3 Rat Destruction in Istanbul and Hamburg

Between the nineteenth and the twentieth century, with rats becoming increasingly a subject of epidemiological attention as carriers and spreaders of plague, fumigation technologies began to be developed in Europe with the explicit purpose of eradicating this particular animal in the holds of steamships. In this chapter we will explore the emergence of these deratization technologies as it unfolded in two distinct locations: the capital of the Ottoman Empire, Istanbul, and the most important harbor of recently unified Germany, Hamburg. These examples make for an unusual sulphuric utopia, as in both countries the chemical compounds chosen to yield best deratization results were indeed carbon based. Nevertheless, we take these sites of experimental fumigation as integral parts of the global history told in this book under the rubric of a hygienic sulphuric vision, as they encapsulate similar principles and comparable experimental systems developed as competitors to sulphurization. Their aim was to achieve the one and same goal: a complete and combined disinfestation and disinfection while causing only minor obstruction to sea trade and minimal damage to vessels, goods, and merchandise. There is, however, another reason why examining the development of maritime fumigation in these two locations is important. Misleadingly, these two sites are often taken as two opposite ends of the spectrum of governmental and scientific development in Europe. On the one hand, the Ottoman Empire is commonly seen as a moribund state, the "sick man of Europe" stagnating in its inability to adapt to the new age of science, technology, and modern statecraft. On the other hand, unified Germany under the Kaiser is commonly seen as the most rapidly industrializing state in Europe, with scientific development tightly tied to industrial expansion and the raison d'état. And yet, as historians like Miri Shefer-Mossensohn, Amit Bein, and Alper Yalçinkaya have recently shown, the late Ottoman Empire was a hotbed of scientific debate and innovation.[1] As Zeynep Devrim Gürsel has argued, this was particularly pronounced in the realm of medicine.[2] At the same time, as late as 1892, Hamburg remained a seat of scientific and governmental resistance, indeed one may properly say reaction, to contemporary bacteriological breakthroughs.[3] The choice of these two sites for the study of the development of antirat maritime fumigation is thus driven by the need to go beyond a comparison based on historical-technological stereotypes (the progress-oriented West versus the tradition-stuck East), and toward a crossed history of technological and public health development that does justice to the political and political economic entanglement of maritime sanitation on the international stage. This will allow us to glimpse how, at the turn of the century, a distinct hygienic utopia, centered on the eradication of rats, arose across Europe, leading in turn to the emergence of chemical fumigation technologies—technoscientific apparatuses that aimed to both protect respective nations or empires from the global march of plague and to regulate maritime trade in ways that were beneficial to respective financial and geopolitical interests.

Rats as an Epidemiological Problem

Today plague is so closely associated, indeed identified, in popular imagination with rats, that it is easy to forget that before the 1870s the rat was generally considered to be a nuisance but not the carrier or spreader of diseases. Catching and destroying rats was of course part of elaborate processes, involving ferrets, dogs, and skilled rat-catchers in a "multi-species labour of rat-catching."[4] These were processes that, on the one hand, involved public spectacles of "ratting," while, on the other hand, developed notions of rat intelligence and intentionality, as is famously evident in Henry Mayhew's 1850s account of the practice.[5] As Neil Pemberton has noted, "these cultural practices invested rats with a menacing and formidable persona: a species co-existing and co-emerging with civilization, devouring it from within."[6]

This was a kind of "hostility" against rats that, in England at least, was further fueled by the discovery of a displacement of the black rat by a malicious "invader": the brown rat. Pemberton notes how, in tandem with naturalists like Charles Waterton, Mayhew construed the brown rat "as a foreign species, notable for its particularly 'rapacious' appetite: calculating and scheming to destroy habitats and human food sources, while cleverly hiding its booty."[7] But even when discussing its otherwise iconically vicious bite, Mayhew failed to note any infective qualities of this particular rodent. Indeed, the rat was considered to be uniquely able "to 'clean' and preserve itself from contamination by the filth and miasma of the sewer."[8] Pemberton notes that "rather than being correlated with plague, the sewer rat's appetite for putrefying matter saved human inhabitants from 'periodical plagues,' which Rodwell insisted were the 'result of deadly gases arising out of the putrefaction of animal and vegetable matter.'"[9] Until the final decade of the nineteenth century, the rat problem was thus not a problem of infection but rather a problem of boundaries and their transgression, including both the unwarranted nocturnal wanderings of the rat into private and familial spaces, and its "invasive," transnational character.

The first note of the rat's implication in human disease came in the mid-nineteenth century from two distinct sources, both from what at the time were considered to be "remote" parts of Asia. First, in the 1840s, British colonial officers noted that in the Garhwal and Kumaon Himalayan districts of the British Raj a disease known as Mahamari (suspected by British doctors to be plague) was claimed by locals to first appear in rats before striking humans.[10] Three decades later, news of a widespread plague outbreak in the Chinese province of Yunnan also reported similar local beliefs.[11] It was, however, not until the Yunnan-originated plague reached Hong Kong, in 1894, that the rat became the object of systematic scientific study and problematization. By the time the outbreak was in full sway, leading medical colonial officers, like James Lowson, still maintained that the disease first struck rats because the plague gases emanating from the soil first reached the nostrils of the earth-bound animal, and humans only later because of their heads standing higher above ground. However, already in his paper announcing the discovery of the plague bacillus in July 1894, Alexandre Yersin included the rat among the nonhuman suspects of carrying and perhaps spreading the disease.[12]

It was not until 1898 that a direct link was established, this time including the rat's flea *Xenopsylla cheopis*, as a rat–human vector. The theory was formulated by another Pasteurian, Paul-Louis Simond, but it was not immediately endorsed by the international medical community, which was at the time faced by the rapid spread of the third plague pandemic across the globe.[13] It would take another eight years for the rat–flea theory to be fully accepted, and only in 1914 would Bacot and Martin, of the Lister Institute, be able to demonstrate the mechanism through which plague passed from fleas into rats and humans.[14] Yet this did not mean that the rat theory remained shelved and ignored. By contrast, the question of the rat formed the ground for an impressive range of studies, theories, and experiments that still await their historian.[15] In the course of this book, we will encounter several of these, particularly as they relate to maritime trade. It is, however, useful to keep in mind that besides the problematization of seaborne rats, the scientific study and intervention on the particular rodent extended into *terra firma*, where other means of rat elimination besides fumigation were developed and deployed—although, for reasons that will become clear, these were largely unemployable on board of ships.

