# The Ghost Map

## INTRODUCTION

### BRIEF BIOGRAPHY OF STEVEN JOHNSON

Steven Berlin Johnson grew up in Washington, D.C., and studied semiotics at Brown University. Later, he received his master's degree in English literature from Columbia University in the City of New York. Johnson remained in New York after completing his degree, and began working as a freelance journalist for various papers and magazines, including the New York Times. He published his first book, *Interface Cultures: How New Technology Transforms the Way We Create and Communicate*, in 1997. Since then, he's published nine other books on a variety of popular science topics, including digital technology, urban planning, and the discovery of oxygen. Perhaps his most successful book was 2005's *Everything Bad is Good for You*, in which he provocatively argued that computer games, reality television, and other forms of "low" culture were actually making society more intelligent. Johnson still lives in New York City, along with his wife and three children.

### HISTORICAL CONTEXT

The central historical event that *The Ghost Map* discusses is urbanization. In the 19th century, with the dawn of the Industrial Revolution, an increasingly large potion of the European population began living in large cities such as London. In part, this was a result of the changes in land laws, which pushed country folk off their lands and forced them to take jobs in factories. Throughout the 19th century, the population of London increased to many millions of residents, making it the biggest city in European history up to that point. With no experience managing a city so massive, London's municipal government in the Victorian era faltered again and again; there was no welfare system, no workable way of disposing of waste, and no reliable transportation system. In large part, Johnson argues, the leaders of big Western cities of the 20th and 21st centuries have been more successful in dealing with their populations because they learned what *not* to do from the Victorians.

### RELATED LITERARY WORKS

Perhaps the most important literary works to which Johnson alludes are the novels of Charles Dickens. Charles Dickens was the most popular and beloved English author of the 19th century, and his novels are remarkable not only for their literary merits but for the honesty with which they confront themes of poverty, urbanism, corruption, and industrialization. In *Bleak House* (1853), Dickens paints a miserable picture of Victorian London; in *Hard Times* (1854), he goes even further, denouncing the soul-crushing structure of the factory system. Johnson also alludes to the political writings of Karl Marx, in particular, *Capital* (1867)—which, Johnson notes, Marx composed partly during his time living in London, and which may have reflected Marx's disgust with the squalid conditions of London.

### KEY FACTS

- **Full Title:** The Ghost Map: The Story of London's Most Terrifying Epidemic—and How It Changed Science, Cities, and the Modern World
- **When Written:** 2004-2006
- **Where Written:** New York City and Washington, D.C.
- **When Published:** October 19, 2006
- **Genre:** Nonfiction, history
- **Setting:** London, mid-19th century
- **Climax:** John Snow tries to convince the local authorities to remove the Broad Street pump handle
- **Point of View:** Third person

### EXTRA CREDIT

**Tech titan.** In addition to his writing, Steven Johnson has been highly successful as a co-creator of websites, including FEED, Plastic.com, and outside.in. In the late '90s and early 2000s, Johnson was one of the reigning figures of "Silicon Alley" in New York City.

**A matter of moments.** One of the most memorable experiences of Steven Johnson's life occurred during a heavy storm in 2004. Johnson and his wife were in their house, looking out the window at the rain. A few moments later, they turned away from the window—just as the storm smashed through the glass. Had they still been standing in front of the window, Johnson reports, they could have been killed.

## PLOT SUMMARY

In the 1850s, London was the largest city in Europe, and one of the filthiest cities in the world. At a time when the majority of the world lived in rural communities, in London millions of people lived within a few miles of each other—and the city lacked a sanitation system that could deal with millions of people's garbage and waste. The sewers were often clogged with waste, and "night-soil men" made good money cleaning up excrement at night and dumping it at the edges of the city.

In 1854, a child became violently ill; the mother, Sarah Lewis, threw the baby's soiled diapers in a cesspool in the basement of her home. Soon afterwards, there was a cholera epidemic in the London neighborhood of Soho. Within a few days, dozens of people had become seriously ill. Cholera is a bacterial, waterborne disease that has existed for thousands of years, although it's only become a major killer in the modern, urban era (in ancient times, most communities weren't dense enough to facilitate the spread of the disease). When it infects a human being, cholera targets the small intestine, causing dehydration, vomiting, and diarrhea. The simplest cure for cholera is a combination of clean water and electrolytes. However, in communities without access to clean water, such as Victorian London, cholera posed a major threat.

During the 1854 epidemic, there was a priest named Henry Whitehead living near Soho. Whitehead knew almost all the families living in the neighborhood, and he traveled from house to house, speaking to the families of cholera victims.

Another important figure in the 1854 epidemic was a young doctor named John Snow. Snow had already made a name for himself as a pioneering anesthesiologist; however, he'd become interested in cholera epidemics after an outbreak of the disease in 1848. At the time, there were two dominant theories for how cholera spread—the contagion theory (that some kind of agent passed between cholera victims) and the miasma theory (that bad odors, emanating from certain environments, caused cholera, especially in people who had certain "internal constitutions"). Snow had assembled convincing evidence supporting contagion theory, and he believed that the 1854 epidemic could further strengthen his case.

Snow's conundrum was that the medical community of the mid-1800s was dead-set on miasma theory. The founder of London's influential General Board of Health, Edwin Chadwick, was a steadfast supporter of the theory. Miasma theory catered to human beings' natural instinct to associate sickness with bad smells, and it may have appealed to certain class biases in Victorian society (e.g., that poor people deserved their sickness). Chadwick's commitment to miasma theory—and his blindness to the truth about how diseases spread—led him to propose the unclogging of the existing sewer system, resulting in millions of pounds of added filth in the river Thames, which almost certainly triggered epidemics throughout the 1850s.

As the 1854 cholera epidemic continued, Snow and Whitehead each visited dozens of households in Soho and interviewed the residents in order to learn more about cholera. Snow began to realize the truth: the disease was being spread through the Broad Street water pump, the main source of "clean" water for most of the community. Snow became surer of his theory after speaking with William Farr, a prominent demographer who'd been collecting data about recent cholera epidemics. Snow also used the data to develop refutations to the popular miasma theory—for example, if bad odors spread diseases, then why had some buildings in the Soho neighborhood been almost completely spared from cholera?

Snow spoke at an emergency meeting of the board of governors at St. James's Parish, and urged the governors to remove the **pump handle** from the Broad Street well. With some reluctance, the board agreed to do so. Though the epidemic had already been dying down, Snow's actions probably prevented the epidemic from continuing any further.

A few months later, the president of the General Board of Health, Sir Benjamin Hall, announced a committee to investigate the causes of the epidemic. However, because Hall was a firm believer in miasma theory, his investigation studied the wrong factors and led to few strong conclusions. Around the same time, St. James Vestry hired Henry Whitehead to lead a committee into the causes of the epidemic. Whitehead had been opposed to Snow's argument that the pump handle be removed. He'd learned from interviewing local families that many of the people who'd *recovered* from cholera attributed their recoveries to drinking water from the Broad Street well. However, in the course of his investigation, Whitehead found himself coming around to Snow's point of view. He realized that the Lewis family had thrown soiled diapers into a cesspool which had contaminated the well, probably causing the outbreak of cholera in the community.

Around the same time, John Snow further strengthened his waterborne cholera theory. He determined that two Soho locals had sent their mother a glass of water from the Broad Street pump, and then been shocked to learn that their mother had died of cholera. He also found that Soho locals who didn't drink from the pump hadn't been afflicted with cholera. Whitehead became one of Snow's foremost advocates. However, miasma theory continued to dominate the medical community.

Snow and Whitehead's investigation into the cholera epidemic of 1854 marked a milestone in urban history: it probably represented one of the first occasions on which a municipal group had come together to make a decision for public health, based on good science and research. Snow's research set a strong precedent for the role of medicine in urban planning—indeed, in the years following the outbreak, Snow's waterborne theory became increasingly well-accepted, to the point where all European and American cities planned their sewer systems with the assumption that diseases were contagious and carried via water. Although Snow died young, long before his theories became universally accepted, his achievements arguably made possible the growth of urban populations: Western cities largely ceased to be centers of disease and filth.

In the Epilogue, Johnson discusses the future of urbanism. For the last 150 years, an increasingly high percentage of the human race has come to live in urban areas, and it seems likely that this process will continue. Two factors that may limit the

unchecked growth of cities are epidemics and terrorist attacks. In cities, epidemics spread at an exponential rate—that's why cholera killed so many people in London in 1854. And cities are practically bull's-eyes for terrorists, since so many people live so close together. If human beings are to continue living in cities, they'll have to find ways to apply their ingenuity and hard work to addressing these dangers—and they would do well to take after Henry Whitehead and John Snow.

## CHARACTERS

### MAJOR CHARACTERS

**John Snow** – John Snow, along with Henry Whitehead, is the closest thing to a protagonist in the book. A brilliant, creative thinker, Snow grew up in a working-class family, and later worked his way up to become one of London's most prominent anesthesiologists. While most doctors in Snow's position would have become complacent, Snow continued to research new topics in medicine; in the late 1840s, he became interested in cholera. During the 1854 cholera epidemic, Snow saw an opportunity to test his theory that cholera was a contagious, waterborne disease—a perfectly uncontroversial theory by 21st century standards, but one which was widely ridiculed at the time. Snow interviewed dozens of families and tested water samples from numerous households, ultimately concluding that the Broad Street water pump was responsible for spreading cholera through the neighborhood of Soho. Although Snow's contributions to anesthesiology and the germ theory of disease would each be enough to assure him a place in medical history, arguably his greatest contribution was his pioneering work in medical cartography. Snow assembled elegant, insightful maps that documented the relationship between foot traffic and the spread of disease. His work remains important in the 21st century, when preventing the spread of disease is one of the central concerns of urban planners. Snow, like Whitehead, was a brilliant, highly dedicated man, who wasn't afraid to challenge the accepted orthodoxy of the medical community. Although he died in his forties, Snow's theories of cholera eventually became as widely accepted as they'd once been controversial.

**Henry Whitehead** – Henry Whitehead is, along with John Snow, the closest thing to a protagonist in *The Ghost Map*. A talkative, beloved priest living in Soho, Whitehead was one of the first people in the neighborhood to recognize the danger of the 1854 cholera epidemic. In addition to his religious duties, Whitehead was a highly intelligent, hard-working man, and as a result, he took it upon himself to research the causes of the epidemic, compiling information that turned out to be crucial to proving the contagion theory of disease. Whitehead was initially opposed to Snow's contagion theory of disease; however, after speaking with hundreds of Soho families about their experiences with cholera, he came around to Snow's ideas. Whitehead then became a great admirer of Snow; later in life, he crusaded on behalf of public health in London, always crediting Snow for the idea that cholera was waterborne. Whitehead was, in short, an impressive, even heroic figure: using his natural gregariousness, as well as his deep commitment to the public good, Whitehead threw himself into the task of researching and preventing epidemics—furthermore, he kept an open mind about the sources of cholera, and accepted the truth even when it went against his original beliefs.

**Edwin Chadwick** – The founder and first president of the General Board of Health, Edwin Chadwick was an influential and controversial figure in the history of public health. Like many of his contemporaries, Chadwick believed in miasma theory—i.e., the idea that diseases are spread through bad odors. Chadwick believed that he could use the Board to rebuild London's sewer system; in the end, however, his defining achievement as president of the GBH was to pump more filth into the River Thames, directly contributing to the cholera epidemics of the mid-19th century, and probably triggering thousands of deaths. Chadwick is a poignant example of "theory blindness"—he was so completely devoted to miasma theory that he refused to see the truth, even after John Snow compiled convincing evidence that miasma theory was wrong.

**Sir Benjamin Hall** – Sir Benjamin Hall was the president of the General Board of Health during the 1854 cholera epidemic; he was also a firm believer in the miasma theory of disease, like his predecessor, Edwin Chadwick. Hall was a dedicated, deeply sincere crusader for public health, but because of his devotion to the false theory of miasma, he arguably did more harm than good in his capacity as president. Hall commissioned endless studies into the cholera epidemic, but by asking the wrong questions about cholera, he guaranteed that the Board would receive misleading answers.

**William Farr** – Influential demographer whose data concerning the outbreak of cholera in London in the 1840s and 1850s was crucial to the research of John Snow. Farr was a firm believer in the miasma theory of disease for most of his early career; however, after befriending John Snow, he became an important advocate for the modern contagion theory, and used his influence to defend public health.

### MINOR CHARACTERS

**Edmund Cooper** – Engineer who researched the 1854 cholera epidemic using sophisticated mapping techniques.

**Charles Dickens** – Beloved 19th century English novelist whose novels, including *Hard Times* and *Bleak House*, confront many of same themes as *The Ghost Map*, including poverty, disease, and urban misery.

**Susannah Eley** – The elderly mother of two Soho locals, who died of cholera after her children sent her water from the

Broad Street pump.

**Mr. G.** – A local Soho tailor who contracted cholera in 1854.

**Arthur Iberall** – Physicist and urban theorist noted for his elaborate theory of human behavior as it corresponds to the different states of matter.

**Robert Koch** – Highly influential German biologist, often credited with isolating the *Vibrio cholera* bacterium in the 1880s (although Italian scientists had done so forty years previously).

**Thomas Latta** – British doctor who, in the 1830s, determined that cholera could be cured by drinking clean water, but whose findings were tragically and bizarrely ignored.

**Thomas Lewis** – London police officer whose infant child is believed to have been the "index case" in the 1854 cholera epidemic.

**Sarah Lewis** – Wife of Thomas Lewis, whose infant child is believed to have been the "index case" in the 1854 cholera epidemic.

**Karl Marx** – Political philosopher who lived in London for many years, best remembered for writing *Capital* and co-authoring *The Communist Manifesto*, the two foundational texts of Communism.

**William Morris** – Boston dentist best remembered for being the first medical practitioner to give a public demonstration of etherized anesthesia.

**Florence Nightingale** – Beloved Victorian nurse and public health advocate, still celebrated for her crusades on behalf of the poor.

**James Richardson** – Scripture reader for St. Luke's parish, and a good friend of Henry Whitehead.

**John Rogers** – One of the first medical officers to visit Soho during the 1854 cholera epidemic.

## THEMES

In LitCharts literature guides, each theme gets its own color-coded icon. These icons make it easy to track where the themes occur most prominently throughout the work. If you don't have a color printer, you can still use the icons to track themes in black and white.

### ILLNESS, DEATH, AND THE UNKNOWN

The central theme of Steven Berlin Johnson's *The Ghost Map* is illness—in particular, the *Vibrio cholera* bacterium, or cholera, which killed hundreds of thousands of Europeans throughout the 19th century. In Victorian London, where most of the book takes place, millions of people lived within a few miles of one another—a scenario that was as unusual at the time as it is ordinary in the 21st century. London, with its unprecedented population density, was a hotbed of art, culture, and finance, but also contagious disease— epidemics swept through the city, killing hundreds every day. Furthermore, at the time, almost nobody knew what caused these epidemics. (The foundational texts of cellular biology appeared in 1855, a year after the cholera epidemic described in *The Ghost Map*; Italian scientists had already isolated the *Vibrio cholera* bacterium, but it took three more decades before Robert Koch brought it to the international medical community's attention.) In short, Victorian Londoners were surrounded by death, and lived in constant fear of the unknown.

The people of Victorian London reacted to the threat of illness in many different ways. Perhaps the most common response to the threat of cholera was also the simplest: sheer terror. However, some wealthy philanthropists treated the cholera epidemics as an opportunity to rebuild the city of London, founding the modern discipline of urban planning in the process. Scientists, such as John Snow, tried to understand the disease through research and experimentation, in the hopes that they would be able to predict and fight the disease's effects on human beings. Religious figures, such as Henry Whitehead, believed that the epidemic represented God's test of humanity's faith. Finally, many Victorians responded with sheer bigotry, blaming the victims and suggesting that women, immigrants, or the poor were particularly susceptible to cholera. The various responses to the cholera epidemics suggest that it's human nature to attempt to understand the unknown. In frightening times, people try to rationalize and even predict death—in a sense, "taming" it with knowledge. John Snow's scientific approach to epidemiology (the study of diseases) was very different from the bigotry with which other Victorians faced the cholera epidemic. However, both responses represented attempts to understand, rationalize, and predict a frightening, mysterious phenomenon. In the last 150 years, thanks partly to John Snow and his fellow epidemiologists, people have generally become much better at understanding and predicting the unknown—relying on science instead of superstition and prejudice.

In the Epilogue to *The Ghost Map*, Johnson suggests that the future of civilization depends upon human beings' ability to predict different kinds of death—a challenging and perhaps inherently doomed project. As Johnson sees it, people have become healthier and safer, but also more vulnerable to danger: in the 21st century, the threats of terrorist attacks and biological warfare hang over society, and, as Johnson argues, it's only a matter of time before someone dangerous gets access to a nuclear warhead. Therefore, people need to use science and other intellectual disciplines to prepare for the unknown before it happens—in a sense, predicting every possible "disaster scenario" and then developing a solution for

it. The problem, of course, is that it's impossible to predict the unknown with 100% percent accuracy—some of the time, danger can only be understood with the benefit of hindsight. Johnson's analysis of Victorian England, coupled with his observations in the Epilogue, adds up to a disturbing vision of society. As he sees it, human beings have devoted much of their intelligence to the problem of avoiding death, particularly from diseases such as cholera. But while humans have had some success in solving this problem, they'll never succeed in vanquishing death altogether—indeed, the more ingenious their methods for doing so, the more dangerous the forms of death seem to become. No matter what people do, they'll have to live in a state of uncertainty, mitigating their fear with knowledge but never quelling it altogether.

