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Jade Maestas
College of DuPage

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by Jade Maestas

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Philosophers and scientists throughout recorded history have attempted to explain the cause of disease and its spread. From the mystical to the mundane, humanity has placed the blame for pestilence on a myriad of debunked sources, including witchcraft, demons, comets, and earthquakes (Karamanou et al. 58). Championed by notable historical figures such as the ancient Greek physician Hippocrates and the celebrated 19th century nurse Florence Nightingale, one such prominent theory of disease held considerable sway around the world for centuries: miasma theory (UCLA Department of Epidemiology, "Prevailing Theories of Cholera"). Though now superseded by germ theory, distinguished physicians and laypeople alike once ascribed to the idea of miasma, or "corrupted air," as an explanation for the existence and spread of diseases.

Texts originating as early as the fifth century, such as those found in the collection of ancient Greek medical works known as the Hippocratic Corpus, warned of miasma and its connection with disease (Van der Eijk 119). According to the theory, air could become polluted with toxic vapors (Karamanou et al. 58). When inhaled, this "miasmatic" air could cause disease within the body (Halliday 1469). Allegedly, the toxic vapors typically arose from decaying organic material or stagnant, foul-smelling places. As such, sources of miasma were supposed to include rotting vegetation, sewage, marshes, swamps, stagnant water, ditches, deep valleys, cracks in the earth, and corpses (Sterner 3; Halliday 1469; Van der Eijk 130). In 1349, Spanish-Arab physician Ibn Khatimah advised that foul odors, specifically, indicated the presence of miasmatic air (Sterner 3). Further, ancient Greek and Roman physicians like Galen of Pergamon and Hippocrates taught that miasma could spread from one area to another via wind (Jones 109-110). Stagnant mists and fog, too, were often considered forms of miasma. For example, Chinese scholars in the Sui Dynasty called the concept "zhang" and attributed malaria and other maladies to the supposedly pathogenic gas produced by mists around mountains and creeks (Zhu 384).

Later, medieval writers referred to the same concept as pestilential, putrefied, or corrupted air, and many cited it as the source of the various plagues that occurred throughout the time period, including the bubonic plague known as The Black Death (Sterner 2; Jones 112). "Marshes, sluggish waterways, damp and dark valleys in the countryside and slaughterhouses, tanneries and garbage heaps in the cities were accepted as potential local sources of disease because of their propensity to generate corrupted and foul-smelling air" (Jones 111). At the time, medical recommendations included instructions to avoid such places and odors and even to remove toxic smells from the air with the use of sweet or strong-smelling fragrances (Hardin Library for the Health Sciences; Jones 111). The bird-like masks associated with plague doctors of the medieval ages are a testament to this advice. The "beak" of one such mask would act as a respirator, filtering the air with "dried flowers (e.g. roses or carnations), herbs (e.g. mint), spices, camphor or a vinegar sponge" (Hardin Library for the Health Sciences). Informed by the miasma theory of disease, civic regulations attempting to improve cleanliness levels were also increasingly enacted in the hopes of limiting miasma production (Jones 111).

The scholars and philosophers who promoted miasma theory largely subscribed to it because of the observation that epidemic diseases seemed most prevalent in dirty, undrained, and foul-smelling areas (Richards 1). In the earlier centuries of recorded human history, the drainage of swamps and removal of corpses from populated areas seemed to improve public health (Curtis 13).

Later on, paved streets, sewers, clean-smelling water, ventilation, and garbage disposal methods were consistently associated with a reduction in disease rates (Nikolova, 540). The success that drainage, waste disposal, and cleanliness measures appeared to have at reducing rates of illness seemed to support the idea that waste, decay, and stagnant mists were in some way related to disease.

With miasma theory at its heart, the sanitary movement of the 19th century revolutionized public sanitation, particularly in Europe and the United States (Pizzi). At first, the success of the movement seemed only to further support the theory of corrupted air. During this time, epidemics rampantly spread throughout concentrated urban areas, seemingly in correlation with the increased filth brought by higher populations and increased urbanization (Pizzi; Committee for the Study of the Future of Public Health 58-59). Yet much success was eventually achieved in controlling these epidemics due to the efforts of sanitation reformers throughout the century. In 1842, Edwin Chadwick, a prominent British sanitary reformer, published his influential *Report on the Sanitary Condition of the Labouring Population of Great Britain*, which called for the implementation of significant sanitary improvements, such as house drainage systems to remove corrupted sewage gas from within and around homes (Halliday 1469). His ideas eventually resulted in a marked improvement of the area's rates of disease and general wellbeing (Boston University School of Public Health). Not long after, in the United States, Lemuel Shattuck proposed a comprehensive plan for public health systems inspired by Chadwick's efforts in Europe (Pizzi). Though not immediately influential, his proposals revolutionized public health systems in the country when they were eventually adopted (Committee for the Study of the Future of Public Health 61). Around that same time, Ellis Sylvester Chesbrough, another proponent of miasma theory, introduced sewage systems based on European models in Chicago, drastically improving public health in the city (Pizzi).