This is not a book on the history of epidemiological approaches of the rat, nor is it a work on the history of the global war against the particular animal as waged from 1894 onward. Instead, our particular focus is on the aspiration of complete maritime sanitation by means of mechanically produced fumigants. In this story, the rat played an important role as, at one and the same time, the most visible and quantifiable opponent. Rats could not only be retrieved from the holds of ships, but could also be counted in order to demonstrate the efficacy of fumigants in ways that insects or bacteria could not. At the same time, rats escaping the deadly grip of fumigation were equally readily observable by the naked eye, even by the least scientifically versed members of the crew. Rats thus operated as readily available proofs and disproofs of the efficacy of different fumigation methods and technologies. However, as we will see, at the dawn of antiplague fumigation, disinfestation did not form an autonomous target, but only one that mattered in conjunction with disinfection. In other words, killing rats in ships' holds was configured as meaningful only to the extent that the gas employed was also shown to destroy the bacteria carried by rats.

Polis Mytilini and Apéry's Machine

In spite of the occasional epidemic in Persia, Mesopotamia, and Benghazi, Ottoman concerns with plague ran relatively low in the second half of the nineteenth century, when, since its first outbreak in Istanbul in 1831, cholera formed the principle worry of health professionals.[16] In the context of wider modernization reforms leading up to *Tanzimat* (1838), and in light of resurgent plague outbreaks in the region and of international concerns over the impact of cholera across the globe, mounting European pressure on the Sublime Porte led to a series of radical changes in public health. These included the establishment of hospitals and the first Ottoman quarantine regulation, issued as early as 1836.[17] It is in this context that in 1839 the Quarantine Council (*Meclis-i Tahaffuz*, also known as the Conseil Supérieur de Santé) was established in the Ottoman capital.[18] This was "tasked with enforcing quarantine regulations in the Mediterranean region. The Council initially consisted of eight Ottoman members and delegates from nine European states (Austria, Belgium, France, England, Greece, Prussia, Russia, Sardinia, Italy). Sixty-three sanitary agencies dispersed across the Ottoman domains reported to the council."[19] As Nuran Yıldırım explains, it was on the same day as the foundation of the Quarantine Council (June 10, 1839) that the Organizational Regulation for Maritime Arrivals was instituted, coming into effect two months later:

> According to this first regulation, every ship that came to Istanbul was to have a health patent to be delivered to the health control officer by means of a long pole. Patents that were given 30 days after the last case of plague were considered to be clean; those given after 15 days were suspect, while those given before 15 days had passed were considered to be infected. Ships with suspect patents and ships with a 10-day infected patent were to wait in quarantine for 15 days. Their goods and passengers were to be placed in the Kuleli quarantine. Every ship, be it from the Mediterranean or the Black Sea, was to be subjected to interrogation and the captain of the ship was to declare the health conditions on board.[20]

Following Yıldırım, Sultan Abdülmecid invited the inclusion of delegates from foreign embassies in the Quarantine Council as this was believed to foster international cooperation, dispel harmful rumors, and promote expediency and efficiency in the implementation of quarantine measures. With the Ottoman members of the Quarantine Council being a minority, its international status was further enhanced as a result of the 1851 International Health Conference in Paris demanding the Sublime Porte to recognize the Quarantine Council as bearing legal status and to give voting rights to foreign delegates. Delegated with "the authority to prepare laws concerned with epidemics and quarantine," the Quarantine Council issued decisions that had to be implemented by local quarantine officers, who were appointable and dismissible directly by it.[21] This placed considerable power in the hands of an organization that by 1897 was solidly under foreign control.[22]

With the notable exception of studies of how it affected the pilgrimage to Mecca, Ottoman concerns about and approaches to plague following the global resurgence of the disease since the 1894 outbreak in Hong Kong remain historically underexamined.[23] Nonetheless, all evidence confirms that international outbreaks, particularly those in the Indian subcontinent, were duly noted in leading Ottoman medical journals at the time. More than being distant events, these raised the question of whether a series of short plague outbreaks in Jeddah (May 1897, April 1898, February 1898), the entry port for accessing Mecca, were derived by means of Yemeni pilgrim caravans from what were generally held to be local endemic regions (the high plateaus of Assyr and other "limitrophic" regions in Arabia), or were instead imported into the maritime gateway to Mecca from Bombay, via the British-held port of Aden.[24]

In her seminal study of plague in the East Mediterranean, Nükhet Varlık mentions that, by the sixteenth century, sources indicate knowledge of maritime trade's involvement in the transport of rats across the sea. The stowaways were indeed considered a nuisance such that "the Ottomans had the habit of carrying weasels or cats on board of ships expressly for the purpose of 'rat control.'"[25] Still, although the concurrent absence of plague and rats was noticed, no etiological conclusion was drawn from this connection at the time. By contrast, the connection between plague and the rat was assumed by late nineteenth-century Ottoman medical experts, well before Paul-Louis Simond's scientific demonstration of the link; 1897 saw the publication of the first extensive study of plague in the Ottoman medical press since the discovery of the bacillus three years earlier. The study, authored by Dr. Nikolas Taptas, made note of the relation between the disease and rat epizootics in southern China (as related to by authors like Emile Rocher) so as to stress that "the rat is an animal that takes on spontaneously the plague more easily than all the other animals."[26] Questions regarding whether plague could in fact spread from rats to humans, and, if so, in which way, remained however inconclusive. On the footsteps of similar opinions prevalent at the time across the British Empire, Taptas maintained that plague is principally contracted through the digestive tract, with rats being infected through eating human corpses.[27] And yet his paper also mentioned *in passim* the potential importance of the rat factor in the transportation of plague via maritime trade, a subject that resonated with contemporary suspicions of quarantine-evasion by smugglers arriving from Bombay by way of Muscat and Hadramaut.[28]