## THE SCIENTIFIC PROCESS

During the cholera epidemics of the 19th century, there were many scientists who tried to understand the precise causes of the disease. One of these scientists, John Snow, was particularly influential in the history of epidemiology (the study of how diseases spread). Snow was a model scientist, combining exhaustive, hands-on research with conceptual rigor to produce a strong, testable theory of the causes of cholera. However, Snow faced many challenges in studying cholera. Unlike many other scientists, he couldn't conduct experiments isolating the causes and effects of the disease; instead, he had to rely upon case studies and statistical analyses of past outbreaks. Throughout his investigations, Snow exemplified the process by which good scientists should try to understand the world.

Perhaps Snow's most valuable quality as a scientist was his willingness to "do the work," putting in countless hours to develop a workable hypothesis about the causes of cholera. In spite of his successful career as an anesthesiologist, Snow continued to research unexplored areas of science, including epidemiology. After the cholera outbreak of 1848, Snow began to study the neighborhoods where the disease had been most common. Snow didn't have the luxury of conducting experiments about cholera; instead, he interviewed dozens of people who'd lost loved ones to cholera, and pored over international reports on the spread of the disease. In the process of researching cholera, Snow developed a hypothesis: cholera was waterborne. By spending so much time studying cholera patients, Snow ensured that his hypothesis would be strong and supported by all the data. He also freed himself from some of the scientific community's misconceptions about cholera—in particular, that it was spread by bad smells.

During the 1854 cholera epidemic, Snow tested his hypothesis. In the process, he illustrated the features of a good scientific theory. First, a good scientific theory should explain a real-world phenomenon: Snow's waterborne theory succinctly explained why a cholera epidemic had broken out in Soho in 1854—the well beneath the Broad Street pump, where thousands of Soho residents got their water, had been contaminated. A good scientific theory should also be "strong" in the sense that it can describe many different cases by analyzing a relatively small number of causes. While other scientists of the era developed highly complicated theories to explain why certain people contracted cholera and others didn't (often attributing the difference to intangible factors such as "internal constitution"), Snow's theory used a single factor (the water from Broad Street) to explain why some people got cholera. Snow could even explain why a woman named Susannah Eley, who didn't even live in London, had contracted cholera at the time of the outbreak—Susannah's sons, the Eley brothers, had sent her a glass of water from the Broad Street pump. Perhaps the most valuable aspect of Snow's waterborne theory—and of any good scientific theory—was its falsifiability. A good theory can be tested and disproven—otherwise, there's no way for other scientists to know if it's right or wrong. If cholera were waterborne, as Snow believed, then one would expect that the people in Soho who didn't drink water wouldn't get sick. Sure enough, the employees of the local brewery, who were paid in alcohol, didn't contract cholera in 1854. Finally, Snow's scientific theory also pointed the way toward further research—it answered questions, but also posed new questions for future scientists to study. Snow's theory explained why certain people did and didn't contract cholera, but it didn't address what cholera itself *was*–only that it traveled through water. It took many years for scientists to determine the "agent" of cholera (i.e., the cholera bacterium).

In the end, Johnson suggests, John Snow's greatest contribution to the history of science wasn't the waterborne theory of cholera itself (which had actually been proposed twenty years previously, and ignored)—rather, it was Snow's willingness to conduct research in order to arrive at a strong, falsifiable theory of disease. In modeling the scientific process so perfectly, Snow inspired other scientists to take after his example, and proved that science is often the most effective tool for responding to a crisis.

## URBAN GROWTH AND PLANNING

In addition to studying cholera and the history of epidemiology, *The Ghost Map* is a meditation on the history and importance of urban planning—a field of study that many people are barely aware exists. In the 19th century, London was one of the only cities in the world to cram so many people into so little space. With its unprecedented population and density, London struck many writers and intellectuals of the era as being inherently unsustainable. For years, the city was so big and poorly organized that it couldn't even dispose of its own trash in an efficient way—instead, "night-soil men" carried huge mounds of excrement to the edges of the city, where they added them to huge, festering

piles. In the face of escalating chaos, officials had to find ways of organizing London, in the process developing many of the organizational principles that modern city-dwellers take for granted.

Perhaps the most important aspect of urban planning that Victorian London's officials were forced to rethink was the urban space itself—in other words, the roads, sewers, and other infrastructure that connected the people of London together. In particular, London officials rethought the sewer system. Following the Public Health Act of 1848, a General Board of Health, funded by taxes and philanthropic donations, made recommendations about how to improve public health. In its early days, the Board's most important project was disposing of trash and excrement. In order to do so more efficiently, Edwin Chadwick, the first president of the Board, ordered the unclogging of the existing sewer system—a policy that dumped millions of pounds of excrement into the River Thames and probably caused the deaths of thousands of people (since the water supply was now contaminated with countless diseases, including cholera). Later, in the 1850s, the Board ordered the building of a brand-new sewer system, which Johnson describes as a technological wonder to rival the Eiffel Tower or the Brooklyn Bridge. The new sewers moved trash and excrement out of London and isolated sewage from the water supply, preventing future cholera outbreaks. The London sewer system illustrates an important principle: the best urban planning is often the least visible (because, oftentimes, ideal urban planning allows urbanites to continue with their normal behavior, and therefore doesn't call attention to itself). The new sewers solved a serious problem in London, but they did so without changing most people's day-to-day lives. Today, few Londoners are even aware that it was once a serious question whether London would survive or drown in its own excrement.

Efficient, invisible infrastructure is important, but it's not enough by itself to ensure a stable city. Urban planners need to be aware of city-dwellers' constantly changing needs; as a result, there should be committees that survey local people and pass recommendations on to the general municipal government. During the cholera epidemic of 1854, John Snow recommended to a board of local governors at Saint James's Parish that the **pump handle** at the Broad Street pump be removed; the board voted, and the handle was removed immediately. John Snow wasn't just a scientist; he'd spent weeks interviewing cholera patients about their afflictions, meaning that, in effect, he was acting as an informed representative for the Soho community. As Johnson sees it, the board's actions marked another milestone in the history of urban planning: a local government used science to make an informed decision about public health, setting a precedent for future municipal governments.

Urban planning is an ancient discipline, but during the Victorian era, city officials developed a new set of tools for dealing with the unprecedented population density of the modern metropolis—infrastructure built according to the principles of modern engineering, and boards whose job was to recognize local problems before they became citywide crises. Perhaps most importantly, Victorians realized that urban planning is an endless, unpredictable struggle against the inherent chaos of millions of different people living together.

## CLASS AND PREJUDICE

The cholera epidemics of 19th century London inflamed prejudice in the city. Cholera kills indiscriminately—all things held equal, people of all races, genders, or social classes are equally likely to die of the disease. However, due to the squalid conditions of Victorian London, the working classes were far more likely to contract cholera and die than were upper-class Londoners, who lived in more spacious neighborhoods where diseases spread more slowly, had access to cleaner water, and received better medical care. As a result, there were many who were willing to believe that London's working-classes had somehow earned their deaths, either because the poor were inherently weaker than the rich, or because poor people's wicked, immoral behavior had led them to contract cholera.

Johnson shows how class prejudices served an important psychological purpose for 19th century London's elite. To begin with, these prejudices reflected all Londoners' fear of cholera—at the time a hideous, effectively incurable disease. Prejudice was a kind of coping mechanism for the elite: by accusing the working classes of weakness (or poor "internal constitution," as it was euphemistically put), the upper classes assured themselves that they would survive the next outbreak. But class prejudice didn't just help London's elites cope with fear; it also helped them rationalize their own indifference to other people's suffering. By blaming the victims—in other words, attributing cholera victims' deaths to some vague, sinful behavior—the rich and powerful convinced themselves that they were morally justified in doing nothing to help their social inferiors. There were almost no welfare programs in London at the time, and many people took seriously the offensive myth that poor people "deserved" their suffering (still apparent in contemporary debates about welfare in America). There were certainly some powerful people who used their influence to help the poor (even if their attempts, like those of Edwin Chadwick, sometimes harmed the poor even further), but many elites were content to fall back on class prejudices as a means of reassuring themselves and justifying their own indifference.

Perhaps Johnson's most important point about class prejudices in the 19th century is that these forms of prejudice infiltrated almost all sectors of Victorian London, even the scientific community. Some of the most popular scientific theories about cholera reflected class prejudice: the miasma theory, for instance, hinged upon the point that some people's "internal

constitutions" were weaker than others. Johnson argues that many proponents of miasma theory—including some of the supposedly neutral scientists who developed it—believed that miasma justified class prejudice: i.e., the poor contracted cholera more often than the wealthy because the poor were weaker than the wealthy. It's important to recognize that most of the class prejudice in 19th century science—and, perhaps, most prejudice in general—was unconscious. Few if any Victorian doctors would have admitted to favoring miasma theory because it upheld their beliefs about the inferiority of the poor; however, taken holistically, the influence of class prejudice on science is impossible to ignore. By the same token, John Snow's heroic efforts to understand cholera epidemics may have had a socioeconomic motive, too: on some level, Johnson suggests, Snow (the son of working-class parents) may have been trying to refute, once and for all, the myth of working-class inferiority.

## SYMBOLS

Symbols appear in **teal text** throughout the Summary and Analysis sections of this LitChart.

### THE PUMP HANDLE

After all his work, John Snow realized that the Broad Street water pump was responsible for the cholera epidemic of 1854. He lobbied the local government to remove the pump handle, and there was no further outbreak of disease. The Broad Street pump handle symbolizes Victorian England's alarming ignorance of health and sanitation, as well as the danger lurking beneath the façade of civilization.

## QUOTES

Note: all page numbers for the quotes below refer to the Riverhead Books edition of *The Ghost Map* published in 2007.

### Chapter 1 Quotes

"London in 1854 was a Victorian metropolis trying to make do with an Elizabethan public infrastructure. The city was vast even by today's standards, with two and a half million people crammed inside a thirty-mile circumference. But most of the techniques for managing that kind of population density that we now take for granted—recycling centers, public-health departments, safe sewage removal—hadn't been invented yet.

**Related Themes:**

**Page Number:** 3-4

**Explanation and Analysis**

Johnson sets the scene for his book, describing the state of Victorian London. The city was large—one of the largest on the face of the planet—but its future was far from assured. Indeed, London was so big and so dense that it was slowly collapsing on itself: the city's authorities had no idea how to dispose of so much trash and excrement, or how to deal with the growth of a permanent underclass that survived by scavenging.

It's almost unbelievable that at a time when England was the most powerful nation in the world, with an empire that stretched around the globe, its own capital city could barely support itself. In a sense, London was a laboratory of urban planning: Victorians had no precedent for dealing with so many people packed into so little space. Thus, many of the techniques for urban planning that 21st-century Westerners take for granted (techniques which Johnson names here) were pioneered or greatly improved during the Victorian era.

"This social topography would play a pivotal role in the events that unfolded in the late summer of 1854, when a terrible scourge struck Soho but left the surrounding neighborhoods utterly unharmed. That selective attack appeared to confirm every elitist cliché in the book: the plague attacking the debauched and the destitute, while passing over the better sort that lived only blocks away. Of course the plague had devastated the "meaner houses" and "bad streets"; anyone who had visited those squalid blocks would have seen it coming.

**Related Themes:**

**Page Number:** 20

**Explanation and Analysis**

During the cholera epidemic of 1854, many wealthy, powerful Victorians concluded that the poor and weak deserved their sickness as a punishment for debauchery, immorality, or other vaguely defined sins. Since ancient times, people have interpreted outbreaks of disease as divine punishment for evil, and Victorian England was no exception. In another sense, it was easier for wealthy Victorians to believe that the poor deserved to die than it was for them to accept that cholera killed indiscriminately (and that they perhaps owed their fellow humans their attention and resources).

Psychologically speaking, the Victorians' belief in the connection between immorality and disease served an important purpose. Wealthy Victorians may have unconsciously gravitated toward such a belief because it justified their own indifference to other people's suffering. Furthermore, Johnson suggests, the belief in a connection between immorality and disease made the cholera epidemic seem more rational, controllable, and generally less frightening. Confronted with a terrifying, inexplicable epidemic, Londoners tried to make sense of the chaos—and, in the process, fell back on old-fashioned bigotry and prejudice.

## Chapter 2 Quotes

❝ At the Lion Brewery on Broad Street, the seventy workers employed there went about their daily labor sipping on the malt liquor supplied as part of their wages.

**Related Themes:**

**Page Number:** 28-29

**Explanation and Analysis**

In this passage, Johnson notes that some residents of the Soho area worked at a brewery, where they were paid in liquor. While few people realized it at the time (one exception being John Snow, the doctor who investigated the sources of the cholera epidemic), the Lion Brewery employees escaped cholera because their water supply was sterilized: when water is used to brew beer and other forms of alcohol, it's boiled, killing all cholera bacteria.

The passage is especially disturbing because it suggests that, for Victorian Londoners, surviving the cholera epidemic was a matter of sheer luck. The Lion Brewery employees had no idea that they were surviving the epidemic because of their water source; thus, they lived through the crisis because of random chance, rather than any particular strength or ingenuity.

❝ For Londoners, the specific menace of cholera was a product of the Industrial Age and its global shipping networks: no known case of cholera on British soil exists before 1831.

**Related Themes:**

**Page Number:** 33

**Explanation and Analysis**

In this passage, Johnson makes the argument that London's horrific cholera epidemics were a product of its technological and political superiority. During the 19th century, England became the most powerful nation in the world, with a navy that transported British goods and British soldiers around the world. Yet this navy also inadvertently spread cholera bacteria around the world, and brought it from India, where the English were the colonial administrators, back to London.

The passage is a good example of Johnson's dialectical, paradoxical approach to the study of history. Intuitively, most people would assume that England's navy was a sign of its superiority; Johnson would agree, with the caveat that the navy was also a thorn in the side of British society. Following in the Marxist tradition, Johnson argues that historical progress (e.g., the growth of the British Empire) engenders its "antithesis"—here, the growing decay and squalor of the city of London itself. Put another way, cholera was the price of globalization and imperialist power.

❝ One British doctor, Thomas Latta, hit upon this precise cure in 1832, months after the first outbreak, injecting salty water into the veins of the victims. Latta's approach differed from the modern treatment only in terms of quantity: liters of water are necessary to ensure a full recovery. Tragically, Latta's insight was lost in the swarming mass of cholera cures that emerged in the subsequent decades.

**Related Characters:** Thomas Latta

**Related Themes:**

**Page Number:** 45

**Explanation and Analysis**

One of the most remarkable details of the history of the 1854 cholera epidemic was that a cure had been discovered more than two decades previously. Thomas Latta realized that clean water and electrolytes were, far and away, the best way to cure cholera. One might assume that Latta's cure would have become highly sought-after, since cholera was one of the deadliest killers of the era. And yet Latta's cure never became particularly well known in the 19th century; there were too many other quack cures for anyone to take Latta too seriously.

In the 21st century, most people would take it for granted

that the cure for a deadly disease would be in high demand. Yet this assumption is premised on the existence of a sophisticated system for verifying and sharing information (in this case, the cure itself). In the Victorian era, sharing information—even information as important as the cure for cholera—was a challenging, tedious process. Thus, instead of rising to the top, Latta's cholera cure was drowned in the cacophony of other, weaker cures for the disease. (It's also possible that Latta's cure didn't become better-known because cholera was largely a disease of the working classes, who had little to no political influence in the Victorian era—the upper classes weren't personally affected by cholera, so they had no strong incentive to popularize a cure for the disease.)

## Chapter 3 Quotes

❝ Snow was a truly consilient thinker […] Snow's work was constantly building bridges between different disciplines, some of which barely existed as functional sciences in his day, using data on one scale of investigation to make predictions about behavior on other scales.

**Related Characters:** John Snow

**Related Themes:**

**Page Number:** 67

### Explanation and Analysis

In Chapter Three, Johnson introduces his readers to John Snow, the closest thing to a protagonist in the book. Snow was a remarkable man in many ways—he was a hard worker, an autodidact, and an endlessly curious doctor. But perhaps the most interesting thing about Snow was his ability to synthesize different schools of information—a quality that Johnson calls "consilience."

Consilience is an important theme of *The Ghost Map* itself: it's impressive to consider how many different kinds of knowledge Johnson himself synthesizes in order to study the 19th century (everything from Marxian dialectics to 21st-century microbiology). Moreover, consilience is an important feature of good urban planning: urban planners need to train themselves to conceive of a city in many different ways, combining art, economics, science, architecture, and more. It is Johnson's thesis that John Snow was a pivotal figure in the fields of epidemiology and urban planning—and perhaps Johnson's strongest argument is that Snow anticipated the consilient style of thinking which has proven so critical to the growth of the modern metropolis.

❝ Snow also recognized the weakness of the contagionist argument. […] Clearly, the cholera was not communicated through sheer proximity. In fact, the most puzzling element of the disease was that it seemed capable of traveling across city blocks, skipping entire houses in the process.

**Related Characters:** John Snow

**Related Themes:**

**Page Number:** 71

### Explanation and Analysis

In the late 1840s, John Snow became interested in studying cholera. At the time, there was a major cholera epidemic underway in his city, and he recognized the vital importance of learning more about the disease's causes and behavior. Snow subscribed to the contagion school of disease—in other words, he believed that cholera was spread by the communication of a literal, material "agent," which passed from person to person in some way. The contagion school has since been proven correct—science now knows that the "agent" in question is a bacterium. At the time, however, contagion was just another theory—in fact, it was a less popular explanation for disease than miasma theory (the idea that disease is spread by bad odors or "vapors").

It's easy for contemporary readers to see the obviousness of contagion theory—but from John Snow's perspective, there needed to be much more evidence of contagion before the medical community came to accept it. Snow didn't know what the agent of cholera was, but he decided to study cholera by measuring the way it spread from person to person—and in the process, Snow made major contributions to the modern discipline of epidemiology.