Toward the end of the century, another prominent sanitarian by the name of Colonel George E. Waring overhauled New York City's street cleaning and garbage disposal methods, transforming the city's streets from some of the dirtiest to some of the cleanest in the world at the time (Pizzi). Waring also promoted his beliefs about "sewer gas" as a cause of disease, and, largely in an effort to curb yellow fever epidemics, he furthered the adoption of standard flush toilets and wide-ranging sewage systems throughout the United States and Cuba (Pizzi). Though the efforts of the 19th century sanitation reformers successfully reduced instances of many diseases, they made little progress against yellow fever. Despite following Waring's advice to rid the city of filth and sewer gas, for example, yellow fever outbreaks persisted in Havana, Cuba (Pizzi). Major Walter Reed later proved that the disease was transmitted by mosquitos, delivering just one of several significant blows to miasma theory's credibility (Pizzi).

While investigating an 1854 cholera outbreak in London, physician John Snow observed that the mortality rate of persons consuming water from a particular water pump on Broad Street was notably higher than in other affected areas, and he convinced the locals to remove the pump handle (Halliday 1470). Snow attributed the subsequent reduction in cholera deaths to the removal of the water source (Halliday 1470). This implied that it was the water itself that had transported or caused the disease, not corrupted vapors. His conclusions were rejected, however, by a committee headed by William Farr and appointed to investigate Snow's claims (Halliday 1471). The committee concluded:

> In explanation of the remarkable intensity of this outbreak [Broad Street Pump outbreak] within very definite limits, it has been suggested by Dr. Snow, that the real cause of whatever was peculiar in the case lay in the use of one particular well, situated at Broad Street in the middle of the district, and having (it was imagined) its waters contaminated with the rice-water evacuations of cholera patients. After careful inquiry, we see no reason to adopt this belief. We do not feel it established that the water was contaminated in the manner alleged; nor is there before us any sufficient evidence to show whether inhabitants of that district, drinking from that well,

> suffered in proportion more than other inhabitants of the district who drank from other sources (…) But, on the whole of evidence, it seems impossible to doubt that the influences, which determine in mass the geographical distribution of cholera in London, belong less to the water than to the air. (UCLA Department of Epidemiology, "Competing Theories of Cholera")

Undeterred, Snow published a paper in the *British Medical Journal* several years later again demonstrating a link between the consumption of sewage-contaminated water and high numbers of cholera deaths in a different area of London (Halliday 1470). However, his proposals were not widely accepted until Robert Koch's 1883 discovery of *Vibrio cholerae* bacteria provided further support for them (Halliday 1469; UCLA Department of Epidemiology, "Prevailing Theories of Cholera").

Microbes were discovered in the 1600s by Dutchman Antony van Leeuwenhoek but had not yet been connected to disease (Yong 29-32). It was not until the mid-19th century that scientists began to speculate upon their role in illness. Around this time, French chemist Louis Pasteur established that bacteria could sour alcohol and spoil meat, leading him to propose that they might also be capable of causing disease (Yong 32). While studying illnesses affecting silkworms in 1865, he isolated eggs infected with microbes and subsequently stopped the conditions from spreading, thereby demonstrating that the microbes had likely caused the conditions (Yong 32). Elsewhere, the bacterium *Bacillus anthracis* had been observed in the tissues of animals affected by an epidemic of anthrax (Yong 32). In 1876, German physician Robert Koch began the first of a series of injections that would push this "germ theory" of disease into the limelight (Yong 32). He injected *Bacillus anthracis* into 20 successive generations of healthy mice, and every mouse died of anthrax (Yong 32). In the decades that followed, scientists discovered bacterial causes for tuberculosis, typhoid, diphtheria, tetanus, bubonic plague, leprosy, and other diseases, firmly cementing germ theory as the more accurate theory of disease propagation (Yong 33). In light of germ theory, surgeons like Joseph Lister began sterilizing their instruments, equipment, and hands, reducing surgical complications from infection and still further demonstrating the theory's accuracy (Yong 33).

After decades of research into bacteria and other microbes, their ability to cause disease is now common knowledge. Acceptance of germ theory has led to even more advances in sanitation, life expectancy, and overall public wellbeing in the form of vaccines, antibiotics, modern food safety and hygiene practices, and other methods and technologies (Pizzi). While the theory of miasma may have eventually fallen to the wayside, its influence laid the groundwork for modern sanitation measures and helped to save lives during its time.

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