Most importantly, Taptas adopted the theory that the rat rendered supposedly soil-borne, attenuated plague bacteria virulent again, eventually leading to human infection.[29] This theory attempted to bridge two prevalent hypotheses at the time: on the one hand, that plague was borne by rats, and, on the other hand, that plague was borne by the soil. Since Yersin's discovery of the plague bacillus in 1894, the soil had been at the center of extensive debate among plague experts, with Yersin himself arguing that it should be considered a reservoir of the bacillus, which could explain recurring outbreaks of the disease in given locations: "It is possible that, in order to renew its virulence, [the bacillus] might have to make a long evolution in the earth."[30] According to this view, under certain conditions the soil functioned as the context of the development or transformation of the bacterium. In other words, the soil was considered as far more than an idle container of plague—it was its medium proper, in the sense that it was seen as giving rise to virulent forms of the pathogen after periods of dormancy or attenuation. What Taptas's theory added to this was the idea that, while they remained dormant in the soil, plague bacteria were picked up by rats and within their organisms the bacillus was able to revive and reattain its virulence, henceforth attacking humans.[31]

By the time that plague had reached Alexandria, in 1899, nobody in Istanbul seemed to doubt that it was an "Indian importation."[32] Following closely the development of the plague epidemic in British India, Ottoman doctors reproduced long-held ideas of plague as an insidious disease: "the plague virus eludes the best efforts of struggle [against it], it annuls the effects of [our] best efforts and it awaits for the most favourable moment, unknown until now to science, for emerging out of its slumber so as to assume its morbid progress."[33] Yet a key question remained: Did the disease retain or lose its force as it distanced itself from its original "soil"?

In the course of the June 30, 1899, session of the Imperial Medical Society in Istanbul, Dr. Stekoulis, the Dutch delegate to the Quarantine Council, expressed an opinion that would come to dominate Ottoman epidemiological reasoning. On the one hand, he defended the view that plague was "a disease of the soil in the same way that cholera is a disease of water," stressing the mediating role of the rat as a "multiplier of the disease."[34] On the other hand, observing the relatively "benign" character of the Alexandria outbreak, he speculated that, as the disease moved further and further from its point of origin or foyer (be that, in his mind, Hong Kong or Bombay), it lost its force and became more and more attenuated.[35]

Such theories and questions would assume particular epistemic and practical importance in light of an incident involving the boat *Polis Mytilini* in the port of Trieste in November 1899, which would destabilize the provenance of boats as an epidemiological datum and challenge prevalent notions of what constituted effective quarantine measures against plague. The boat had sailed from Istanbul and reached Trieste on October 28, after stopping at several Greek and Ottoman ports. There, a sailor reported sick with bronchial catarrh. Soon after being admitted to hospital, he developed red spots in his abdominal area and lower limbs, leading to the suspicion of typhoid fever. The patient was put in isolation where he died on November 4. Autopsy, however, seemed to confound the original diagnosis, with the presence of pyaemia leading the doctors to suspect plague instead, a suspicion confirmed by bacteriological examination.[36] What was more worrying than the rather common initial misdiagnosis, however, was the fact that the ship had not sailed from a contaminated harbor. Though seemingly an isolated incident, the *Polis Mytilini* case was catalytic in promoting calls for the deployment of maritime fumigation in the Ottoman Empire.

In the November 24, 1899 session of the Imperial Society of Medicine, Stekoulis analyzed the report sent to the Board by Dr. Stiepovich and related that the captain of the ship reported a curious fact:

> Two men having descended into the hold in order to disinfect it fell almost dead. We removed them and brought them back to life, after which we aerated the hold and wanted to remove drums containing molasses. At that moment, we perceived the presence of a large number of rat cadavers. It was without a doubt the emanations from the fermentation of the molasses in the drums, mainly carbonic acid, that provoked the asphyxiation of the rats.[37]

This bizarre incident led Pierre Apéry to comment: "We should profit from this accident for crafting a method or means for destroying rats in boats' holds. In effect, this acid unites all advantages: it is non-inflammable, inodorous, more dense than the air and does not damage goods."[38]

Apéry was the scion of one of the most powerful pharmacist families in Istanbul. Founder and editor of the two leading francophone Ottoman medical journals, *Revue Médico-Pharmaceutique* and *Gazette Médicale D'Orient*, he was also the inheritor and owner of the Grand Pharmacie in Galata, where, on account both of its products and well-stocked international library, Istanbul's medical elite flocked.[39] An investigative mind, Apéry had already noted that the *Polis Mytilini* incident appeared to be operating on the same chemical process identified sixty years earlier by Alfred Swaine Taylor as the principle behind the then very popular volcanic tourist attraction of Grotta del Cane in Foro di Pozzuoli. There, in a cruel spectacle that formed a popular part of the "Grand Tour," dogs were introduced in the Neapolitan cave (figure 3.1) so that the spectators could watch them suffocate and die from exposure to CO_2.[40] Apéry concluded that carbon dioxide could be artificially manufactured for deratization, especially onboard ships, and with the purpose of eradicating plague. In his opinion, carbon dioxide was especially fit for that purpose given the inefficiency of rat poisons and the odorous nature of other fumigating agents, which, he argued, led rats to seek refuge in their nests or outside of the hold, beyond the