## Chapter 4 Quotes

❝ Fear might not have been a contributing factor in the spread of disease, but it had long been a defining emotion of urban life. Cities often began as an attempt to ward off outside threats—fortified by walls, protected by guards—but as they grew in size, they developed their own, internal dangers: disease, crime, fire, along with the "soft" dangers of moral decline, as many believed. Death was omnipresent, particularly for the working class.

**Related Themes:**

**Page Number:** 84

**Explanation and Analysis**

In the 19th century, Londoners lived in fear of an epidemic. At the time, disease was utterly mysterious to the public: it wasn't until the late 19th century that the germ theory of disease became generally accepted. As a result, cholera epidemics were frightening—not only because they were lethal, but because nobody could understand what caused them, let alone how to prevent them.

In part, Johnson's book studies what it's like to live in fear of the unknown. In the face of a crisis, Victorians compensated for their fear in a variety of ways. Some turned to religion, using the Bible to justify and rationalize mass death. Others tried to justify the cholera epidemic by claiming that it targeted the immoral, "debauched" poor population of London (a bigoted theory that nonetheless influenced some of Victorian England's most prominent medical researchers). In all, the passage paints a disturbing portrait of 19th-century English life. Londoners wanted to understand the dangers surrounding them—and when science and reason failed them, they turned to faith, superstition, and sheer prejudice.

> In a very practical sense, no one had ever tried to pack nearly three million people inside a thirty-mile circumference before. The metropolitan city, as a concept, was still unproven. It seemed entirely likely to many reasonable citizens of Victorian England—as well as to countless visitors from overseas—that a hundred years from now the whole project of maintaining cities of this scale would have proved a passing fancy. The monster would eat itself.

**Related Themes:**

**Page Number:** 89

**Explanation and Analysis**

During the Victorian era, the human race was going through some major changes, the consequences of which people are still dealing with today. In particular, the Victorian era marked the beginning of the era of the metropolis. Before the 1850s, no European city had ever been as a big and, even more importantly, as dense, as London. London's proportions were so unprecedented in Western history that there were many thinkers who sincerely believed that London would collapse upon itself in the near future—in other words, they argued that no metropolis as cramped and heavily populated as London could endure forever.

While these intellectuals' opinions may seem rather naïve by 21st-century standards (21st-century New York City, to name only one example, crams three times the population of Victorian London into less space), they reflected a significant crisis in the urban spaces of the era. London really *was* on a collision course with itself—had urban planners not figured out a way to deal with the city's waste and sanitation problems, then London might have collapsed, much like Rome or Babylon before it. In short, 19th-century London was one big experiment in urban planning—and at the time, nobody knew for sure how the experiment would turn out.

## Chapter 5 Quotes

> No doubt he had done more than anyone alive to focus attention on the shameful condition of the industrial poor, and to mobilize forces to correct those problems. But some of the most significant programs he put in place ended up having catastrophic effects.

**Related Characters:** Edwin Chadwick

**Related Themes:**

**Page Number:** 113-114

**Explanation and Analysis**

Edwin Chadwick, the founder and first president of the General Board of Health, is a controversial figure in the history of urban planning. Chadwick's sincerity is undeniable—he spent countless years of his life fighting to keep the population of London healthy and safe. And yet Chadwick's *record* is far more questionable. There is significant evidence to suggest that, in his capacity as president of the Board, he did more harm than good, ensuring that the River Thames became infected with hundreds of deadly diseases, including cholera. In short, Chadwick's career testifies to the danger of "theory blindness"—becoming so wedded to one particular way of looking at the world (in this case, miasma theory) that one ignores the blatant truth (namely, that dumping waste into the Thames would cause more disease).

Some of those forces were ideological in nature, matters of social prejudice and convention. Some revolved around conceptual limitations, failures of imagination and analysis. Some involve the basic wiring of the human brain itself. Each on its own might not have been strong enough to persuade an entire public-health system to empty raw sewage into the Thames. But together they created a kind of perfect storm of error.

**Related Themes:**

**Page Number:** 126

**Explanation and Analysis**

In this passage, Johnson attempts to answer a difficult question: why did so many elite members of the medical community believe whole-heartedly that diseases were caused and spread by bad odors, despite the mountains of evidence to the contrary? There may be no simple answer to this question: perhaps people believe things because of a host of small, vague factors, rather than one big, overarching factor. In the case of Victorian disease research, for example, the medical community embraced miasma theory because it appealed to class prejudices, intuitions about the relationship between smell and sickness, and sheer intellectual laziness. It's a little disturbing to think that a group of scientists could allow its own biases to determine what it did and didn't believe—but then, one of Johnson's most insightful points in *The Ghost Map* is that scientists aren't always as unbiased as they'd like to believe.

Miasma became so powerful that it inspired a massive, state-sponsored intervention in the daily lives of millions of people, clearing the air by draining the cesspools. That intervention, miscalculated as it was, had the paradoxical effect of making the patterns of the epidemic more visible, at least to eyes that were capable of seeing them. And seeing the patterns more clearly means progress, in the long run at least.

**Related Themes:**

**Page Number:** 135

**Explanation and Analysis**

During the bulk of the 19th century, miasma theory—the theory that diseases like cholera are transmitted by noxious, dirty environments and bad smells—was highly popular in the medical community, despite an overwhelming lack of evidence. However, as this passage suggests, the popularity of miasma theory also brought about its own destruction. In other words, miasma theory became increasingly accepted in the medical community, to the point where it began to dictate public policy. While the results of these policies were often disastrous (perhaps even causing a wave of deadly cholera epidemics), they also made the irrationality of miasma theory much easier to see. In this way, miasma theory destroyed itself.

The passage is especially important because it applies a dialectical (or even Marxist) approach to the history of science. Just as Karl Marx believed that capitalism would bring about its own ruin by empowering and organizing "its own gravediggers," so does Johnson argue that miasma theory brought about its own ruin by inspiring a generation of scientists, including John Snow, to recognize the theory's internal contradictions. In the short term, a bogus theory might become very popular, but in the long run, the passage suggests, bogus theories prove themselves false, and the best idea wins out.

## Chapter 6 Quotes

In explaining Snow's battle against the miasma theory and the medical establishment, it's not sufficient to point to his brilliance or his tenacity alone, though no doubt those characteristics played a crucial role. If the dominance of the miasma model was itself shaped by multiple intersecting forces, so, too, was Snow's ability to see it for the illusion that it was.

**Related Characters:** John Snow

**Related Themes:**

**Page Number:** 144

**Explanation and Analysis**

In this passage, Johnson poses a challenging question: why was John Snow one of the only scientists in 19th-century London who recognized the falsehood of miasma theory? There were many brilliant scientists working in London at the time, so it's not enough to say "John Snow was a genius" and be done with it. As Johnson goes on to demonstrate, there were various factors in Snow's career that allowed him to see especially clearly what was wrong about miasma theory. To begin with, Snow was an anesthesiologist, who studied the dissemination of gas through the human body. Therefore, Snow recognized that miasma theory—which hinged on the idea that vapors and smells can enter the human body and affect different people in different

ways—was simply unsupported by the evidence. Snow was also a working-class man who, perhaps more than his medical peers, wanted to challenge the class prejudices that had wormed their way into miasma theory. In all, the passage rejects the notion, so common in historical texts, that Snow was a "great man" who revolutionized science because of his intrinsic genius. Snow was a brilliant man, but there were plenty of brilliant people in London in the 1850s: Snow had all sorts of conceptual and material advantages over his peers, which permitted him to see through miasma theory.

❝ Whitehead thought the connection unlikely. He had personally seen so many residents recover from cholera after drinking Broad Street water. He himself had enjoyed a glass a few nights before, and had thus far resisted the plague. Perhaps Richardson had drunk too little.

**Related Characters:** Henry Whitehead, James Richardson

**Related Themes:**  

**Page Number:** 151

**Explanation and Analysis**

During his research into the 1854 cholera epidemic, Henry Whitehead—a priest, Soho local, and gregarious personality—considered many hypotheses for the cause of the epidemic. Whitehead was no doctor, but he was endlessly curious about the world, and he was so well connected in the neighborhood that he had a relatively easy time collecting information from the grieving families of cholera victims. As a result, Whitehead quickly began to piece together the evidence and attempt to construct theories about cholera. Whitehead entertained the idea that the Broad Street water pump was responsible for spreading the epidemic—but he ignored his own suspicion when he remembered that he had "enjoyed" a drink from the pump a few days ago.

Whitehead had no way of knowing why he'd been able to drink from the pump without getting sick: he'd consumed the water, but also mixed it with alcohol, which sterilized the cholera bacteria. From a contemporary reader's perspective, it's utterly obvious that the Broad Street pump was responsible for the epidemic. Nevertheless, for Londoners in 1854, there were too many confounding factors at play to settle on such an explanation immediately. Whitehead eventually came to believe in John Snow's waterborne theory of disease, but he had to weigh a tremendous amount of evidence in order to do so—and in the end, even Snow's waterborne theory couldn't explain why Whitehead had drunk the water without contracting cholera. The passage underscores one of *The Ghost Map*'s most important points: ideas that are uncontroversial *now* were once hotly researched and disputed.

## Chapter 7 Quotes

❝ Snow's argument was persuasive—and, besides, they had few other options. If Snow was wrong, the neighborhood might go thirsty for a few weeks. If he was right, who knew how many lives they might save? And so, after a quick internal consultation, the Board voted that the Broad Street well should be closed down.

**Related Characters:** John Snow

**Related Themes:**   

**Related Symbols:** 

**Page Number:** 160

**Explanation and Analysis**

While the 1854 cholera epidemic was dying down, John Snow appeared before a board meeting at the St. James Vestry and argued that the local governors needed to remove the handle from the Broad Street water pump immediately—otherwise, more people would contract cholera from the well beneath the pump, and the epidemic would probably continue. The board members weren't entirely convinced by Snow's argument, but they recognized that the potential reward of their decision greatly outweighed the risk.

As *The Ghost Map* portrays it, Snow's argument before the St. James Vestry—and the board's decision to remove the pump handle—was a milestone in epidemiology and urban planning. For perhaps the first time in London's history, a doctor had presented good, well-researched science to a municipal government committee, and the committee had translated the scientist's research into concrete public policy—policy which probably saved many lives.

❝ Hall's list is a kind of straitjacket for an eventual document. You can tell from just scanning the instructions what kind of document they will ultimately produce: a rich and impossibly detailed inventory of the smells of Soho circa 1854.

**Related Characters:** Sir Benjamin Hall

**Related Themes:**

**Page Number:** 165

**Explanation and Analysis**

Following the 1854 cholera epidemic, the General Board of Health, presided over by Sir Benjamin Hall, launched an investigation into the causes of the epidemic. Unfortunately, Hall allowed himself to be blinded by miasma theory, and he unconsciously structured his investigation in such a way that it ended up merely confirming the assumptions of miasma theory, producing little in the way of meaningful information about the epidemic's sources. In brief, Hall posed all the wrong questions about the epidemic—and therefore, he got few, if any, meaningful answers. The passage is a particularly striking example of the tyranny of theory: instead of maintaining an open mind about the epidemic, Hall allowed his preconceptions about disease to limit his scientific process.

Standing in front of his haggard parishioners in the half-empty church, he noted the disproportionate number of poor, elderly women in the pews. He congratulated them on their "remarkable immunity from the pestilence." But even as he spoke the words, he wondered: How can this be? What kind of pestilence spares the old and the destitute?

**Related Characters:** Henry Whitehead

**Related Themes:**

**Page Number:** 168

**Explanation and Analysis**

Following the cholera epidemic of 1854, Henry Whitehead continued to investigate the causes of the epidemic, convinced that John Snow was wrong to attribute the outbreak to the Broad Street water pump. Whitehead's investigation into the causes of the outbreak was notable because Whitehead kept an open mind, explored a wide variety of factors, and didn't let himself become too loyal to any single theory. In general, he did everything right that the General Board of Health, led by Sir Benjamin Hall, did wrong.

Whitehead's investigation revolved around an honest, open-ended question—why did so many elderly people, almost always the first targets for an outbreak, survive the cholera epidemic? It's instructive to compare this question with the narrow, circularly phrased questions that Benjamin Hall posed (nearly all of which centered around particular smells and vapors). Whitehead was, in may ways, a natural scientist: he kept an open mind and didn't let preconceived notions bias his procedure. As a result, he came to see the striking weaknesses of miasma theory.

This is circular argumentation at its most devious. The committee begins with the assertion that cholera is transmitted via the atmosphere. When it discovers evidence that contradicts this initial assertion—a clear case that cholera has been transmitted by water—the counter-evidence is invoked as further proof of the original assertion: the atmosphere must be so poisoned that it has infected the water as well.

**Related Themes:**

**Page Number:** 186

**Explanation and Analysis**

Following the cholera epidemic of 1854, John Snow presented his research to the elite scientists of London, but was met with resounding indifference. Most doctors and medical researchers were so loyal to miasma theory that they went out of their ways to think of reasons why Snow's strong, intuitive waterborne theory was wrong. For example, some doctors argued that Snow's points about the water supply becoming contaminated were true, but only insofar as the atmosphere had *caused* the water supply to become contaminated. In other words, doctors were forced to accept that the water supply was the source of the epidemic, but then twisted the evidence to make it seem that atmospheric factors were the underlying cause of the contaminated water, thus confirming miasma theory.

The passage illustrates why it's so important for good scientific theories to be falsifiable. Miasma theory was, at least as the Victorian medical establishment conceived of it, impossible to disprove—even when Snow produced conclusive evidence that the cholera epidemic was waterborne, scientists found dubious ways to use this evidence to support miasma theory.

## Chapter 8 Quotes

As for influence, it's pretty to think of John Snow unveiling the map before the Epidemiological Society to amazed and thunderous applause, and to glowing reviews in *The Lancet* the next week. But that's not how it happened. Its persuasiveness seems obvious to us now, living as we do outside the constraints of the miasma paradigm. But when it first began circulating in late 1854 and early 1855, its impact was far from dramatic. Snow himself seems to have thought that his South London Water Works study would ultimately be the centerpiece of his argument, the Broad Street map merely a piece of supporting evidence, a sideshow.

**Related Characters:** John Snow

**Related Themes:**

**Page Number:** 198

**Explanation and Analysis**

One of the most revolutionary things about the way John Snow studied the cholera epidemic was his extensive use of maps. Snow spent countless hours mapping foot traffic, both in the Soho neighborhood and in London in general. Then he compiled this information into an elegant visual form—a map of London, showing the relationship between water supply and the spread of disease. However, when Snow presented his findings to London's greatest scientists, he wasn't taken entirely seriously—people continued to doubt his premise that cholera was waterborne. Furthermore, because other scientists weren't used to the extensive use of maps and statistics in the study of disease, they remained unconvinced by Snow's visual aids.

In short, the passage demonstrates that the scientific community isn't always receptive to new theories, even when these theories provide a simpler, more convincing explanation for complex phenomena than does the existing paradigm. In the 1850s, the dominant paradigm of epidemiology was miasma theory—the idea that vapors and bad odors transmit disease, rather than physical agents of contagion. Because the miasma paradigm was so firmly established in England at the time, no amount of research or data could sway the scientific community, no matter how well Snow presented it.

The construction of the new sewers was every bit as epic and enduring as the building of the Brooklyn Bridge or the Eiffel Tower. Its grandeur lies belowground, out of sight, and so it is not invoked as regularly as other, more iconic, achievements of the age.

**Related Themes:**

**Page Number:** 207

**Explanation and Analysis**

Following the groundbreaking work of John Snow, the city of London began to rebuild its sewer system. Officials came to recognize that cholera and many other diseases were waterborne, meaning that it was imperative that London separate its waste system from its water supply. To this end, engineers designed a new sewer system—one which, according to Johnson, rivals the Brooklyn Bridge and the Eiffel Tower as the great engineering feats of the era. The difference between the London sewer system and the Eiffel Tower, of course, is that the former is purely practical, while the latter, in spite of its practical utility, was also designed to be an aesthetic marvel, to be seen, marveled at, and enjoyed.

In some ways, the passage suggests, the most elegant and successful urban structures are the ones that urbanites don't consciously notice. London's sewer system was a "success" because it allowed Londoners to continue with their regular routines—using a certain amount of water, going to the bathroom, etc.—without any hitches. Seen in this way, the fact that, in the 21st century, Londoners rarely stop to *think* about the sewers proves that the sewer system was successful. Instead of drawing attention to itself (which might suggest that it's not working efficiently), the sewer system disposes of waste in a quiet, efficient manner. Only 150 years ago, many people believed that London would drown in excrement—so the fact that this hasn't happened (and, in retrospect, seems ridiculous) is a testament to the genius of the sewers.

Cities are invariably shaped by their master planners and their public officials; Chadwick and Farr had a tremendous impact on Victorian London—most of it positive, despite the miasma diversions. But in the last instance, the energy and vitality and innovation of cities comes from the Henry Whiteheads—the connectors and entrepreneurs and public characters who make the urban engine work at the street level.

**Related Characters:** Edwin Chadwick, William Farr, Henry Whitehead

**Related Themes:**

**Page Number:** 225

**Explanation and Analysis**

Here, Johnson discusses some of the innovations in urban planning that John Snow and Henry Whitehead pioneered in the 1850s. Perhaps Snow and Whitehead's most important contribution to the science of urban planning was to establish a precedent for the flow of information from "local experts" to a local board of government to a city-wide board. Snow presented his findings to the St. James board, which enacted a policy (removing the pump handle) on the basis of his research. Then, later on, the board's policy inspired a citywide rethinking of the sewage question.

In the 21st century, it's commonly accepted that a good city needs a good system of communication between locals, experts, and governors. But just 150 years ago, this assumption was revolutionary. Snow and Whitehead's cholera research changed the way that people think about cities—and, by the same token, the way that cities run themselves.

