above the Mason-Dixon line after 1822. Anti-contagionists and health reformers in afflicted communities championed sanitary reforms. In response to these demands, local governments began to examine their roles and responsibilities in protecting health and ensuring the welfare of their citizens.

Community responsibility for public and personal health was a newly emerging concept. Following the 1800 Baltimore outbreak, which claimed nearly twelve hundred lives, an anonymous writer noted, "We have fire companies, we have insurance companies, and we have banking companies; but no company could equal the extensive or essential benefits desirable from a health company."¹⁵ Baltimore established a "health company" of sorts in 1801. For a five-dollar subscription, members could refer up to two patients to the newly established city dispensary in the Fells Point section of town. The system quickly drew criticism since many of the people it was created to help, the city's poor, could not afford the five dollars and sponsors were scarce.

Public health reforms enacted to improve the health of the entire population were more common and successful. In response to repeated invasions of yellow fever, which clearly caused great economic disruption and soiled a city's reputation, boards of health were established in such cities as New York, Boston, Baltimore, and Philadelphia. These agencies began to look inward as well as outward for the source of the yellow fever poison.

In the time before germs were linked to disease, the boards of health focused on filth as a reservoir of the unknown agents of yellow fever, cholera, and smallpox. Public works projects spurred on by the need to control these diseases included trash removal, draining swamps, and building municipal water and sewage systems. The boards' edicts, issued in ignorance of any of these diseases' true causes, were based on common sense and good intentions. Sanitary improvements also resulted in tangible evidence of a board's worth. There was clear evidence of progress for politicians to point to. Citizens could see and smell the changes in their surroundings. And public works projects created jobs.

More important, the improvements did reduce sickness and mortality. In the case of yellow fever, eliminating standing water could significantly

reduce the threat of an outbreak. The still-to-be-discovered carrier of yellow fever, the *Aedes aegypti* mosquito, thrived in standing water and the urban environment. To become an efficient yellow fever vector, the mosquito needed to rapidly increase its population. Close proximity to both blood meals and breeding grounds was essential for her survival. The mosquitoes' life cycle was fatally disrupted by working street drains, closed water supply systems, and underground sewage lines.

Beginning with the great Philadelphia epidemic of 1793, some combination of sanitation and quarantine was the standard response to the arrival of yellow fever. In some places and in some time periods, one or the other dominated public health practice. That battle for supremacy also began in 1793, as the city's physicians split into contagionist and anticontagionist camps.