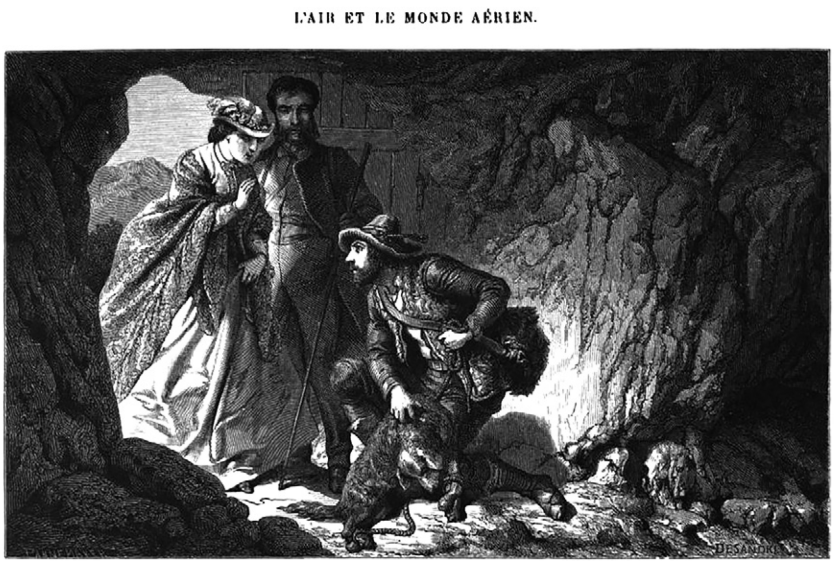

Figure 3.1
The Neapolitan Grotta del Cane.
Source: Arthur Mangin, *L'air et le monde aérien* (Tours, France: Alfred Mame et fils, 1865), 162. Wikimedia Commons.

reach of the gases.[41] A few months later, in a session of the Imperial Society of Medicine on May 11, 1900, Apéry presented his thoughts on CO_2 as a means of deratization of ships in a systematic manner, attributing its inspiration directly to the *Polis Mytilini* captain's comments on the molasses incident.[42] In the context of plague having made new ravages in Arabia and in Egypt, Apéry argued, the destruction of rats on board of ships, which had for long "preoccupied the attention of commerce, navigation and sanitary science," became all the more pertinent.[43]

Apéry stressed that, by contrast to sulphuric acid, which was produced by burning sulphur directly onboard ships, carbonic acid is odorless and thus imperceptible by rats.[44] But most importantly, he noted that, if placed inside a large glass bottle where carbon dioxide was then inserted, rats died after eight minutes, with rat cadavers being preserved in a good state inside the gas for even one week, without putrefaction if the bottle was well sealed. This was considered a distinct advantage as it meant that rat cadavers would not contaminate merchandise and especially foodstuff carried in the holds of the boat before being discovered and removed. It thus allowed, first, for holds to be fumigated without goods being unloaded, and second, for a relative delay in the discovery and removal of all rat cadavers following the operation, commonly by simply throwing them into the sea. As a result, if that method were to be applied, in most cases at least, rat removal could wait until after the boat had reached its destination and goods had been unloaded onto the docks—a distinct advantage from a financial perspective and in light of the broader urge to minimize detention time.

Faced with critique by members of the Society that the removal of rats after the application of the gas would be practically impossible, Apéry responded that his method first immobilized and then killed the rat, thus not allowing it to seek refuge in the structural gaps of the boat, like other methods did. A more pertinent critique related to the production of the necessary quantity of carbon dioxide, which, in the words of Dr. Leon Fridman "would require mountains of chalk or marble."[45] Fridman explained: "for a cubic meter of carbon dioxide we need more than 2 or 3 kilos of chalk and equal amount of sulfuric acid."[46] Hence a hold containing up to 16,000 cubic meters would require more than forty-eight tons of chalk to kill the rats lying therein. Apéry retorted that in the case of *Polis Mytilini* just a few drums of fermenting molasses sufficed to kill the rats in the boat's hold.

Reminded by the presiding Dr. Spyridon Zavitziano (the US delegate to the Quarantine Council) that nobody had performed a chemical examination of the rat corpses in said boat, and hence their cause of death remained speculative, Apéry returned to the subject in the session of the Society a week later (May 18, 1900) so as "to provide satisfaction" to Fridman's observations.[47] Taking as the hypothetical volume of a boat's hold Fridman's aforementioned 16,000 cubic meters, Apéry asked how much marble it would actually take to produce the needed CO_2. He calculated that it would indeed require 68 tons, but, at a medium density of 2.7, this would represent no more than 25.5 cubic meters—only 1/640 of the overall volume of the hold in question. Hardly thus a "mountain" of marble, as Fridman had originally maintained. Moreover, Apéry argued that only a tenth of the hold had to be filled with CO_2 for fumigation to be effective, and thus the necessary and sufficient volume of marble for this operation would be drastically reduced to only 6 or 8 tons; a space occupying no more than 2.5 cubic meters. Fridman did not leave this syllogism uncontested: "If carbon dioxide accumulates entirely at the bottom of the hold, being almost in a pure state, I do not see how the air, free from carbonic acid in the beams, can kill the climbing rats there."[48] Moreover, in order for the antiputrefaction effect described by Apéry to be operative, Fridman argued, it would not suffice to simply generate enough gas to asphyxiate the rats; it would instead require a total replacement of air by carbon dioxide, something that could only be brought about by large quantities of calcium carbonate and sulphuric acid, with the help of enormous machines for the production of CO_2.

Apéry had himself considered the use of mechanized pumping of his gas into the boat holds, with the help of a Kipp generator and of a rubber tube, which would bring the gas down to the holds where it would circulate by means of properly arranging corridors between merchandise before the start of the fumigation process.[49] And yet he angrily confronted these objections, claiming that his suggested quantities "mathematically" sufficed both for asphyxiating all rats in the holds and in preserving them from putrefaction; indeed an effect that, he argued, could be brought about simply with the help of "a few enameled basins" containing "pieces of marble," and certainly not necessitating the employment of big machines.[50] Pressed by his colleagues to provide a more satisfactory description and demonstration of his method, Apéry announced that "one of the most honourable navigation companies" of Istanbul (he did not clarify which one) had expressed its interest in putting a boat at his service for applying his deratization process.[51]

In spite of this commercial interest in it, Apéry's method faced a severe limitation. This was pointed out by the member of the Belgian Royal Academy of medicine, V. F. J. Desguin, with whom Apéry maintained a heated argument: besides its deratization properties, the method had no disinfecting ones.[52] This meant that, even after deratization had been successful, any "infected cargo" still needed to be destroyed or disinfected by other chemical agents. Desguin presented Apéry with a real case, which illustrated the problems posed by this: When the steamer *Berenice* arrived from Canton into the port of Trieste, in December 1899, four reported cases of plague among its crew led it straight to the harbor's lazaretto. Composed of over thirty-five tons of coffee, the boat's cargo was worth more than two million Austrian florins. Although it had not been in contact with the crew, the cargo immediately became the object of sanitary contestation. While sanitary authorities proposed disinfection, the city's population demanded the incineration of the coffee sacs. In this dire situation, what good would Apéry's deratization method be? Desguin reasoned that "it would modify in nothing the embarrassing situation in which we find ourselves."[53]