## Epilogue Quotes

❝ We will enter a new era: a planet whose human population is more than 50 percent urban. Some experts believe we are on a path that will take us all the way to 80 percent, before we reach a planetary stabilization point.

**Related Themes:**

**Page Number:** 231

**Explanation and Analysis**

In the final chapter of the book, Johnson directs his attention to the future of urban planning. It's curious that history classes don't devote more attention to the rise of cities in the last 200 years—urbanization is probably one of the most significant changes in civilization, and yet it's still not very well understood. In the passage, Johnson posits that humans will continue moving to cities, to the point where the majority of the world's population will live in an urban center of some kind. For the rest of the chapter, Johnson will study some of the important ramifications of such a demographic change: in particular, the advantages that it represents for culture, diversity, and energy conservation, as well as some of the inherent dangers of urban life.

❝ The great cities of the world would start to look like giant bull's-eyes: millions of potential casualties conveniently stacked up in easily demolished high-rises.

**Related Themes:**

**Page Number:** 241

**Explanation and Analysis**

Perhaps the biggest disadvantage of living in a large city, Johnson suggests, is that it's a potential magnet for terrorist attacks. Big cities are, as Johnson puts it in the passage, bull's-eyes. Because so many people live there, packed into a small amount of space, it would be relatively easy for a terrorist to detonate a bomb (or release a virus) that kills thousands of people (whereas it would be almost impossible for a terrorist to kill a similar amount of people in a more spread-out rural community).

The passage is representative of Johnson's "consilient" style of thinking and writing. Johnson poses many different questions in the Epilogue to his book, and brings in many different academic disciplines in an attempt to answer them. Instead of resolving the issue of urban terrorist attacks, Johnson prefers to leave the issue open-ended. To borrow from Donald Rumsfeld, urban terrorist attacks are a "known unknown"—it's impossible to know exactly when and where terrorists will strike, but it's very important to be aware that an urban terrorist attack is a possibility.

❝ Perhaps urban nuclear explosions will turn out to be like hundred-year storms: a bomb goes off once a century, millions die, the planet shudders in horror, and slowly goes about its business.

**Related Themes:**

**Page Number:** 254

**Explanation and Analysis**

Here, Johnson brings up the possibility of nuclear warfare, as it relates to the growth of big cities. If a huge chunk of the world's population is concentrated into cities, then more people will be vulnerable to a nuclear attack (whereas if people were spread out in many different rural communities, then the population would have a much greater likelihood of surviving a nuclear war).

Nuclear war is a big, challenging topic, and it might seem a little odd for Johnson to bring it up with less than ten pages of his book left. However, Johnson's point isn't simply to frighten the reader with descriptions of death and destruction. Rather, his argument is that urban migration is

likely to continue for the foreseeable future: it has become the dominant paradigm of contemporary life, to the point where it's easier to imagine the destruction of individual big cities than it is to imagine people leaving cities and returning to the countryside. Moreover, the threat of a nuclear attack reiterates another one of the book's key themes: to live in the modern world is to be surrounded by new, frightening forms of death. In some ways, the constant fear of death is the price that modern human beings pay for their civilization.

❝ The global challenges that we face are not necessarily an apocalyptic crisis of capitalism or mankind's hubris finally clashing with the balanced spirit of Gaia. We have confronted equally appalling crises before. The only question is whether we can steer around these crises without killing ten million people, or more. So let's get on with it.

**Related Themes:**

**Page Number:** 256

**Explanation and Analysis**

After bringing up a series of chilling possibilities—a global viral epidemic, a nuclear holocaust, etc.—Johnson brings his book to a disturbing, yet cautiously optimistic finish. While it is true that the human race faces some major challenges, Johnson doesn't want his readers to throw up their hands and admit defeat. As daunting as nuclear attack may seem to 21st-century people, it's no more daunting than cholera must have seemed to the average Londoner of the 1850s. Indeed, nuclear attack is probably *less* daunting than cholera was to the Victorians, since, at the very least, 21st-century people know how nuclear bombs work (whereas Victorians didn't have the first clue what caused cholera). Thus, instead of throwing in the towel, people should apply their intelligence and ingenuity to the great problems of the contemporary world, taking as their role models such dedicated, hard-working figures as John Snow and Henry Whitehead.

## SUMMARY AND ANALYSIS

The color-coded icons under each analysis entry make it easy to track where the themes occur most prominently throughout the work. Each icon corresponds to one of the themes explained in the Themes section of this LitChart.

### CHAPTER 1: THE NIGHT-SOIL MEN

In 1854, London was full of scavengers: working-class people who survived by going through trash. At night, "toshers" could be seen waving lanterns on the banks of the Thames, searching for anything they might be able to use. Meanwhile, "pure-finders" made their living collecting dog excrement, while bone-pickers picked the meat off of thrown-away carcasses. In short, "the scavengers lived in a world of excrement and death." In London, the richest city in the world, an entire class of poor scavengers had emerged. There was a vast underground market for refuse, for which there were full-time merchants and expert appraisers. In a way, the scavengers of 19th century London were some of the most important people in the city: they performed the crucial civic function of getting rid of trash (and, in fact, recycling it).

*The book begins with a nightmarish scene, all the more bizarre because it takes place in the not-too-distant past, in a city that is often regarded as one of the most sophisticated and advanced in the world—London. In the Victorian era, Johnson argues, London's municipal government had no idea how to run a metropolis. As a result, the city's poorest people had to take care of themselves, and developed a bizarre, complex economy of trash harvesting, selling, and reusing. The beauty of the scavenger economy was that, although individual Londoners were just looking out for their own interests, they benefited the city overall by recycling.*

Few people realize that recycling is an ancient practice—even the ancient Greeks had composting pits. In the Middle Ages, farmers recycled waste of all kinds to nourish their soil. In nature, waste recycling is "a crucial attribute of diverse ecosystems." Microbes do most of nature's recycling work, decomposing waste into its molecular components. It's likely that, if the bacteria responsible for natural recycling disappeared overnight, "all life on the planet would be extinguished." But although microbes can play a vital role in preserving life, they played the opposite role in 1854: indeed, they threatened to wipe out London's human population.

*The passage is typical of Johnson's encyclopedic knowledge and penchant for combining different disciplines (in this passage alone, we get microbiology, urban studies, history, and ecology!). The implicit message here is that in the natural world, there's a delicate balance of life and resources—but in early modern cities, such as London, people disrupted this natural balance, and had to figure out new ways of coexisting with their environments.*

Like every socioeconomic class, London's scavengers had their own system of rank and privilege. City landlords paid "night-soil men"—i.e., people who harvested excrement—a good wage. As London grew (eventually becoming the biggest city in Europe), night-soil men began earning higher wages, since it took hours for them to travel to the edges of the city to dump the excrement. In the middle of the 19th century, the modern water closet (i.e., toilet) was patented; as a result, the average Londoner used more water than ever before. London's plumbing system wasn't equipped to deal with the additional water and excrement, meaning that sewers often overflowed. Altogether, the practices of night-soil men, the popularization of the W.C., and population growth meant that London was filthier than ever before.

*Three major factors (the scavenger economy, the invention of the modern W.C., and population growth) contributed to the growing filthiness of London. The passage is a good example of the kind of analysis that Johnson uses throughout his book, showing how a big, seemingly inevitable historical trend (London's public health crisis) emerged from the confluence of multiple unrelated factors.*

As London grew bigger, the city experienced "a surge in corpses." Often, the dead bodies of the poor were buried in mass graves—a sight that inspired the author Charles Dickens to write that, in London, "civilization and barbarism walked this boastful island together." Dickens's point was that the growth of civilization hinged upon filth and misery. Around the same time, the political philosopher Karl Marx was living in London; Marx's impressions of the city's decay inspired his theory of Communism.

*The decay of Victorian London inspired figures as different as Charles Dickens (often regarded as a liberal reformer) and Karl Marx (the father of Communism, one of the most radical responses to the advent of Western capitalism). Both Marx and Dickens believed in some of the same premises: above all, that something was fundamentally wrong in London. Furthermore, both Marx and Dickens took a dialectical approach to their society: they recognized that urban squalor was not a footnote to the growth of a capitalist civilization, but rather its direct result.*

At the time, Londoners believed that dead bodies and bad smells spread disease—a belief that turned out to be completely false. In Soho Field, for example, there had once been a mass burial of plague victims. For years after the burial, few dared live in Soho; however, beginning in the late 18th century, Soho suddenly became one of the "hippest" parts of London, and a magnet for artists, entrepreneurs, and intellectuals. By the 1850s, Soho was also one of London's most densely populated neighborhoods. Soho's streets were narrow and cramped—indeed, they'd been designed this way, by urban planners who'd intended for Soho to be a working-class neighborhood. During an outbreak of disease in 1843, wealthy Londoners claimed that the disease was killing a disproportionate number of poor people because the poor were immoral or debauched—but in reality, the disease spread more rapidly through the dense, cramped neighborhoods where the poor lived.

*The passage juxtaposes two of the most harmful myths of 19th century England: first, that bad smells spread disease (a misconception that probably caused thousands of deaths), and second, that poor people deserved their diseases because they were immoral in some vague way. In a sense, these two myths are manifestations of the same instinct: fear of the unknown. Thus many people, desperate for some explanation for the epidemic, convinced themselves that there was a method to the cholera's madness: cholera spread in a certain way, or only killed certain people. This instinct to define, rationalize, and "tame' the unknown is one of the most important themes of* The Ghost Map.

In the 1840s, a London police officer named Thomas Lewis was living on Broad Street, near the heart of Soho, with his wife, Sarah Lewis, and his young, sickly child. The child died after ten months; then, in 1854, Sarah gave birth to a baby girl. On August 28, 1854, around six a.m., baby Lewis began vomiting and excreting. Sarah took her baby's soiled diapers and threw them in the cesspool in her basement. "This," the chapter concludes," it how it began."

*This simple event sparked a deadly epidemic and a total reconsideration of epidemiology and urban planning. In a densely populated metropolis such as London, even the simplest behaviors (such as throwing out some soiled diapers) can have enormous repercussions.*

## CHAPTER 2: EYES SUNK, LIPS DARK BLUE

For two days after the Lewis child began vomiting, life carried on normally. Not too far away, there was a clergyman named Henry Whitehead. Whitehead had attended Oxford University, and he was known for his gregariousness. He was a devotee of tavern life—he loved to spend his night talking politics or philosophy with friends. Since 1851, he'd been a priest for St. Luke's church, where he specialized in helping the slum dwellers of Soho. At the time, the area around St. Luke's was filthy even by London standards: there was a slaughterhouse up the street, and the streets were always full of horse manure.

*Henry Whitehead is one of the book's two main characters (the other is John Snow, not yet introduced). Whitehead was a likeable, talkative man, and he was clearly devoted to helping other people. In an era when many people were understandably consumed with fear of losing their lives to disease, Whitehead devoted his own existence to selflessness and good will.*

On the morning of Saturday, September 2, 1854, Whitehead walked to a nearby coffeehouse and may have paid a visit to a military factory run by the Eley Brothers. Whitehead stopped to say hello to many people—he was a friendly man, and he knew the area's residents well. At this time, Charles Dickens' latest novel, *Hard Times*, about the misery of working-class city life, was being serialized; Whitehead may have mentioned Dickens to someone at the coffeehouse. But not one of Whitehead's conversations broached the topic of cholera.

*Johnson alludes to the novelist Charles Dickens many times in* The Ghost Map*; Dickens was one of Victorian England's greatest critics of social injustice and urban squalor. Whitehead and his friend do not discuss cholera: not only because nobody knew what caused it, but also because it was a taboo topic in Victorian society, reflecting people's deep fear of contracting the disease. (This is also the first time in the book that Johnson has used the word "cholera.")*

Seen from above, the area around Broad Street (one of the biggest streets in Soho) would have looked utterly chaotic, with people moving in all directions all day long. The most heavily trafficked part of the street, however, was the Broad Street water pump, long regarded as a good source of clean water. The pump connected to a well underground, and it was so popular that people would go out of their way to get Broad Street water, which was generally colder than the water from other pumps. In August 1854 alone, tens of thousands of people must have used the pump, including the Eley Brothers and Mr. G., the community's tailor, who lived above the Lewis family. Some locals didn't drink water from the pump, however—the laborers at the nearby Lion Brewery, for example, were paid in alcohol, meaning that they rarely drank water.

*Without talking about cholera explicitly, Johnson creates a strong sense of foreboding, relying upon his readers' knowledge of how diseases are spread. Thus, the passage strongly implies that the Broad Street water pump spread cholera to thousands of people. More generally, though, the passage illustrates some of the perils of urban life: in dense, highly crowded areas such as Soho, deadly diseases spread easily from one host to another (whereas in earlier, less dense societies, the disease might have stopped short of an epidemic due to a lack of available hosts).*

The history of epidemics is a challenging subject, because it requires historians to pore over banal details of people's lives. Amazingly, cholera historians have been able to determine what many people were doing on the morning of September 2. On Wednesday, for example, Mr. G. the tailor began to feel sick to his stomach, and he wondered if he had food poisoning (which, at the time, could be lethal).

*For now, Johnson doesn't go into detail about* how *epidemiologists obtained so much information about Mr. G. and his peers—however, he later explains that much of modern epidemiologists' information about the 1854 outbreak was gathered by John Snow and Henry Whitehead.*

London has a long history of epidemics, stretching back to the Great Plague. Furthermore, cholera is an ancient disease—it's been suggested that there were cholera outbreaks in the Middle East in 500 B.C. However, until the 1800s and the rise of globalization, cholera was mostly limited to Asia. In 1829, cholera spread from India, then under the control of the British Empire, back to England. In the 1830s, there were cholera outbreaks in England and Wales, which claimed tens of thousands of lives.

*One of Johnson's most provocative points is that civilization is a victim of its own success. For example, the age of imperialism brought tremendous wealth and power to England—but, as we see here, it also brought deadly diseases back to England from around the world (and vice versa).*

On Wednesday, Mr. G. began to grow frightened. He vomited through the night and had muscle spasms; he also began excreting odorless, watery stool, full of tiny white particles (later dubbed "rice-water stool"). By Friday, he was feeling cold, his skin was pale, and his heart was barely pumping. Within a few more hours, he and a dozen other Soho residents had died.

*Cholera has evolved to the point where it causes its human hosts to excrete watery diarrhea (rice-water stool) that can spread the cholera bacterium to other human hosts.*

Cholera is a bacterium—i.e., a microscopic organism consisting of single cells containing DNA. Bacteria are diverse and abundant. They can survive on nitrogen and sulfur, live in extreme temperatures, and process most organic molecules. Bacteria are essential energy providers, and they're responsible for recycling waste. The history of life on Earth, it's been suggested, is just one long "Age of Bacteria." In small quantities, the cholera bacterium, or *Vibrio cholera*, is harmless for human beings; only when millions of cholera bacteria group together do they become lethal. Humans can touch cholera bacteria safely, but when they ingest cholera, they become horribly sick.

*We might be predisposed to think of ourselves as the strongest, most important creatures on the Earth—but in fact, we have some stiff competition from bacteria. If longevity and propagation are signs of a "successful" life form, then bacteria are, far and away, the most successful creatures on the planet—far more so than human beings. The Age of Humans is relatively recent, but the Age of Bacteria is still going strong after millions of years.*

Cholera bacteria inject a toxin into the small intestine, causing the body's cells to expel water (hence rice-water diarrhea). Over time, cholera dehydrates the human body; as a result, it causes the heart to pump faster, resulting in muscle spasms and a tingling sensation. The kidneys begin to fail, and the heart slowly weakens and shuts down. Because cholera victims excrete and vomit, they expel cholera bacteria from their body, sending them to potential victims.

*From a human being's perspective, cholera bacteria are terrifying creatures who cause pain and suffering. Seen objectively, however, this pain and suffering is just a means to an end for cholera bacteria—the "end" of replicating themselves and passing into another human host.*

When discussing cholera, it's important to resist the temptation to personify the bacterium—i.e., to think about what cholera "wants" and "tries" to do. While cholera bacteria aren't conscious, one could say that cholera "desires" to move into a certain environment, which allows the bacteria to reproduce more efficiently. In a sense, cholera "desires" to be in a moist environment, where it can reproduce quickly and spread to other hosts (i.e., living bodies). For most of human history, cholera spread slowly, because humans didn't ingest other humans' excrement—but cholera survived in rivers and puddles. On the occasions when prehistoric humans *did* contract cholera, the disease didn't spread rapidly, since the population density of early human society was low. But with the growth of civilization—and especially the growth of cities—cholera could spread from human to human more quickly.

*In this passage, Johnson at first criticizes the tendency to speak of bacteria as if they're conscious beings (in literature this is called personification or the pathetic fallacy), but then falls into that same tendency himself. Even if cholera bacteria aren't conscious beings, they could be said to "desire" a human host in the sense that they've evolved to seek out human hosts. Charles Darwin's theory of natural selection can be used to show how, over millennia, cholera bacteria evolved to infect human beings: cholera bacteria that could do so survived and thrived, while cholera bacteria that could not simply died out.*

As cholera bacteria spread through human hosts, it became increasingly lethal. Bacteria evolve faster than humans because their lives are shorter and because they produce millions of offspring. Furthermore, bacteria produce offspring whose DNA is arranged in far more diverse combinations than in the case of human reproduction. The result is that cholera bacteria can adapt to their environment very quickly. The most successful bacteria survive and reproduce, passing on useful traits to their offspring, while the least successful bacteria die out. In the case of London in the 1850s, the most "successful" cholera was the most lethal: it reproduced quickly (depriving its hosts of water) and induced vomiting and diarrhea (spreading to other hosts). To be clear, cholera didn't consciously develop a strategy for survival—rather, natural selection caused cholera to become deadlier.