It is thus indicative of the need to arrive at some practical solution, however incomplete, that in spite of this obvious limitation and the universally agreed importance of combined disinfection and disinfestation at the time, Apéry's method soon received broad international recognition and endorsement. The Superior Council on Public Hygiene of Belgium brushed aside Desguin's objections and his proposed alternative (deratization via carbon monoxide) so as to accept Apéry's method as "the most rational and most practical."[54] Apéry's method appealed even further afield, with the Liverpool Board of Trade declaring it the most reliable method for rat destruction in its circular "On the Influence of Rats in the Propagation of Plague" in the autumn of 1900. The Board even suggested some practical amendments to the method: placing pieces of cheese at the center of the hold so as to attract rats before introducing the gas.[55]

At the same time, and in light of a chain of new plague cases observed in Smyrna in the spring and summer of 1900, the Ottoman's Empire protection from plague assumed new importance. The fear was that Smyrna could turn into "a foyer of plague."[56] When, "finally," in September 1900, Istanbul "had also the honour to be visited by plague," the inability to trace the origin of the infection of the patients (all of them passengers of the steamship *Niger*) troubled medical authorities.[57] Indeed the German delegate to the Quarantine Council, Dr. Andreas David Mordtmann, saw this as no less than a proof of the "complete bankruptcy" of the quarantine and cordons system.[58] These measures, he claimed, were both totally inefficient and economically disastrous: "The reform of the methods of defense against plague become day by day more urgent."[59] A similar opinion was echoed a month later when Stekoulis, celebrating the cessation of plague in what he saw as the three foyers of the disease in the Ottoman Empire (Smyrna, Beirut, and Jeddah), claimed that this was brought about by the implementation of local measures against the disease (isolation and disinfection)—the only "rational ones against an epidemic."[60] This was explicitly contrasted to quarantine, which was portrayed as an economic affliction in its own right, often graver than plague itself.

Key to the antiquarantine stance of the Society, and the subsequent call for reform of international regulations, was the oft-repeated belief that modern plague was dissimilar to plague in historical times; the main difference allegedly being that once the former distanced itself from its point of origination, it lost its virulence, assuming an attenuated or even "benign" form, as the recurrent but sporadic cases of the disease in Istanbul appeared to have confirmed.[61] However, as we have already seen, this epidemiological reasoning entailed an important contingency. The same medical authorities that maintained the nonvirulence of "distanced" plague also argued that plague was an "insidious" disease, which, on the one hand, remained largely unknown to scientists, while, on the other hand, retaining a capacity to assume its famous "frightening forms" once it had "found the necessary conditions."[62] Plague, it was argued, even when in an attenuated or benign state, hung above the Empire like Damocles' sword, ever ready to assume "its terrible side."[63] This double rationality put center stage the rat, whose role as the main carrier of the disease rendered quarantines "chimeric," urging their replacement by a "rational" system of deratization.[64] The question of quarantines was extensively discussed at the session of the Imperial Society of Medicine on November 29, 1901, under the presidency of Stchepotiew, where Mordtmann's positions on the "chimeric" nature of quarantine and the need to "bury" it, as more harmful than plague itself, were fully adopted. Stchepotiew went as far as to express the opinion that the imposition of quarantine measures against neighbouring countries are "a means of war in a time of peace."[65] Stchepotiew largely reflected a century-long tradition of mercantilist logic when he stressed that "movement is life" and that the best prophylactic against disease is the fortification of individual organisms against it.[66]

Apéry's ambition to promote his method was nested in this debate, with the editor of the *Revue Médico-Pharmaceutique* pondering "why we persist in destroying [rats] in the holds of boats by primitive processes such as sulphuric acid and other gases [which are] deleterious and more or less ineffective"; "a little less routine," he stressed, "and a little more of practical experimental spirit" and the superiority of carbonic acid "would be recognised as one of the most useful developments in naval hygiene."[67] However, we need to pay close attention to Apéry's stance toward quarantine here. As we have already noticed, his method involved deratization but not disinfection. Apéry was sceptical as regards the ability of disinfection to abolish the time-wasting and trade-hampering necessity of quarantines. This position made him very unpopular with his colleagues. Already in an editorial published in the *Revue Médico-Pharmaceutique* on November 1, 1901, Apéry openly doubted the effectiveness of disinfection, claiming that, in any case, "the germ will escape in 50 out of 100 times, often lodging where disinfectants cannot reach it" so that it might reappear when least expected.[68] The supposedly elusive, "hiding" character of plague, as well as other diseases at the time, needs to be once again underlined here. For in Apéry's ontology of the disease, this was not simply one of its traits, but instead a mechanism of nature itself aimed at "saving the race of the microbe."[69] The only solution under these circumstances would be to act as one does in any situation of war against the stealthy attack of the enemy: "to set up sentinels" who can open fire at the first sight of our foes.[70] These sentinel devices, Apéry argued, were no other than quarantine, which could push back any surprise attack. This perhaps marks the earliest instance when a proponent of fumigation openly declared disinfestation to be the sole aim of fumigation and an adequate measure against plague. Yet for Apéry this could only work in combination with quarantine as a sentinel device.