*In Darwin's theory of natural selection, the "fittest" species survives and reproduces, passing on useful genetic traits to the next generation, and so on. In bacteria, this process occurs thousands of times a year, because bacteria reproduce at a tremendous rate. Even if cholera bacteria themselves are unconscious of being successful or unsuccessful (or anything else, for that matter), they've evolved to become some of the most "successful" living creatures on the planet—at least in the sense that they've colonized every corner of the Earth.*

The tragic irony of the cholera epidemic of the 1850s is that it could have been prevented with one thing: water. When cholera victims are treated with clean drinking water and electrolytes, they usually survive with nothing more than bad diarrhea. As early as the 1830s, a British doctor named Thomas Latta had determined that water could be used to cure cholera patients; however, his findings never seriously influenced the British medical community, and there were too many other, dubious "cholera cures." At the time, untrained quack doctors sold their "miracle cures" for various diseases—and many people, unable to access good medical care, bought them. Some salesmen sold absurdly overpriced castor oil to cholera victims, making huge profits in doing so.

*It's remarkable that British doctors (or at least one British doctor) were aware of a cure for cholera twenty years before the cholera epidemic of the 1850s. In the 21st century, it seems obvious that a cure for a deadly disease would quickly be offered to the public, as so many people would have a strong incentive for the cure to be made available. But in the 19th century, there wasn't a strong system of peer review (and there were too many quack doctors selling "miracle cures"), meaning that some important medical findings, such as Latta's, could go unnoticed for a long time.*

While quack doctors peddled their cures on the streets and in newspapers, "serious doctors" couldn't agree on how to treat cholera, either. Some argued that the cure for cholera was to drain the patient of blood; others prescribed purgatives, such as rhubarb. Many doctors' treatments worsened their patients' conditions instead of curing them. Few realized that hydration was the most effective cure for cholera.

*Doctors proposed complicated cures that, in retrospect, seem almost funny (except that they hastened the deaths of many patients). Perhaps it was the very simplicity of the cure for cholera that made it so hard to find—doctors were used to overthinking things, and thus never recognized the importance of clean water.*

Johnson returns to the specifics of the 1854 epidemic. By Friday, hundreds people were dying throughout Soho, and "the fear was inescapable." Whole families lay ill together, slowly dying in agony. When Whitehead traveled to Peter Street, he found that half the people living there were seriously ill. Perplexingly, however, Whitehead realized that there were very few ill people living in the dirtiest, smallest homes on Green's Court. It appeared that the cleanliness of the household had no bearing on the residents' chances of avoiding the disease.

*London was a center of politics, finance, and intellectual life in the 19th century (and today)—but it was also a hotbed of disease and fear. In the midst of so much chaos and uncertainty, few people could keep a clear head—but one of those few was Henry Whitehead. Instead of listening to the conventional wisdom, he recognized the truth: some "dirty" people got cholera, but others didn't.*

Around the same time that Whitehead was exploring the street, a medical officer named John Rogers was visiting patients who'd fallen ill in the last day. Rogers realized that the Soho neighborhood was in the grips of a cholera epidemic. As he visited houses on Berwick Street, he inhaled the sickening stench of vomit and excrement. He came to the Lewises' home, where he found that their baby daughter had died.

*John Snow and Henry Whitehead were far from the only people going door-to-door in Soho to study the cholera epidemic. Notice that John Rogers "inhaled" the stench of cholera—which, according to most doctors at the time, should have proved fatal.*

In the afternoon, Whitehead visited a family of six (for the purposes of the book, Johnson calls them the Waterstones—no record of their real names exists). Whitehead found that the Waterstones' young daughter was barely conscious. Outside, someone placed a yellow flag in the middle of the Street, signaling that there was a cholera outbreak. The flag was superfluous, however—the streets were already full of dead bodies.

*The passage conveys Whitehead's dedication to his mission—providing comfort and relief for the sick and miserable. It also emphasizes the chaos and ineffectuality of the authorities in Victorian London—they couldn't do anything more for their own people than plant a useless flag in the middle of the street.*

## CHAPTER 3: THE INVESTIGATOR

On Sunday, September 3, Soho had become eerily calm. Few people went to get water from the Broad Street pump—most of the people walking the streets that morning were doctors and priests. News of the outbreak had reached the rest of London—there had been cholera outbreaks before, but none so deadly.

*One of the eeriest things about the 1854 cholera epidemic was that it traveled faster than the news—by the time the rest of London heard about it, it had already eliminated a sizeable portion of Soho's population.*

On Sunday, a forty-two year-old Soho regular named John Snow was walking through the streets. Snow's father was a Yorkshire laborer. When the young Snow showed signs of brilliance, his father arranged for him to work for a Newcastle surgeon, where he witnessed the ravages of cholera. In the 1830s, Snow was a prominent member of the temperance (i.e., anti-alcohol) movement; at twenty-three, however, he decided to study medicine in London. Snow quickly proved to be a superb doctor, quick-witted and calm under pressure. In the 1840s, he'd published dozens of articles. By 1843 he'd earned his M.D. from the University of London, and within a year he'd passed his exams and become a doctor.

*Here, we're introduced to John Snow—the closest thing to a protagonist in the book. Snow was a fascinating figure, in particular because of his ambition and curiosity about the world. Snow had to work hard to go to medical school, and he kept up the same work ethic even after he graduated. It's ironic that Snow promoted temperance, considering that the consumption of alcohol saved the lives of dozens of people during the cholera epidemic of 1854, which he later studied.*

Most doctors in Snow's position would have settled into a comfortable, upper-middle-class life. However, Snow remained ambitious—in particular, he wanted to study pain management. At the time, Western medicine had only two reliable forms of anesthesia: alcohol and opium. Surgeries were torturous for patients, and surgeons prided themselves on being fast, rather than careful. In the fall of 1846, however, the Boston dentist William Morris gave the first public demonstration of etherized anesthesia, and by the end of the year, the use of ether had spread to London. However, the first doctors to use ether were clumsy—sometimes, they used so much of it that their patients never woke up.

*Snow's curiosity was boundless—based on his career, he seemed to enjoy the thrill of learning about a new field of medicine more than the financial perks of being a highly sought-after doctor. The use of anesthesia is so uncontroversial in 21st century medicine that it's striking to think that, just 150 years ago, doctors had virtually no way of controlling their patients' pain, and had to sacrifice accuracy and care just to shorten their procedures.*

Snow devoted himself to determining correct ether dosages. By January 1847, he'd published a table of correct dosages; he also designed an ether inhaler device. When Snow discovered that chloroform was often a better anesthetic than ether, he became London's most sought-after anesthesiologist. Snow wasn't just a fast worker and a quick thinker; he was also a world-class "consilient thinker." In other words, his thinking bridged different disciplines, including chemistry, biology, and mechanics.

*It's incredible that, just a few months after Morris's demonstration, Snow had already developed a sophisticated method of controlling the flow of ether. The principle of consilience isn't just a good way to understand the way Snow's mind worked—it's a good way of describing* The Ghost Map *itself, as Johnson synthesizes several disciplines, including philosophy, history, futurology, epidemiology, microbiology, literature, and urban planning.*

By the end of the 1840s, John Snow had become fascinated with cholera. There was a cholera outbreak in 1848, and Snow wanted to determine the cause. Some doctors believed in the "contagion theory"—that cholera was caused by an "agent" that passed between its victims. Others advocated the "miasma theory"—that cholera was caused by unsanitary spaces and bad odors. At the time, miasma theory was far more popular with medical insiders, including the London sanitation commissioner and London's chief demographer, William Farr. Few argued that cholera was spread by contaminated water.

*Snow, as it turned out, believed the correct theory of cholera—that it was spread by a material agent (which doctors later determined to be bacteria) rather than emanating, vapor-like, from certain environments. Notice, however, that Snow was far from certain of his theory—he didn't even know what the precise agent of cholera was, and therefore couldn't be sure of his contagion theory.*

In the course of his research, Snow found reports of a Hamburg steamship, one of whose crew members checked into a lodging house and later died of cholera. An Englishman who later stayed in the lodging house also contracted cholera, and the disease then spread around the neighborhood. The evidence could have supported the miasma model, except that it would have been a wild coincidence if the lodging house became a noxious environment on the exact day when a sailor from Hamburg—then experiencing its own cholera epidemic—arrived.

*Although Snow didn't know what the "agent' of cholera was, he studied the evidence and realized that cholera must be caused by an agent of* some *kind. If miasma theorists were correct, then one would have to believe that the sailor's lodgings became noxious overnight—a pretty big assumption. (It's interesting to consider how few cases of cholera passing from a person of one nationality to another—cases which clearly supported contagion theory—there were in the 1850s: 19th century Europe was certainly not as globalized as the present.)*

By 1849, Snow was ready to present his research to the public: cholera, he argued, was caused by an agent that its victims ingested, either through contact with waste matter or ingestion of contaminated water. Snow strengthened his theory after an outbreak of cholera in Horsleydown; all the evidence pointed to the disease spreading aquatically. Snow also studied William Farr's data and maps on the spread of cholera. He found that cholera deaths correlated closely with certain shared water supplies. He further found that there was little correlation between squalid conditions and cholera outbreaks—sometimes, one slum building would be full of cholera victims while the one next door would be cholera-free. Other doctors were appreciative but skeptical of Snow's argument; even if Snow had established a correlation between water supply and disease, they argued, he hadn't confirmed the cause of the epidemic.

*In retrospect, it seems utterly obvious that John Snow was correct about the causes of cholera—but at the time, his evidence seemed anything but conclusive. Snow could show a strong correlation between water supply and cholera outbreaks, but because he had no idea what the contagious agent of cholera was (in the 1840s, nobody did), his theory was much weaker than it seems in retrospect. At the time, miasma theory—in which the only "agent" was smell—seemed a much more tangible, intuitively believable theory than contagion theory (which was only proven true after scientists identified microbial cells in the 1850s and 1860s).*

In 1854, with the cholera outbreak, Snow began to study Soho's water supply. He was surprised to find that the water looked normal—it wasn't even cloudy. Meanwhile, Susannah Eley, the mother of the Eley Brothers, had fallen ill after drinking water from the Broad Street pump, which the Eley Brothers had shipped specially to Hempstead for her.

*Snow had access to Soho's water supply but he didn't have a good way of studying water samples. Victorian scientists had access to microscopes (which had been around since the 1700s), but it took decades before the germ theory of disease was universally accepted.*

Whitehead spent September 3, 1854 walking through the streets of Soho, alarmed by how empty the neighborhood had become. When he came home, he contemplated the rumors that people living in rooms on the upper floors of Soho's buildings were more likely to die than those living on the ground floor. This information appealed to London society's strong class bias—at the time, ground floor rooms were more hotly desired than rooms on the upper floor. But as he considered the matter, Whitehead realized the truth: more upper floor residents people were dying because more people *lived* on upper floors.

*The book parallels Snow's investigations into cholera with those of Henry Whitehead. While Whitehead lacked Snow's scientific genius, he was singularly devoted to his neighbors and friends, and used pure common sense to see through the medical obscurantism of the time. In a way, Whitehead is a lot like the ideal reader of* The Ghost Map*: he lacks any particular medical knowledge, but he has enough common sense to understand the nature of the epidemic.*

The very same evening, John Snow was looking over the mortality numbers for the 1854 outbreak compiled by William Farr. Snow and Whitehead had one thing in common that evening: they were both sitting in their rooms with glasses of water pumped from Broad Street. Snow examined his glass, suspicious that it contained the mysterious cholera agent. Whitehead, however, mixed his water with brandy and drank it.

*One reason that Whitehead was skeptical of contagion theory was that he'd drunk from the Broad Street pump himself, and survived. 21st-century readers will recognize why: brandy is sterile, and actually kills bacteria, so the water Whitehead was drinking no longer contained living cholera.*

## CHAPTER 4: THAT IS TO SAY, JO HAS NOT YET DIED

By Monday, September 4, Soho was becoming a ghost town. The Eley Brothers factory was almost abandoned—most of its workers had taken ill, as had Susannah Eley. But at the Lion Brewery, just a few hundred feet away from the Broad Street Pump, not one person had contracted cholera.

*From readers' perspective, it's perfectly clear that the Broad Street pump was responsible for the outbreak: that's why Susannah Eley, miles away, died of cholera—though Johnson hasn't yet revealed why the brewery workers didn't.*

On Monday, Whitehead visited the Waterstone family again, only to find that their daughter had died in the night. Meanwhile, the Waterstone patriarch was slowly dying of cholera, too. Some superstitious residents believed that the construction of a new sewer system had disturbed the corpses of ancient plague victims, buried underneath the ground. These people were half-right—the sewer system was responsible, but not because it had disturbed corpses. Rumors about the outbreak spread through London, yet newspapers were mostly silent on the topic.

*In times of crisis, many people turn to religion and superstition. Psychologically, religion and superstition can be powerful sources of comfort, because they convert the unknown (in this case, a deadly, unpredictable disease) into a set of events with clear, comprehensible causes.*

Fear consumed London—and, in a way, fear had been the defining emotion of working-class Londoners for a long time. Studies have found that, in 1842, the average gentleman died at forty-five, while the average "tradesman" (i.e., typical working-class man) died in his mid-twenties. In other parts of England, the average working-class man died around the age of sixteen. This was so largely because of the high infant mortality rate; in the mid-19th century, the majority of all recorded deaths were of children under five. Death was everywhere in Victorian society, to a degree that many contemporary people probably can't understood.

*The average age in 19th-century London seems shockingly low by 21st-century standards—although, as Johnson partly acknowledges, this is largely because of the disproportionate number of children who died before the age of five. In reality, a Victorian who lived past the age of ten had almost the same life expectancy as an American living in the 21st century. Death is, of course, a threat for all people, but in the 19th century people had no way of predicting or understanding when another cholera epidemic would hit—thus, what terrified Victorians wasn't just the prospect of death, but their fear of the unknown.*

Throughout the 19th century, people lived in fear of disease, yet they had almost no idea how disease spread. The miasma theory—i.e., that there were specific places and odors that fostered the spread of disease—was still popular, in spite of Snow's research. Clergymen like Whitehead, meanwhile, clung to their religious faith in times of cholera epidemics. Over the course of a lifetime, many Londoners became numb to the news of cholera outbreaks—they learned how to live normal lives with the threat of death hanging over their heads.

*In Victorian England, there were many theories about what caused disease, but very little* science. *Johnson even speculates that people became numb to the threat of death—they came to accept that they, or some of their close friends or family, would probably die a hideous, painful death in the near future. Through this coping mechanism, Victorians managed to lived relatively "normally."*

Seen through a Marxist lens, London in the 19th century was engaged in a vast dialectic (a clash or tension between an idea and its opposite, usually on an epochal or historical scale), as the "thesis" of progress and civilization was rapidly confronting its "antithesis"—disease, squalidness, and misery. London was the center of England, the most powerful country in the world; it was a hub of industry, finance, and intellectual life. And yet there were many thinkers who argued that London would collapse on itself, like Rome, Babylon, and other great cities of history. London was, after all, unprecedented in human history—never before had millions of people been packed into a thirty-three mile circumference. Lurking beneath people's fears about cholera was an even more basic fear—the fear that the metropolis itself was an inherently doomed idea.

*Karl Marx's theory of history suggests that human civilization consists of a series of competing material and economic forces. For example, the growth of urban spaces and sophisticated industry brings about the growth of an opposite (antithetical) force: disease, squalor, and urban misery. In the 19th century, it remained to be seen what the result (or synthesis) of these two competing forces would be: would London be able to survive itself, or would its own expansion tear it apart?*

If London was such a miserable place to live, one might ask, then why were people clamoring to live there? While there were plenty of good answers to this question—economic opportunities, family, intellectual life, school—many people thought of the city of London as having taken on a life of its own. London expanded during the 19th century because of innovations in the flow of energy accompanying the Industrial Revolution. After the 1750s, London became a center of steam and coal energy; thus, one could argue, London became a sprawling metropolis not so much because individual people chose to live there, but because of the spike in available energy. The physicist and urban theorist Arthur Iberall argued that human organizations are analogous to different states of matter: over time, humans have moved from a hunter-gatherer (gaseous) stage to "the crystalline density of the walled city."

*Johnson implies that to answer the question of why people moved to London, it's not enough to look to the explicit, stated reasons individuals gave. Rather, social scientists must look to the broad, population-wide forces that may have pressured people to move to London without their being aware. For example, regardless of why people say they moved to London, one might argue that the real reason for London's growth was its monopoly on energy sources such as steam and coal, which "created" a new class of people to operate them and benefit from them (although Johnson doesn't delve into detail about how this happened).*

But the upsurge in available energy cannot, by itself, explain the growth of London's population. London grew in part because there was a sudden spike in the population, specifically the population of people willing to change locations. Surprisingly, one can trace this population explosion back to tea. In the 18th century, tea became the most common British drink. With its medicinal properties and—crucially—sterilized water, tea may have prolonged the average Englander's life, thereby "supplying a larger labor pool to the emerging factory towns."

*The passage is characteristic of Johnson's "consilient" approach to writing about history: he briefly touches on the importance of tea in English history, but doesn't have time to go into depth on the subject (however, interested readers should consult A History of the World in Six Glasses by Tom Standage).*

Cities are life's "largest footprint," and bacteria are its smallest. And yet in Victorian London, these two extreme specimens of life were locked in combat, almost as if they were keeping each other in check. In 1854, epidemiology was still in its infancy—Victorians weren't accustomed to conceiving of their cities as complex systems, and therefore they had a hard time conceiving of the ways that diseases spread. Cholera, John Snow quickly found, couldn't be studied in isolation: it had to be seen from a "bird's eye view."