It was not long before this opinion clashed publically with prevailing ideas about quarantine in Istanbul. In the session of December 13, 1901, Apéry staged a small revolt against the antiquarantine line dominating the Society at the time. Apéry's stance on the question of quarantine was rather more nuanced than the one of Stekoulis or Mordtmann, whom he reminded that while they were ridiculing the idea of quarantine they were equally accepting the hospital or home-based isolation of the sick. In which way did the two practices differ in principle?—"Is it the word quarantine which frightens you?" Apéry asked.[71] If you think, he argued, that disinfection methods can abolish quarantine, should we also abolish the isolation of the sick? This abolition doctrine ignored the limited efficacy of disinfection, a method that was effective, in Apéry's mind, only in combination with quarantine and isolation. If his colleagues were right, Apéry reasoned, in stressing the harmful effects of quarantine, what was needed was to improve existing lazarettos, not to abolish them: "in order for commerce to profit it is not right for the merchant to perish"—for, "if movement is life," Apéry argued (referring back to Stchepotiew's antiquarantinism) "it is this movement too which is the cause of death."[72]

Apéry thus struck a middle-ground approach that saw maritime fumigation as a synagonistic rather than antagonistic partner of quarantine. Arguably this stance was miscalculated, for while his fumigation method was hailed by several quarters as successful, it ultimately failed to galvanize support from parties aspiring to an end of quarantine, and the liberation of maritime trade in the Mediterranean and the Red Sea from its politically susceptible time delays. By contrast, one of the key supporters of Apéry's method was the Ottoman court, which was anxious to maintain its system of quarantine control in spite of technological revisionism. At the international congress on maritime security held in August–September 1901 in the Belgian port of Ostand, Apéry's method was unanimously voted as the superior maritime deratization method in existence.[73] If in practice this was an endorsement of little practical effect, Apéry still capitalized on it as it attracted the attention of the inspector-general of the Ottoman Department of Sanitation and plague expert, Cozzonis Effendi, who in a letter to Apéry informed him that the Quarantine Council had decided to conduct an experiment with his deratization method with the help of the inspector of the Quarantine Council, Dr. Charles Zitterer.[74]

Soon after, Apéry received another endorsement, this time from the Sultan's chief chemist and general inspector of public hygiene, Bonkowski Pasha.[75] This lengthy and extremely flattering letter expressed the pasha's warmest congratulations for the international success of Apéry's method, and for his ingenuity in having derived the method from the *Polis Mytilini* incident. Bonkowski informed Apéry of his keen interest in the method and his belief that only CO_2 fulfilled all the desired goals of deratization without any of the usual disadvantages of other gases or methods employed on board of ships. Then, on December 30, 1901, the members of the Constantinople Board of Health as well as of various embassies and legations to the Ottoman capital received an invitation by Apéry to witness the demonstration of a rat destruction method on board of *Chios*, a Greek vessel belonging to the Aegeum Company (*L'Egée*). By the time of the experiment, Apéry had revised his previous, rather simple method of producing CO_2 by means of adding acid, such as hydrochloric acid to any carbon, such as marble, on the upper hold corridors. Instead he proposed the use of large CO_2 generators, such as the Hermann Lachapelle machine (usually used to produce steam but which Apéry thought could be retrofitted to generate CO_2 with the help of sodium bicarbonate and SO_2), either placed on piers or on smaller boats and connected to the ship's hold by means of tubes. However, Apéry maintained that the most practical solution would be to use liquid CO_2, as was the case in Marseilles. The experiment on the *Chios* appeared to be successful insofar as the rats placed in different parts of the hold were all found asphyxiated after two hours of fumigation.[76] However, as Franck Clemow, the British delegate to the Quarantine Council and plague enthusiast, noted, the experiment crucially failed to show whether the gas could reach every nook and cranny of a fully loaded hold by its own weight, leaving no place where the rats may seek refuge.

If the history of technological innovation in the late Ottoman Empire remains an underdeveloped field, the story of Apéry's fumigation method points out the way in which technoscientific debates about the relation between disinfection, disinfestation, and quarantine lay at the heart of Istanbul's emergent biopolitical apparatuses. Central to the turn toward a technoscientific management of maritime trade's public health aspects was the inclusion of animals, rats in particular, in the problematization of human health. Accounting for the swift adoption of what we would today call a zoonotic perspective of plague by Ottoman public health institutions at the end of the nineteenth century, when similar institutions in the West maintained a much more hesitant position as regards the import of human–animal interaction as regards the unfolding pandemic, requires an analysis of late Ottoman perceptions (both lay, religious, and scientific) of nonhuman animals that cannot be carried out here.[77] What is important, in terms of our study of the history of maritime fumigation, is that setting the rat and its destruction at the center of antiplague control measures allowed Ottoman authorities to develop technologies that could compete with European (and indeed North American) methods of maritime sanitation, challenging the view (both historical and contemporary) that Ottoman power simply relied on antiquated regimes of quarantine.

This was all the more important, as on the other side of Europe, in Hamburg, a fumigation technology was being developed to protect newly unified Germany against plague. Also carbon-based, but embodying distinct engineering and chemical principles, this was a maritime technology that would also place the rat at the center of its destructive attention.

Nocht's Hamburg Experiments

In the summer of 1892, Hamburg was hit by a cholera epidemic, leading to over 15,000 cases and over 8,000 deaths. The extent of the outbreak was so shocking that Robert Koch himself remarked that the sight of devastation made him "forget that I am in Europe."[78] As Richard Evans has described in great detail, the 1892 cholera epidemic marked a watershed in the public perception of bacteriology and hygiene.[79] Koch, like others before him, had shown that the cholera bacillus was water-borne. But Hamburg's miasmatists denied that the disease could have such a simple and unicausal origin. In any case, they argued that Hamburg's piped water system was new and efficient. But it was precisely the centralized but badly filtered piping system that had led to the outbreak's catastrophic dimensions. When Koch, sent to save the city, took charge, he dealt a fatal blow to both miasmatic theory and the cholera outbreak by cutting the water supply to the affected areas and by propagating strict boiling of all drinking water.

The city officials, impressed by the rapid success of Koch's intervention, reacted fast. In September 1892, a student of Koch, Georg Theodor August Gaffky, was elevated to the rank of hygienic counselor to the city and immediately set up a hygienic laboratory. Another successful student of Koch, Bernhard Nocht, at the time drafted to the German navy, proposed the installation of a permanent port physician at Hamburg's busy harbor. The city followed his suggestion and created the position, which Nocht filled himself from 1892 to 1906.

Since his nomination as port physician in the aftermath of Hamburg's cholera epidemic, Nocht aimed to establish a rigorous system of protection against the importation of diseases. Already in 1894, he complained about the lack of progressive chemical solutions, specifically designed to be applied in ships with the purpose of killing not only pathogens but all possible vectors in the hull of vessels as well as in the cargo itself. Nocht considered the application of sulphur as pointless, as he was convinced that its properties did not allow it to penetrate surfaces or densely packed goods.[80] While his early experimental procedures were heavily influenced by the threat of cholera importation, and were thus dedicated to the successful disinfection of bilge water, he would later dedicate years of work to the protection of Hamburg against plague and consequently against the importation of rats. In 1897 he published his concerns on the matter, stressing two points: a) that a simple translation of anticholera procedures would not work against plague, and b) that reinstatement of general quarantine against plague would neither provide the desired protection nor justify the immense economic cost.[81] Instead, as the recommendation from the 1897 sanitary conference in Venice stated, the focus should move toward the possible transmission of plague through rats. Yet, "the destruction of rats and mice on board," Nocht wrote in 1897, "still remains an unsolved task."[82]

At the time, vessels arriving from non-European ports were required to perform deratization upon each arrival at Hamburg, whereas vessels visiting the port on regular basis from European ports were only required to perform deratization every three months. Boats plying the River Elbe were required to perform deratization once a month.[83] The process was two-fold, comprising in combined rat-catching or poisoning, and fumigation. The former was applied to passenger and crew cabins and other small compartments, with the help of professional rat-catchers (so-called Kammerjäger). Although a respected profession, the method yielded quite mediocre results, as many rats managed to escape the hunters, whereas traps were not always effective in bringing the rats out of their hiding places in ships. Following rat-catching, the hold of the vessel was fumigated "after the receipt of the written permission of the chief harbor master, under the supervision of the harbor police."[84] Taking place directly at the place of disembarkation (and not in quarantine stations or lazarettos), fumigation proceeded after unloading the cargo, and was thus applied to empty holds. The usual process involved the burning of sulphur and charcoal in iron pots. At twenty and ten kilos respectively for every 1,000 cubic meter area, these were placed in the lower parts of the holds and burned for ten hours. An alternative method, used in cases where quicker processing was required, was the use of a newly invented chemical compound, called Pictolin.

Invented by the Berlin-based Swiss physicist, Raoul Pictet, Pictolin consisted of sulphur dioxide and 3 to 4 percent carbon dioxide and was liquefied under pressure and then delivered in iron bombs. Comparable to the Clayton machine, it was introduced into the holds of vessels via a system of generators and tubes. With twenty kilograms of Pictolin, about 1,000 cubic meters of space could be freed of rats. It was originally invented to further Pictet's development of fridges and refrigeration technologies. It was its surprisingly efficient capacity in killing rats—probably due to its high ratio of sulphur dioxide—that led it to be included in German disinfection efforts. Its unique stench promised an additional layer of safety for humans, as its presence was (unlike that of carbon dioxide) clearly recognizable. Once a Pictolin "bomb" was opened, it operated by quick evaporation, leading to the replacement of air with its asphyxiating gas. The gas was usable only on empty holds, with noninflammable properties, a trait that was a great advantage in spite of the greater cost of the process.[85]

Nocht had amassed a prestigious amount of experience in India, where he had worked with Robert Koch, and developed a keen interest in the emerging discipline of tropical medicine.[86] Chief Medical Officer of the Harbour of Hamburg since 1893, he became eventually the director of the newly founded *Institut fuer Schiffs-und-Tropenkrankheiten* (Institute for Maritime and Tropical Diseases, from October 1900). As his field of expertise enjoyed institutionalization, he was keen to also set methods of fumigation on sound scientific grounds. Instead of trusting the already established methods of deratization, in 1899 he began to devise a more sophisticated system to destroy rats on ships, using a mixture of carbon monoxide and carbon dioxide.

A fundamental problem with Pictolin at the time was not only the enormous cost involved, but also its inconvenient nature as regards a long list of valuable merchandise. To fumigate with Pictolin, Nocht remarked, required the merchandise to be fully unloaded, which posed a risk of escaping rats, and required additional methods to disinfect the merchandise by other means.[87] Instead, Nocht developed and refined his own method of utilizing

CO_2. In close collaboration with Robert Koch, who was interested in ascertaining the best fumigation method, Nocht undertook various experiments from 1899 onward, employing gas produced by the reaction of hydrochloric acid on marble. The looming question for Nocht concerned the correct density of the gas for arriving at the desired result: disinfestation. Although the Hamburg experiments with CO_2 were conducted even before reports of the *Polis Mytilini* reached the German port city, Nocht remained critical of Apéry's method of testing the asphyxiating quality of the compound. To sink little candles into the holds of fumigated ships and to judge upon their expiration whether the amount of oxygen was sufficiently low, seemed to Nocht inconclusive when testing the gas's capacity to kill rats. Apéry's reports, Nocht complained, did not provide detailed or systematic descriptions of experiments, which could be repeated and tested with similar configurations in different places. Furthermore, Nocht considered the use of carbon dioxide as problematic, as its gaseous distribution was difficult to maintain and progressed only very slowly.

Instead Nocht aimed to bring fumigation into more sustainable application with a special mixture of CO and CO_2: Kohlenoxydgas. The gas had no smell, it did not damage the merchandise, yet it was poisonous enough to be lethal even in small dosages. Furthermore, it was distributed rapidly and led to a quick onset of paralysis in rodents before their imminent death. Nocht initially tested the introduction of 20 percent CO_2 into a loaded hold, where cargo was estimated to be occupying 50 percent of the total hold volume. A few years later, the 1903 report of the International Sanitary Conference in Paris detailed his experimental setup:

> He had three hundred rats enclosed in cages in the empty holds of a large boat, *Bulgaria*. These cages were distributed on different points and were entirely covered with mattresses, bags and similar objects piled up on a large height. Other cages were placed in holes. The generating gas containing carbon monoxide was then sent and all the rats were killed. This experiment was renewed with liquid sulphurous acid, but then the rats remained alive.[88]

In the years to follow, Nocht refined and improved his system of CO_2 fumigation, and in 1903 he published a lengthy report, which demonstrated the superiority of his apparatus in comparison to the Clayton machine but also to other CO_2-based methods tested by Haldane in the UK.