*Here, Johnson builds on his analysis of urban growth in the 19th century by providing a "bird's eye view" of both cities and microbes. It's not enough to conceive of epidemics, or cities, as collections of individual units—rather, one must conceive of them as autonomous systems to be studied holistically. Such an assumption has long been a fixture of social science, but in the 19th century, it was still something of a novelty (perhaps because sprawling metropolises were still new).*

On Monday, John Snow was busy trying to find a "wider perspective" for the study of cholera. Around the same time, Florentine scientists had isolated the *Vibrio cholera* bacterium, a milestone for the germ theory of disease. However, the scientists' papers on the subject were ignored for the next three decades. Meanwhile, in the absence of conclusive evidence for the existence of a cholera bacterium, Snow collaborated with the demographer William Farr. Farr was a scientist, but he still clung to the miasma theory; he thought that cholera was caused by putrid fog emanating from London's riverbanks. However, Farr was open-minded enough to record information about cholera victims' water supplies, recognizing that Snow's theory might be correct.

*It's remarkable that Italian scientists' discovery of the cholera bacterium wasn't widely publicized in Europe; in the mid-19th century, there wasn't a strong international scientific community that shared important discoveries. As a result, Snow continued to search for a contagious agent that could explain the behavior of cholera. William Farr was an important figure in Snow's research: although he disagreed with Snow, Farr provided Snow with invaluable demographic information that Snow used to isolate the causes of the cholera outbreak.*

Throughout history, human beings have struggled to find clean water. The invention of alcohol was crucial to human history, because (unbeknownst to anyone before the 19th century), the brewing process sterilized the water, rendering the drink potable. It's been suggested that modern humans are better at "holding their liquor" than people who lived thousands of years ago, because holding one's liquor is a major evolutionary advantage—people who can drink a lot have access to a bacteria-free supply of liquids.

*Alcohol has played an important role in human civilization. Not only does it sterilize water, rendering it safer for drinking; it also may have played a vital role in the development of agriculture (again, interested readers should consult A History of the World in Six Glasses).*

In the 19th century, water was becoming a staple of the urban European's diet, to an unprecedented degree. Wealthy 18th century Londoners had built private water pipe systems to provide themselves with clean water from streams outside the city; however, by the 19th century, water pipe companies had consolidated in major firms that designed piping systems for the whole city. When researching the spread of cholera in the late 1840s, Snow discovered that the people dying of cholera lived in a district of London whose piping needs fell under the domain of two firms, S&V and Lambeth. Snow realized that he had an opportunity to prove his theory: if he could show that cholera deaths in Soho correlated with one piping firm or the other, he would have strong evidence that cholera was waterborne, reinforcing the contagion theory.

*It's striking to consider that Europeans drank relatively little water before the 19th century (it's even been suggested that, without beer and liquor to nourish the population, urbanization and industrialization would never have occurred in Europe). Snow's training was in medicine, but in order to study the cholera outbreak, he essentially had to found a new branch of medicine—epidemiology. By using statistical analysis, Snow was able to establish a strong correlation between certain water sources and cholera—and while this didn't prove causation, it was a clear step in the right direction.*

Leading up to the cholera outbreak of 1854, John Snow had been visiting the Soho slums and inquiring about cholera victims' water supplies. He visited hundreds of households, collecting water samples from each house's tap. Since one piping firm used more salt than the other, it was easy to test which water came from which pipes. In the middle of his investigation, news broke of the new cholera outbreak. Snow realized that the outbreak might give him another opportunity to strengthen his research.

*Snow didn't have the luxury of conducting well-ordered experiments to establish a cause-effect relationship between water and cholera outbreaks. Instead, he had to examine the existing statistical record, searching for any strong correlations and then using his medical knowledge to build correlative data into a strong, causational theory.*

## CHAPTER 5: ALL SMELL IS DISEASE

On Tuesday, September 5, 1854, the situation in Soho began to improve. People were dying, but others were recovering—and many of the people who were improving attributed their recovery to the fact that they'd been drinking lots of water from the Broad Street pump. Henry Whitehead believed that the cholera outbreak was almost over.

*It took a long time before the medical community came to accept the waterborne theory of cholera, partly because there were many confounding factors—in particular, the fact that water could be a cure for cholera, as well as a cause.*

Medical officers from the General Board of Health visited Soho to inspect the situation and scatter chloride and bleach on the streets. In the past five days, some five hundred residents of the neighborhood had died; however, the Board believed that it could reduce further disaster with chloride and bleach. Walking the streets that day was Sir Benjamin Hall, the new president of the Board.

*The Board subscribed to existing medical theories of disease, and believed that it could ward off further death by eliminating bad smells—a timeless example of how people who desired to do good let misguided theory get in the way.*

Benjamin Hall's predecessor on the Board was a man named Edwin Chadwick. Chadwick had made a name for himself by conducting groundbreaking research into the London sewer system. He was a pioneer of the idea that the government should be engaged in protecting its citizens' health and well-being, especially its poorest citizens. He was, for better or worse, an advocate of "big government" as people now understand it. However, Chadwick inadvertently caused the deaths of tens of thousands of cholera victims due to his lack of understanding of the germ theory of disease, and his irrational belief that disease was spread by bad smells.

*Edwin Chadwick is a strikingly modern figure—he was a pioneer of the idea, now fairly uncontroversial, that the municipal government should play a significant role in helping its citizens survive. (At the time, there were many who advocated for various versions of Social Darwinism, the idea that the poor and the weak should be allowed to die in order to strengthen the gene pool). However, Chadwick also exemplifies the danger of enacting policy based on faulty theories, and the importance of basing policy on data and science, not just conjecture and conventional wisdom.*

The problems that Chadwick wrestled with continue to challenge society in the 21st century: how can societies industrialize humanely?; how can government control the free market?, etc. But perhaps the most pressing question of Victorian society was a much more basic one: "*What are we going to do with all of this shit?*" London had a huge excrement problem—as Chadwick had shown in an influential 1842 study, human waste was piling up at an alarming rate, with no real plans for disposal. Some proposed using human waste as a form of fertilizer. Others suggested a system of sewers that could transport London's excrement out to the countryside, where it could be put to use on farms. Some thinkers believed that human excrement could solve all problems of population growth—by feeding plants with human waste, society could grow without experiencing a crisis in resources.

*It may seem unbelievable that one of the biggest, most intellectually sophisticated cities on the planet had no plan for dealing with its waste—but indeed, London in the 1840s had never had to deal with so many people living in such a small amount of space, and so there was no "master plan" for garbage disposal. Thinkers were intelligent enough to propose solutions to the problem, but until Chadwick, no government agency had the clout to enact any one of these proposals. The "shit crisis" pointed to a broader problem with urban planning itself—it wasn't clear if it was possible, in the long run, for so many people to live together.*

Edwin Chadwick launched a crusade on sanitation issues, resulting in the Public Health Act of 1848, which established the General Board of Health, with Chadwick leading it. Chadwick recognized that London needed new sewers. Under the current system, people discharged their waste into pipes, which flowed into the Thames River. At times, the sewers became so clogged that there would be an explosion of methane gas. However, Chadwick's proposed solutions made the problem worse: the sewers were unclogged, but as a result, more sewage flowed into the Thames. As one Victorian said, "the Thames is now made a great cesspool instead of each person having one of his own."

*Chadwick thought that he was saving London from its own waste problem, but in fact, he created a much bigger problem when he dumped this waste into the Thames, where tens of thousands of people got their water every day. Because he lacked any understanding of the germ theory of disease, Chadwick was unable to execute policies that could genuinely help Londoners—only policies that appeared to do so.*

Chadwick's "innovations" in public health directly contributed to London's cholera epidemics of the mid-19th century. It seemed never to have occurred to him that he was dirtying the water that millions of Londoners drank—he was so blinded by his theory of bad smells and miasmatic vapors that he couldn't see the truth.

*Theory blindness is an important theme of the book: Chadwick and other powerful establishment figures in London refused to see the facts, because they were so used to seeing things through the lens of their own ideas.*

The miasmatic theory of disease remained powerful throughout the 19th century. In one edition of the *Times*, authors explored a series of theories about cholera, most of which were miasmatic—electric signals, "emanations from the earth," etc. The theory that cholera was waterborne never came up. Even Florence Nightingale, the most beloved medical figure of the Victorian era, supported the idea that invalids' "vapors" and "smells" must be kept as pure as possible. Many miasma theorists were arrogant about their views—they couldn't tolerate the notion that they might be wrong. Yet none of them could explain the fact that scavengers and sewer workers spent all day inhaling horrible smells, and yet seemed no worse off than anybody else. Why was miasma theory so persuasive in England? Perhaps there is no single answer—many failures of imagination and analysis created the "perfect storm of error."

*The popularity of miasma theory in Victorian society contradicted some of the most basic requirements of good science, as articulated by scientific theorists such as Thomas Kuhn and Karl Popper. For example, Popper argued that good scientific theories should be falsifiable (i.e., other scientists should be able to test theories and prove them wrong). And yet, even after strong evidence contradicted the miasma theory, doctors continued to believe it, inventing elaborate rationalizations for their ideas. Perhaps, as Thomas Kuhn argued, miasma theory was a "paradigm"—an unverifiable underlying idea about a scientific phenomenon. In the end, it was arrogance, poor communication, and a general lack of common sense that led scientists to uphold their belief in miasma.*

One partial explanation for the popularity of miasma theory was tradition. Since ancient times, doctors believed that bad smells caused illness. Miasma theory also worked well with religious tradition—for example, Henry Whitehead insisted that Earth's atmosphere could, with the will of God, foster a plague. Another reason for the popularity of the miasma theory was instinct. Human beings' sense of disgust has always led them to associate smell with illness—indeed, studies have shown that bad smells can inhibit the ability to think clearly, or do anything other than escape the smell. Smelling a rotting animal is disgusting, and it signals the presence of bacteria, but the smell itself won't kill anyone. Thus Victorians mistook a *sign* of disease (the smell) for the disease's cause—they mistook the smoke for the fire.

*The idea of an intangible, almost atmospheric source for disease reflected many Christian theologians' views on divinity. And although miasma theory was un-scientific in many ways, it* was *based on direct observation—people intuitively associate bad smells with sickness and disease, to the point where the two concepts can't be easily separated. (Johnson's discussion of "signs" in this section betrays some of his training as a semiotics major at Brown University.)*

Another reason for the popularity of miasma theory is that smell is a stronger sense than sight. It only takes a few molecules for a human being to perceive the smell of decay—on the other hand, "eyes are useless at the scale of molecules." People reacted negatively to the bad smells of 19th century London, but they had no way of *seeing* the hundreds of millions of cholera bacteria all around them. Furthermore, miasma theorists had lots of correlative evidence on their side: for example, the fact that many neighborhoods with high rates of cholera smelled disgusting. Furthermore, the miasma theory was a convenient way for Victorians to justify bigotry. Some doctors argued that bad smells had more of an effect on certain people than others, based on their internal "constitution." Based on such arguments, others argued that the poor, or non-white races, were simply weaker. (However, there were also plenty of liberal thinkers, such as Nightingale and Dickens, who subscribed to miasma theory.)

*Usually, one would hesitate to say that tradition or cultural values play a strong role in the development of science. But in fact, scientists are no more immune to cultural bias than anyone else. The popularity of miasma theory is a good example: scientists allowed their prejudices about certain patients to nudge their findings in the direction of conventional opinion. Put another way, scientists allowed their theories to reflect the common belief that the poor were weaker than the rich and thus, on some level, deserved to die of cholera. Bias, along with correlative evidence and a lot of other minor, vaguely defined factors pushed the medical community into accepting miasma theory long after it should have been proved wrong.*

Miasma theory exemplifies the concept of "overdetermination"—in other words, an idea that persuades because of many small, compatible arguments, rather than any single, really convincing point. But in the end, the "miasma dam" burst, and scientists made progress toward solving the mystery of the cholera epidemic. In fact, the popularity of the miasma theory—and its persistent failure to better Londoners' lives—made it easier for people like John Snow to see the theory's weaknesses, so that miasma theory ultimately collapsed on itself.

*Again, Johnson enlists a Marxist dialectical theory to explain the progress of science over time. Here, the very popularity of miasma theory brought about its own destruction (much like how, in Marxism, capitalism creates its own "gravediggers").*

John Snow spent Tuesday, September 5 walking through Soho, searching for cholera patterns. He visited the Registrar-General's Office, where Farr worked, and spoke with Farr about the latest body counts for the neighborhood. Snow wondered if the Broad Street pump could be responsible for the cholera outbreak. He realized that he needed "footprints" to prove his point, not just "body counts."

*For the time being, Snow had no way of isolating the contagious agent in cholera; therefore, he tried a "macro approach"—analyzing hundreds of people's behavior in the hopes of finding some overarching pattern.*

## CHAPTER 6: BUILDING THE CASE

On Cross Street, not far from the Broad Street pump, there lived a tailor named Mr. G. Mr. G. and his son died early in the cholera epidemic of 1854, but their deaths became an important piece of the puzzle for John Snow.

*Mr. G.'s death helped John Snow understand the relationship between a cause (consumption of water) and an effect (death from cholera).*

After studying Farr's latest figures, Snow came to realize that, while most of the cholera victims of 1854 had gotten their water from the Broad Street pump, and lived very close by, a few victims also lived on Cross Street—from which the Broad Street pump was slightly inconvenient to reach. Snow realized that he could use the Cross Street data to strengthen his theory and disprove miasma theory. But by the time Snow arrived at Cross Street to speak to Mr. G.'s surviving family, he learned that they were dead—"their late-night thirst for Broad Street water had destroyed them all."

*Snow knew that there had to be a connection between the consumption of water and contracting cholera; however, he was unable to get the information he needed because many of his subjects died before he could talk to them. While Snow's waterborne theory seems obvious from a 21st-century perspective, Snow had to amass enough evidence to make his theory airtight—thus, the loss of more Soho locals to cholera was a devastating blow for his research, as well as a great human tragedy.*

In following interviews, John Snow was able to determine that some of the other cholera victims living on Cross Street had gotten their water from the Broad Street pump. However, his sample size wasn't big enough to be convincing—and there were two victims who had had no apparent connection to Broad Street. In order to make his case airtight, Snow needed to find examples of people who'd lived on Broad Street but *hadn't* contracted cholera, because they hadn't drunk from the Broad Street pump.

*Snow's research upheld one of the most basic scientific principles: a good theory should be falsifiable. By tracing the connection between the water pump and cholera, Snow didn't merely strengthen his waterborne theory of cholera; he also developed a hypothesis that could be tested and proven false (i.e., if Broad Street locals who didn't drink from the pump had died of cholera, then clearly Snow was mistaken in some way).*

After more research, Snow discovered that not one of the Lion Brewery's employees had died of cholera—quite possibly because these employees were paid partly in beer, and had a private water pipeline and well. In the nearby Eley Brothers factory, by contrast, dozens of employees had fallen ill—the Eley brothers had provided their workers with two large tubs of water, taken from the Broad Street pump. After learning that the brothers' mother (Susannah Eley) had died, Snow discovered that they'd sent her some water from the pump.

*Snow caught a lucky break (if "lucky" is an appropriate word for discussing a cholera epidemic) when he learned about the brewery and the Eley brothers' mother—with this information, he strengthened the connection between the water pump and the cholera epidemic, eliminating many of the other confounding factors that had led other doctors to question the causational link between water and disease.*

John Snow was a brilliant man, crusading against a medical establishment that believed in a false theory. But brilliance alone isn't enough to explain why Snow didn't buy miasma theory. In part, he had begun to question miasma after working with anesthetics. Snow's entire career as an anesthesiologist was predicated on the assumption that vapors have a predictable, mechanistic effect on people who inhale them. He realized that ether, a miasma, was seemingly indifferent to the "inner constitution" of humans who inhaled it. He also decided that vapors emanating from excrement would be diffused through the air, to the point where they couldn't do any damage. Snow further noticed that cholera attacked patients' intestines first and foremost—if cholera was caused by vapors, wouldn't it damage its victims' respiratory systems?

*Johnson resists the temptation to portray John Snow as a heroic crusader who fought for the waterborne theory of disease because he knew it was right. In reality, Snow, like any good scientist, was mostly looking for evidence to support his theory in order to convince himself, not just other scientists. Snow had some good reasons to believe that he was right about cholera (his experience as an anesthesiologist, for example), but these reasons didn't add up to certainty—not even close. Rather, Snow's life experiences and research gave him an advantage in seeing the issue of the cholera epidemic in a clear, unbiased manner.*

It's worth remembering that Snow lived less than six blocks from the outbreak of the cholera epidemic—suggesting that his interest in cholera was partly the result of pure geographic chance. Furthermore, Snow had a lot in common with the working-class victims of cholera in Soho; perhaps his own working-class background led him to treat his patients less prejudicially. In all, Snow's resistance to miasma theory was "overdetermined" in the same way that miasma theory itself was overdetermined: it stemmed from small, almost unconscious factors, rather than a big, conscious decision.

*In part, Snow was able to accumulate evidence in support of the germ theory of disease because of sheer random chance—had he been born in Paris or New York around the same time, it's possible that he would never have gotten the opportunity to study cholera in such great detail, and miasma theory might have survived for another ten or twenty years. Johnson suggests that scientific progress—and, perhaps, progress in general—occurs because of a confluence of random factors, not simply because of the contributions of "great men" like John Snow.*

As Henry Whitehead spent more time with cholera victims, he found himself growing increasingly furious with wealthy Victorians who claimed that the poor had "brought this on themselves." When James Richardson, St. Luke's scripture reader, failed to show up to church, Whitehead went to Richardson's home and found his friend sick with cholera. The "inner constitution" explanation for disease was a lie, Whitehead was sure—Richardson was one of the strongest people he knew. Richardson mentioned to Whitehead that he'd drunk a glass of water from the Broad Street pump, and it occurred to Whitehead that the pump might have had something to do with the outbreak. Then, he decided this theory was silly—he'd had a glass of water himself, and he wasn't sick.

*Henry Whitehead was unlike John Snow in many ways, but they had some things in common—in particular, their lack of patience for conventional dogma and prejudice. Whitehead and Snow were uncommonly clear-eyed thinkers—however, Whitehead had a hard time believing in the waterborne theory because he didn't have all the information (nor, for that matter, did Snow). Whitehead had no way of knowing that the glass of brandy had saved his life the previous evening, killing the cholera bacteria in the water.*

It's not clear what was happening in the well below Broad Street. By Wednesday, fewer people were contracting cholera, suggesting that cholera bacteria were dying. Perhaps the bacteria were victims of their own success. In other words, the fact that the cholera outbreak took place in a dense neighborhood meant that the bacteria could spread like wildfire—but the epidemic killed off so many people that the remaining bacteria had fewer hosts to infect. It's also possible that the bacteria had been starving in the cold, dark water beneath the pump.

*Johnson has to admit that it's still not clear why the cholera epidemic ended when it did. In retrospect, readers have no problem seeing how the 1854 epidemic verifies the germ theory of disease—at the time, however, the sudden end of the epidemic posed a significant challenge to Snow's research, and made other doctors question whether or not cholera was a contagious agent.*

As Whitehead visited other sick and recovering cholera victims, he found that many people said they'd begun to recover from their illness after drinking water from the Broad Street pump. However, many other people who'd drunk from the pump earlier in the week weren't available for discussion—since they were dead. It is possible that the cholera bacteria in the pump had died off, or perhaps the flow of groundwater had cleansed the pump supply.

*This passage suggests how cholera epidemics "resolved" themselves before the era of germ theory —either the epidemic killed so many human beings that it lost its ability to grow exponentially, or natural factors swept away the germs that had launched the epidemic.*

By the end of the day, John Snow had built a strong case against the Broad Street pump: the vast majority of deaths Farr had recorded had occurred in houses for which the Broad Street pump was the nearest available water source, and of that group, the majority consisted of habitual pump drinkers. There were six victims Snow couldn't account for, however—they didn't appear to drink from the pump at all. But Snow had also learned that there was a coffeehouse owner who sold sherbet mixed with Broad Street water—and many of her patrons had died. In a single day, Snow had interviewed dozens of people and strengthened his contagion theory. It's even possible that Snow's vigorous questioning of Soho locals *curbed* the spread of the disease, since some of his questions made the locals question their own behavior regarding the well.

*Snow reviewed the evidence and concluded that he had a strong case for a waterborne theory. The theory was "strong" because it not only explained why certain people contracted cholera; it also explained why other people (such as the brewery employees)* didn't *contract it. The passage also shows Snow inadvertently influencing people's behavior in the act of trying to study it—i.e., by asking questions about the water pump, he probably convinced some of his interviewees to be suspicious of drinking from the pump.*

Although the epidemic may have been in decline, it was still killing people. A dozen people died in Soho that day—ten times the normal rate. Snow prepared to finalize and publish his research, but before he did so, there was "a more pressing matter"—removing the actual culprit for the outbreak.

*Snow was about to embark on the most revolutionary phase of his investigation—translating medical research into public policy, something that had rarely been done before (at least not when the medical research in question was scientifically sound).*

## CHAPTER 7: THE PUMP HANDLE

On the night of Thursday, September 7, the board of governors of St. James's Parish had a meeting to discuss how the neighborhood would respond to the cholera outbreak. John Snow spoke at the meeting, insisting that the community needed to remove the pump as soon as possible. The Board was skeptical. They knew that everybody loved Broad Street water, and many of them subscribed to the miasma theory, not Snow's waterborne theory. But Snow's arguments were very persuasive, and in the end the Board voted to close down the well.

*Snow was able to convince a local administrative board to enact public policy (specifically, performing the symbolic and life-saving act of removing the pump handle). One could argue that the real heroes of the 1854 epidemic were the board members who kept open minds, set aside their biases toward miasma theory, and voted to follow Snow's recommendations.*

On the morning of Friday, September 8, the Broad Street **pump handle** was removed. The deaths would continue in Soho for another week, and none of the newspapers reported that the Board had removed the pump handle. Indeed, the Friday paper included a miasmic story about how changes in the weather were going to improve the cholera situation. However, as the days went on, it became clear that the worst of the outbreak was over—few people were contracting the disease. In all, some seven hundred people near the Broad Street pump had died in less than two weeks.

*Even after the board of governors agreed to remove the pump handle, the investigation into the cholera epidemic was far from resolved. People continued to die, meaning that, as far as many doctors were concerned, Snow hadn't proven his theory at all. In reality, these victims had probably already drunk from the Broad Street pump; nevertheless, it was difficult for people to see a clear causal relationship between the removal of the pump and the aversion of further death.*

The removal of the Broad Street **pump handle** probably didn't seem like a major event. But it was quietly momentous—a public institution had made an informed intervention in a cholera outbreak, based on "a scientifically sound theory." Reason triumphed over the disease. However, many people were furious that the pump had been shut down. Meanwhile, Sir Benjamin Hall commissioned an investigation into the Soho neighborhood, attributing the disease to factors such as slaughterhouses and "peculiarities of ventilation." Hall ordered that researchers should study the pipe system beneath the neighborhood, but overall, his assignment reflected a loyalty to miasma theory, which acted as a kind of intellectual "strait-jacket." Hall took the waterborne theory of cholera into account, but it wasn't a priority for him—for months, he and his research team asked the wrong questions about why the outbreak happened.

*John Snow's cholera research—and, just as importantly, his collaboration with the local municipal board—set an important precedent for public health policy. However, the miasma theory of disease continued to reign supreme in England for a long time after Snow's "victory" in 1854. Benjamin Hall's mistake was to investigate the wrong factors in the epidemic, focusing on smells, "noxious environments," and other data that implicitly favored the miasma theory. Put another way, Hall unconsciously posed a series of leading questions that inevitably led his research team to confirm the miasma theory.*

At first, Henry Whitehead thought the **pump handle**'s removal was a foolish choice. He was so displeased, in fact, that he vowed to disprove the waterborne theory of cholera—and in the end, his opposition to Snow's theory proved invaluable, since it strengthened Snow's theory. Whitehead began by interviewing elderly people who'd survived the cholera epidemic—"What kind of pestilence," he wondered, "spares the old?" Meanwhile, Snow began writing a monograph on cholera, which he published in the fall.

*Henry Whitehead, like Benjamin Hall, didn't believe that the removal of the pump handle played a decisive role in ending the cholera epidemic of 1854. However, unlike Hall, Whitehead kept an open mind and asked a series of important, open-ended questions that didn't simply confirm his convictions about the disease.*

As Whitehead continued with his research, he became aware of the lack of correlation between sanitary conditions and mortality rates on Broad Street. He then composed his own monograph on the cholera outbreak of 1854; in it, one can see Whitehead struggling with the theological meaning of so many deaths. He claims, for example, that God had a greater plan in mind for London—by sending a plague of cholera, God was drawing mankind's attention to the problem of poverty. But in addition to his theological musings, Whitehead offered some important data in his monograph.

*Johnson doesn't editorialize about the role Whitehead's religious faith played in his investigations. In some ways, his faith may have preventing him from seeing the truth about the epidemic; however, one could also argue that it inspired him to keep working long after most people would have given up. Furthermore, in trying to understand God's "plan" with the 1854 epidemic, Whitehead had to adopt the "bird's eye view" that Johnson considers so essential to urban planning and epidemiology—instead of seeing Soho as a hodgepodge of individuals, Whitehead's faith enabled him to see the community more holistically.*

In late November, the St. James Vestry founded a committee to investigate the Broad Street cholera outbreak; however, the committee was weakened by the fact that Sir Benjamin Hall refused to share his Board's findings with anyone else. Hall's refusal turned out to be a good thing, though, as it encouraged the committee to hire Henry Whitehead, the only local with an encyclopedic knowledge of the outbreak. On the committee, Whitehead offered a vigorous attack on John Snow's theory that the Broad Street well was to blame for the outbreak, pointing out that many of the cholera victims who'd *survived* the outbreak attributed their survival to drinking from the well.

*Whitehead's attempts to disprove John Snow's waterborne theory perfectly encapsulate why it's so important for scientific theories to be falsifiable. When a theory is falsifiable, other scientists can attempt to accumulate enough data to refute the theory—and in the end, they either succeed in doing so or, just as often, end up verifying and strengthening the original theory.*

As Whitehead conducted further research, he began to come around to John Snow's theory. Some of the families who Whitehead interviewed later remembered that their deceased loved ones had drunk from the well, contrary to what they'd told Whitehead initially. In particular, Whitehead realized that young children were the well's most frequent patrons—many of them had to fetch water from the well as part of their chores. He further realized that many elderly men and women had survived the outbreak not because of their inner constitutions, but simply because they lived alone and hadn't had anyone bring them water from the well.

*In the act of trying to disprove Snow's theory, Whitehead came to realize how convincing the waterborne theory of cholera really was. Snow's theory answered Whitehead's initial question, explaining why the old and infirm had been spared in the epidemic—they hadn't been able to venture outside and drink the contaminated Broad Street water.*

Whitehead was coming around to John Snow's theory, but he still had some objections. First, he wondered why the outbreak hadn't occurred near some other well with a reputation for inferior water. Second, he couldn't explain why some Soho residents had survived the outbreak after drinking extra water from the well. Finally, Whitehead couldn't explain why *he'd* survived the outbreak, considering that he'd drunk Broad Street water. Furthermore, studies had concluded that the Broad Street well wasn't connected to the sewer lines in any way. Whitehead received a copy of Snow's monograph, and later wrote Snow a letter listing his objections to Snow's theory. Whitehead wondered why the cholera outbreak had plateaued so quickly—if the disease was waterborne, and if people were passing rice-water diarrhea, wouldn't the spread of the disease have accelerated?

*In trying to understand Snow's theory, Whitehead's biggest weakness was his inability to grasp how certain bodies of water become contaminated. But of course, neither Whitehead nor Snow had a convincing answer for this question, since the germ theory of disease was still in its infancy. Whitehead's questions about the cholera epidemic were very insightful—notice that Johnson already devoted a lot of space in a previous chapter to answering them (the reason why the epidemic didn't accelerate, Johnson believes, is either that the cholera germs were swept away from the well or that the epidemic claimed too great a portion of Soho's population).*

As the data about the cholera outbreak continued to pile up, Whitehead began to believe Snow's theory. He began searching for an "index case"—i.e., the earliest cholera victim of 1854. While studying the data, he came across the medical report for baby Lewis, who'd experienced diarrhea before dying. Whitehead interviewed Sarah Lewis and learned that she'd thrown soiled diapers into a cesspool. Whitehead realized that the baby's cholera evacuations must have been deposited near the Broad Street well. He commissioned surveyors to examine the cesspool, and the surveyor found that it had, indeed, leaked into the well. Earlier investigations had missed the cesspool connection, perhaps because they were too focused on miasma. Whitehead realized that the surveyor had answered his objections to Snow's theory. The reason the cholera body count hadn't grown exponentially was that only the Lewis family could access the cesspool—therefore, baby Lewis's waste was the only source of cholera in the well, and the cholera agent wasn't growing exponentially.

*Whitehead came to believe Snow's theory, even though it couldn't explain every aspect of the cholera epidemic (for example, Whitehead had no way of understanding why he hadn't died after drinking water with brandy). Whitehead and Snow went from being intellectual opponents to friends and collaborators. Johnson doesn't provide much information about their personal relationship (How many times did they actually meet? Were they friends? Were they close?), and as he later acknowledges, it's not clear how well they actually knew each other. Whitehead came to admire Snow's theory for explaining a complex phenomenon, the cholera epidemic, in terms of one simple factor (water from Broad Street).*

The St. James Vestry Committee issued a report hypothesizing that, just as John Snow had argued, the cholera outbreak was caused by contamination of the Broad Street well. The Committee's report further attacked the popular miasma theory of the era. And yet, around the same time, Benjamin Hall's own Committee issued a report on the epidemic concluding that Snow's theory was unverifiable and unlikely. The Board of Health Committee was so blinded by miasma theory that it couldn't accept any other explanation for cholera. The Committee's report on the outbreak analyzed a stunning number of factors (including humidity, wind velocity, and atmospheric pressure), all of which reflected a miasmatic conception of the disease.

*In the scientific community, the best idea wins in the long run—in the short term, however, personal bias, a lack of common sense, and sheer arrogance often get in the way of the truth. Here, for instance, the popularity of miasma theory obscured most of its gaping holes. Furthermore, Snow's theory was weakened by the fact that 1) he didn't know anything about the contagious agent in cholera, and 2) he couldn't conduct a scientific experiment on cholera, and instead had to support his findings with correlative data.*

Hall's Committee's report hit on one problem on its miasmatic hypothesis: the death of Susannah Eley, miles away from Broad Street. The Committee explained Eley's death by saying that the water she'd received from her sons was "impure with organic contamination." However, the Committee stressed that, during an epidemic, contamination in the atmosphere can *also* contaminate the water. This was "circular argumentation at its most devious." Thus, miasma theory survived the 1854 outbreak intact.

*Miasma theory exemplifies most of the features of a bad scientific theory—above all, its* un-*falsifiability. Even when Snow offered a persuasive challenge to miasma theorists' notions of noxious fumes and contaminated environments, miasma theorists performed elaborate mental gymnastics to justify their beliefs—practically agreeing with Snow's theory in the process!*

Perhaps the last person to die of the 1854 outbreak was Thomas Lewis, who succumbed to his illness on September 19, 1854. After baby Lewis's death, the Lewis family stopped emptying cholera-infected waste into the cesspool—however, after Thomas took ill, Sarah Lewis began emptying *his* diarrhea into the cesspool, infecting the Broad Street pump once more. Had Snow not convinced the authorities to remove the **pump handle**, the outbreak probably would have continued.

*John Snow died before his theory of cholera became universally accepted, but his contributions to epidemiology surely saved lives. In the 1854 epidemic alone, he may have prevented a second cholera outbreak by preventing additional people from drinking from the Broad Street pump.*

## CHAPTER 8: CONCLUSION

Shortly after the **pump handle** was removed from the Broad Street pump, an engineer named Edmund Cooper began researching the epidemic on behalf to the city's sewer commission. Cooper wanted to "bury" (as it were) the rumor that ancient corpses had caused the outbreak. Thus, he created a map of the outbreak, superimposed over the city's sewer lines. Cooper's map was a milestone in epidemiology (the study of diseases and how they spread), setting the standard for future "dot mapping." However, Cooper's map offered too much data, and too many confounding factors in the cholera outbreak.

*John Snow wasn't the only researcher trying to make sense of the cholera outbreak of 1854. Necessity is the mother of invention, and various researchers and committee members realized that there was significant value in being able to map the spread of a disease—doing so might enable city planners to predict how future epidemics could travel across London.*

John Snow then began making his own map of the cholera epidemic. Snow's map showed each victim's proximity to the Broad Street pump, emphasizing his waterborne theory. Snow also used icons representing the foot traffic around the pump—implicitly refuting any miasmatic theories that the pump was emitting noxious fumes. To make his map, Snow employed a mathematical tool called the Voronoi diagram. A Voronoi diagram divides a two-dimensional space into distinct spaces, whose common quality is that they consist of points that are closer to a specific, predetermined point than to any other point. For his map, Snow divided London into color-coded regions, based on the region's closest available water pump.

*John Snow's maps of London were a crucial part of his argument, and indeed, he designed them specifically to refute the miasma theory that dominated English medicine at the time. Snow's techniques were sophisticated yet relatively simple to understand; as a result, his maps were masterpieces of persuasion—they expressed the waterborne theory of cholera in a form that anyone could see.*

John Snow's map was a milestone in the history of epidemiology, reflecting both Snow's training as a doctor and the painstaking research he conducted in the Soho area between the late-1840s and mid-1850s. However, the map still failed to convince the London Epidemiological Society of Snow's waterborne theory of cholera. For the time being, the miasma "paradigm" (framework of assumptions or ideas) proved too strong.

*The key word in this passage is "paradigm." The philosopher and science historian Thomas Kuhn argued that science can be understood as a set of distinct paradigms—unproven assumptions about the world—which disappear as soon as they're replaced with a new paradigm. The germ theory of disease was a major paradigm shift for science, decimating the old miasma paradigm.*

Even if John Snow's map failed to convince the medical establishment, it convinced one very important person of the veracity of the waterborne theory: Henry Whitehead. Had Whitehead not seen Snow's maps, he might not have been converted to the waterborne theory, and he might not have convinced the St. James Vestry Committee to conclude that contaminated water started the outbreak. The St. James Committee's conclusion was a decisive step forward in the history of epidemiology, accelerating the public's adoption of Snow's theory.

*Snow's maps didn't convince the city officials, but they convinced Whitehead, who went on to convince the St. James Vestry. Johnson doesn't go into any detail about how future epidemiologists or city planners viewed the St. James Committee's ruling, however—raising some questions about how influential Whitehead really was in the history of epidemiology and urban planning.*

The 1854 cholera epidemic was a horrific episode in London's history, but it had a silver lining: it was a triumph of science. Snow was a master at drawing bold conclusions from the data. Furthermore, the aftermath of the epidemic represented a triumph of amateur research: Henry Whitehead was a local figure with no particular training, but he used his rapport with Soho locals to assemble crucial data. It's unclear how much of a personal relationship Snow and Whitehead had with each other—however, it would appear that "a powerful bond formed between them."