Nocht's fumigation machine was built in collaboration with the Berlin-based J. Pintsch Company and was installed on a floating platform

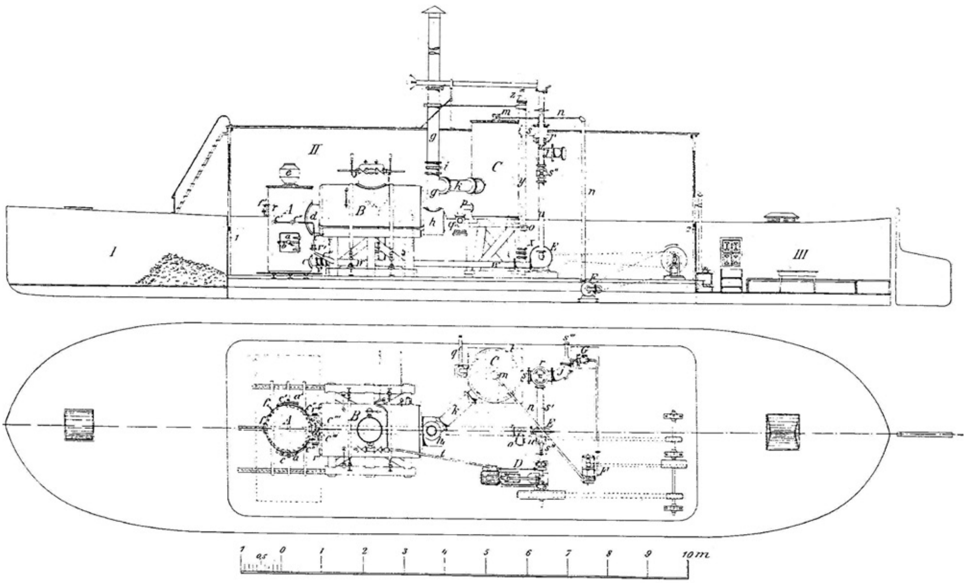

Figure 3.2
Plan of Nocht's fumigation machine.
Source: Bernhard Nocht and G.Giemsa, "Über die Vernichtung von Ratten an Bord von Schiffen. Als Massregel gegen die Einschleppung der Pest," *Arbeiten aus dem Kaiserlichen Gesundheitsamte* XX, no. 1 (1904): 98.

(figure 3.2). The aim was to provide enough gas of the highest quality, to succeed in the total eradication of rodents, but to also provide a mixture that would prevent the gas from becoming an explosive compound ("Kohlenoxydknallgas"). As it was produced in a simple generating furnace, Nocht called his invention "Generatorgas."

The gas was produced by burning charcoal through the injection of large amounts of oxygen. Part of the heat was used to operate a steam engine to drive a water pump and a ventilator. The apparatus was able to inject gas, as well as to suck the remaining gas out of the holds of vessels. After the gas was generated in the furnace, it was cooled and cleaned through steam and sprinkling water. The gas was designed to have at least twice the amount of CO_2 compared to CO and was thus considered to be noninflammable.[89] The average proportions were 4.95 percent CO, 18 percent CO_2, and 77.05 percent N. The introduction of the gas into vessels was carried out in comparable manner to the existing practices of the Clayton machine: The apparatus would be attached to the existing vessel-borne tubes, while all openings were roughly closed with fabrics and cushions (figure 3.3). The only substantial difference was to be found in the imminent and lasting danger of the undetectable gas, which was, even at a 0.5 percent density, capable of leading to substantial poisoning and possible death in humans. Recommendations were therefore given for an extensive circulation of fresh air and for testing the safety of the holds through mice, lowered down to the holds inside cages.[90] Detailed experiments with infected rats in ships like the *Bulgaria* would prove that the apparatus was capable of destroying all rats and mice in every part of the vessel, even in hiding places under large quantities of goods of all kinds. Being absolutely nonhazardous to goods, holds, and the vessel's structure, the Generatorgas had proved, so Nocht claimed, to be the best instrument against the introduction of plague.[91]

However, a persistent problem with the machine was its tendency to leak gas at various points within the piping system. Due to the lack of smell and visibility, the leakages led to a series of dangerous incidences including three fatalities. This prompted Nocht to redesign the apparatus, allowing for the gas to be less pressurized inside the machine, owing to an improved arrangement of the exhauster. Passed Assistant Surgeon Victor G. Heiser from the U.S. Public Health and Marine-Hospital Service observed the apparatus in 1909 and reported his favorable impressions. In particular, the capacity of the machine to produce over 3,000 cubic meters of gas per hour was noteworthy, especially in combination with the low cost of material required to generate the gas from coal. Heiser particularly emphasized the utility of the apparatus for all cargo that was shown to react unfavorably to fumigation with sulphur, including camphor, silk, and tea, as these appeared to be left unharmed by the Generatorgas. Most importantly, the machine seemed to be fulfilling its prophylactic purpose: being used in the fumigation of twenty-one plague-infected vessels and leading to the death of 171 verified infected rats, it was praised as the reason why not a single human plague case had been reported in Hamburg.[92]

Ottoman and German carbon-based fumigation technologies consolidated the rat as the prime target of maritime fumigation well before the particular animal had been scientifically stabilized as a host of plague. Yet lacking a mechanically sophisticated application, Apéry's machine never competed with other fumigation apparatuses on the global stage.

Figure 3.3
Photograph of Nocht's fumigation process applied to a vessel in the port of Hamburg. Source: Bernhard Nocht and G. Giemsa, "Über die Vernichtung von Ratten an Bord von Schiffen. Als Massregel gegen die Einschleppung der Pest," *Arbeiten aus dem Kaiserlichen Gesundheitsamte* XX, no. 1 (1904): 106.

By contrast, Nocht's machine was to become the main rival of the Clayton machine. In this way these two carbon-based fumigation technologies brought together quarantine, disinfestation, and disinfection in ways that catalyzed technoscientific visions of maritime sanitation that would dominate European visions of hygienic modernity in the opening decades of the twentieth century.

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Sulphuric Utopias

A History of Maritime Fumigation

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