*Snow and Whitehead adopted different yet strikingly parallel approaches to studying the cholera epidemic of 1854. Both were devoted, painstaking researchers who never tired of visiting more subjects and asking them questions. What's remarkable is that Whitehead and Snow were able to make their voices heard at a time when there were lots of irrational views about the causes of the epidemic. Thus, future generations should admire Whitehead and Snow not only for their intelligence but also for their tenacity.*

In the years following the outbreak, the waterborne theory of cholera grew more popular, but miasma theory continued to dominate, thanks largely to Sir Benjamin Hall's authority. However, "the confidence of the miasmatists" took a big hit in 1858, when winds blew the disgusting smell of the Thames through the city. To miasmatists' surprise, the death rate for London in 1858 was perfectly normal. But just as miasma theory was beginning to collapse, John Snow suffered a stroke, and died days later—he was only forty-five.

*Snow died before he could enjoy the total collapse of miasma theory—he only saw the beginning of its end. Yet as the very existence of Johnson's book makes clear, Snow's influence lived on long after his premature death.*

In the late 1850s, partly because of Snow's groundbreaking research, the London municipal government decided to build a new sewer system. London's sewer system was a triumph of engineering every bit as impressive as the Eiffel Tower or the Brooklyn Bridge; it was also a triumph of urbanism, proving that a city's population could work together to benefit itself.

*The best urban planning, Johnson suggests, is often the most invisible. To this day, few Londoners realize how brilliantly designed their sewer system is, and how important its role is in avoiding a major crisis of the kind London experienced in the mid-19th century.*

In 1866, London experienced its last great outbreak of cholera, largely in its East End. William Farr assembled the evidence and concluded that the vast majority of the victims had been customers of the East London Water Company. He then commissioned notices that all Londoners should boil their water before drinking it. Farr's actions prompted a city-wide investigation of the East London Water Company's policies, and it was discovered that eels swam in the company's water supply. Henry Whitehead was an important figure in the 1866 investigation; he helped uncover a pattern of company negligence that almost certainly resulted in thousands of deaths. Although Snow was dead by this point, Farr and Whitehead regularly credited him for his waterborne theory of cholera. Indeed, Farr (who'd once been a miasmatist) wrote as if he and the medical community had always agreed with Snow. The waterborne theory had at last become the dominant scientific paradigm.

*Snow died before the epidemic of 1866, but his approach to research—based on statistical analysis, hands-on research, and rigorous scientific testing—lived on after him in his disciples, such as Whitehead and William Farr. Inspired by Snow's success in 1854,Whitehead and Farr succeeded in making their voices heard, popularizing the new waterborne paradigm in the process. 1866, in other words, marked a "paradigm shift," after which the idea that cholera travels through water became as uncontroversial as it had once been contentious.*

In the 1880s, the great German scientist Robert Koch discovered the *Vibrio cholera* bacterium, further strengthening the waterborne theory of cholera. Some figures, such as Edwin Chadwick, continued to support miasma theory, but most public health institutions embraced Snow and Koch's research. In London, the new sewer system resulted in cleaner drinking water and a cleaner Thames. In the early 20th century, there were cholera outbreaks in many Western cities, but these outbreaks almost always prompted the authorities to modernize infrastructure. By the 1930s, cholera had "become an anomaly in the world's industrialized cities." However, cholera continues to threaten the developing world.

*Koch wasn't the first to discover the cholera bacterium—remember that Italian scientists had discovered it back in the 1850s. Nevertheless, the fact that Koch is still remembered for isolating the bacterium demonstrates the importance of paradigms in scientific discourse: the Italians had made a vital discovery, but in part because it didn't gel with the dominant miasma paradigm, few paid attention. The new germ paradigm enabled the growth of cleaner, better-managed European cities, in which keeping the water clean was a top priority.*

In the 21st century, the world's biggest cities contain more than 20 million people. The scavenging classes of Victorian London live on in New Delhi, Dhaka, and other cities. Squatters have built entire communities for themselves, without the help of urban planners or the municipal government. But of course, these squatters face considerable dangers, not the least of which is a lack of clean water. Every year, some two million children die from diseases, like cholera, resulting from a lack of clean water. If the urban planners of the 21st century are to fight these problems, they'll be dealing with ten times as many people as Farr or Chadwick had to deal with.

*Johnson suggests that, in some ways, the scavengers of contemporary cities such as New Delhi have arranged themselves into classes and subcultures in the same ways that the Victorian scavengers did 150 years ago. And perhaps, even if a lot has changed since the 19th century, urban planners in New Delhi should take after Farr and Snow, prioritizing clean water in order to minimize the risk of deadly cholera epidemics.*

Urban planners have proposed ingenious solutions to the problems of disease and disorganization in large cities: small, cheap water purifiers, and generators that run on excrement. Furthermore, the world's largest cities don't seem to be on "a collision course with themselves," as was the case in London in the 19th century. Using the cartographical and epidemiological methods pioneered by John Snow and Henry Whitehead, contemporary thinkers have found ways of reorganizing cities more efficiently. The Internet has also expanded the amount of information available to researchers—gone are the days when Snow and Whitehead had to go door-to-door to learn about the cholera outbreak.

*The idea of studying cities as large, complex systems has proven highly influential in the discipline of urban planning. Urban planners recognize that cities are living, constantly changing things, and need constant tending and repairing. Furthermore, 21st-century urban planners have major advantages over their 19th-century counterparts, not least of which that they can use the Internet to accumulate useful information about people, rather than having to go door-to-door, as Snow and Whitehead did.*

In contemporary times, cities show no signs of disappearing. The modern metropolis may be overcrowded and crime-ridden, but "many people actually like the density of urban environments, precisely because they offer the diversity of Viennese bakeries and art movies." Furthermore, many cities have become safer, partly because of new information technologies. For instance, New York City introduced a 311 phone service, designed for people who wanted to report information less urgent than the kind usually repotted by calling 911. During the 2003 New York blackout, hundreds of people called 311 to inquire about storing insulin (which is usually supposed to be kept refrigerated). 311 calls alerted the city authorities to a health issue they hadn't even considered.

*Johnson (who lives in New York City) begins with the assumption that cities, in spite of some disadvantages, are generally worth preserving. To this end, many city planners have installed services promoting the easy exchange of information, giving urban planners an efficient way of responding to their citizens' needs. Compare 311 phone service with the situation in London in 1854, when much of the city wasn't aware of a cholera epidemic until days after it had begun.*

The 311 calling system reflects a paradigm for urban planning that emerged thanks to John Snow and Henry Whitehead's cholera research. The first aspect of this paradigm is the importance of "local experts"—i.e., people like Henry Whitehead with vast, valuable experience with their community. The second aspect of the urban paradigm is the "cross-disciplinary flow of ideas." Often, the best way to solve an urban problem is to mix different disciplines and people from different professions. John Snow was a true polymath: a mapmaker, chemist, demographer, and physician who embodied the paradigm.

*One of the main components of modern urban planning is the use of local experts—and, perhaps even more importantly, a "chain of command" for converting experts' recommendations into public policy. City planning is challenging because it incorporates so many other disciplines into itself—and John Snow, then, was something of a one-man planning team, with encyclopedic knowledge of many disciplines.*

In his later years, Henry Whitehead served as a minister in various northern English cities; he died in 1896. A portrait of John Snow hung in his office—to remind him that "in any profession the highest order of work is achieved … by patient study of eternal laws." If Whitehead were to walk through the streets of Soho today, most of the things he'd see would be utterly foreign to him. However, the basic spirit of innovation and entrepreneurship hasn't changed much in the last 150 years. The one building that has remained constant since Whitehead's time in Soho is the pub at the corner of Cambridge Street, just a few feet from the old Broad Street pump—a pub that's now called The John Snow.

*Whitehead admired Snow for the rest of his life, even if it's unclear how well the two men actually knew one another. Even after Whitehead's death, Snow has remained celebrated in the medical community, the city of London, and the field of urban planning—many people still acknowledge his role in averting cholera outbreaks and saving countless lives.*

## EPILOGUE: BROAD STREET REVISITED

Before too long, the planet's human population will be more than fifty percent urban. Perhaps in a few decades, that figure will shoot up to eighty percent. At the time when Snow and Whitehead were alive, a mere ten percent of the population was urban. Human thought is still catching up to the urban revolution of the last 150 years—history books treat modern history as a series of interactions between *nations*, but the city is becoming the dominant unit of civilization.

*In some ways, the growth of cities is the defining event of modernity, and yet it's rarely an important part of history classes. The study of cities is still in many ways a vague discipline: Johnson argues persuasively that people should become more aware of the science and sophistication that go into building a successful metropolis.*

Living in a city has big advantages. Studies suggest that urbanites live longer than those living in rural areas. Furthermore, health and air quality in American cities is as good as it's been in two centuries. Perhaps most surprisingly, cities have become important forces of environmental health: urbanites consume less energy than their rural counterparts. Additionally, cities act as a form of population control—families in agrarian economies tend to have more children, for the simple reason that they need more hands to help. Cities, on the other hand, tend to offer more opportunities to women without children. In many urbanized countries, the birthrate has dropped below "replacement level" (i.e., the population is shrinking).

*In many ways, the most popular stereotypes about cities—that they're congested, unlivable, etc.—are a century behind the times. Cities are some of the healthiest and cleanest forms of human society; they also offer more opportunities to minorities and women. Thus there are good reasons to believe, and even to hope, that the future of humanity hinges on the future of cities.*

To no small extent, Snow and Whitehead made the contemporary urban world possible. Thinkers no longer doubt that it's possible to crowd tens of millions of people into a small radius—and in large part, that's because scientists learned how to control microbes. Since Victorian times, cities have become "great conquerors of disease," centers of scientific research and public health measures.

*Few if any thinkers would seriously dispute that it's possible for a big city to survive indefinitely, provided that it's run efficiently. But only 150 years ago, cities such as London were laboratories of public health and urban planning—the fate of urbanism in general rested on the survival of places like London, and therefore, the work of men like Whitehead and Snow.*

It's unclear what the future of cities will be. However, for the time being, "cities are where the action is." They're centers of "tolerance, wealth creation, social networking, health," etc. While it's been argued that the Internet will curb the growth of cities, since it reduces people's incentive to move to cities, it seems that the Internet won't be enough to prevent cities from expanding. It's been argued that global warming will spell the end of urbanism—many big cities are within a few miles of the rising oceans. However, it seems likelier that global warming will damage some cities without challenging the premise of urbanism. Others have argued that the decline of available oil will prevent urbanism; however, the increased energy efficiency of cities would seem to refute such a claim. If anything, the decline of available energy will *accelerate* urbanization.

*Urbanism has become the dominant paradigm for the human race—country by country, populations tend to be migrating out of rural communities and into large cities. Johnson acknowledges that global warming or the Internet might undo some of the growth of urbanism (since, if you have good Wi-Fi, you can get many of the same experiences you'd otherwise only be able to get in a metropolis). In a way, however, these challenges to urbanism resemble Snow's challenges to miasma theory: even if they chip away at the feasibility of urbanism, people will continue moving to cities for a long time to come.*

It would be wrong to claim that urbanization is inevitable—new, unpredictable problems are always threatening cities. The September 11 attacks on the World Trade Center illustrate one of the great weaknesses of cities: a densely packed area is a prime target for a terrorist attack. Another factor to consider is the threat of nuclear war: if a larger portion of the population is packed into cities, a nuclear blast could do far more damage than it would if the population were spread out into smaller towns. In a way, big cities are bull's-eyes—it seems inevitable that, one day, a troubled soul will find a way to detonate a nuclear bomb in an urban center.

*Perhaps the biggest downside to living in an urban center, Johnson argues, is that it's a potential target for terrorist attacks. Terrorists looking to do harm to a great number of people have no better target than a city, where thousands of people might be packed into a single building. There have been many unforgettable attacks in cities—for example, the bombings of Hiroshima or Dresden, or the attack on the World Trade Center in New York City. But these disasters seem to have had no effect on the growth of cities, suggesting that urbanism is here to stay.*

Perhaps the greatest danger of urban life is the heightened possibility of an epidemic. Ten people infected with Ebola in Manhattan could easily infect millions of others. However, it's important to remember how far epidemiology has come since the 19th century. In the 2000s, there's been a lot of debate over the possibility of an avian flu epidemic, which could claim tens of millions of victims. In 2004, Thai health officials began requiring poultry workers to receive conventional flu vaccines, in order to prevent an avian flu outbreak. In doing so, the officials decreased the probability that the H5N1 flu virus (for which conventional vaccines are useless) would come into contact with an ordinary flu virus and mutate into a stronger virus that could set off a human epidemic.

*The possibility of a global avian flu epidemic is still an important research topic in the medical community. As Johnson characterizes it, medical research into avian flu is a constant process of anticipating what avian flu* could *do, and then preventing it from happening. For example, when officials ordered that poultry workers receive their flu vaccines, they were trying to "nip in the bud" the possibility that the avian flu could merge with an ordinary flu virus and form an incurable epidemic.*

In the 1990s, two Harvard scientists discovered that the cholera bacterium had evolved to be lethal to human beings by acquiring genes from a virus called the CTX phage. In other words, cholera "is not a born killer"—rather, it acquires a genetic code that allows it to infect a human host. In the 21st century, doctors fear a similar "merging" of the H5N1 virus and the conventional flu viruses that cause millions of people to become mildly sick every year. Health officials regularly launch "preemptive strikes" against the global flu epidemic.

*Johnson explains why it's so important to vaccinate poultry workers against ordinary forms of flu: if poultry workers don't receive this vaccination, there's a possibility that their flu viruses could merge with the H5N1—in more or less the same way that the CTX phage merged with the ancestors of the modern cholera bacterium. The medical community faces the constant possibility that a new virus or deadly bacterium will emerge—and must ensure that these possibilities don't evolve into realities.*

Some have argued that a global flu epidemic is inevitable, especially with so much of the world's population crowded into cities. But if such an epidemic occurs, it's unlikely that urbanization will reverse itself. Again and again, after a major urban disaster, the city's population continues to grow. However, if a virus killed half a million New Yorkers, other New Yorkers would probably move somewhere else.

*At this point in the history of urbanization, it's unclear how much danger urban dwellers will be willing to put up with before they move out of cities and back to rural communities. In the last hundred years, cities have been bombed, ravaged by war and disease, etc.—and yet people have continued moving to cities.*

Perhaps humanity's greatest weapon in fighting a global epidemic is biology. Scientists' knowledge of DNA code might one day enable them to rewrite the code of viruses and bacteria in order to render them safe for human beings. In the twenty-first century, humans are locked in an arms race with microbes—scientists are developing ever-more complicated tools for fighting disease, while most viruses and bacteria possess no more than a few genes. It's been suggested that terrorists will one day give up using bombs and instead use viruses to kill millions of people. The difference is that viruses have vaccines—bombs don't. It seems likely that defensive tools, such as vaccines, will prove more powerful than the viruses themselves. And one of the most powerful defensive tools humans have is mapping, of the kind pioneered by John Snow. It's not enough to research new vaccines in response to outbreaks of disease—urban planners must also make maps that anticipate how an epidemic will spread.

*Microbiologists have developed a formidable arsenal of tools for fighting diseases. In many ways, they're winning the war with disease: they're getting closer and closer to being able to "reprogram" viruses and bacteria so that they pose no significant harm to* homo sapiens. *And even if microbiologists don't succeed in doing so, they can construct ingenious maps, the descendants of the maps designed by John Snow, that can be used to predict the spread of disease and then minimize the damage.*

But even if humanity should be optimistic about the threat of a virus, there's less reason to be optimistic about nuclear weapons. Nobody is working on a way to "neutralize a nuclear explosion"—explosions can be anticipated, and the effects of radiation poisoning can be curbed, but the explosions themselves can't really be prevented. Perhaps "urban nuclear explosions will turn out to be like hundred-year storms"—catastrophes that kill millions without threatening the survival of the human race itself.

*Nuclear war is a big, complicated topic for Johnson to introduce in the final pages of his book. However, it illustrates an important principle that Johnson has alluded to throughout: there may be some problems for which human beings will never have perfect solutions. Perhaps humans will learn to live with the threat of nuclear war, much as generations of Victorians learned to live with the constant threat of an epidemic.*

In all, urbanization is far from inevitable—viruses and bombs could easily turn cities into centers of danger and death, incentivizing people to move back to smaller communities. But there are two things human beings can do to sustain urbanism. First, they can embrace science—in particular, genetics, Darwinism, and environmental science. Doing so will allow us to predict what viruses and bacteria will do in the future. The second thing people can do to sustain urban life is to support strong public health systems.

*Even if humans can't avert nuclear destruction, they can immerse themselves in science and public health projects. In doing so, they maximize the likelihood that the scientific community will be able to develop cures for new, deadly diseases.*

There have been many challenges to urbanism, science, and public health in the last few years. Intelligent design theorists spend millions attacking the theory of evolution, even as the United States spends millions on nuclear weapons. But humanity would do well to remember Henry Whitehead and John Snow. Instead of despairing in the face of what seemed an unsolvable problem, Whitehead and Snow used ingenuity and hard work to save lives. Humanity has confronted appalling crises before, and emerged victorious. Hopefully, in the 21st century, it will emerge victorious once again.

*In the 21st century, humanity faces some serious challenges, some of which seem not to have a solution of any kind. Science has made people healthier and lengthened lifespans, but it's also led to the creation of weapons like nuclear warheads that have made the world dangerous in ways the Victorians couldn't comprehend. Furthermore, there's a limit to human beings' ability to predict the future—some dangers can't be anticipated, and therefore can't be prevented. However, Johnson offers a cautiously optimistic conclusion: the future of the human race seems pretty dire, but no more so than it did to Snow and Whitehead. Perhaps science and research will prove to be humanity's salvation, just as it was in Victorian England.*

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