Punch (September 2, 1854)

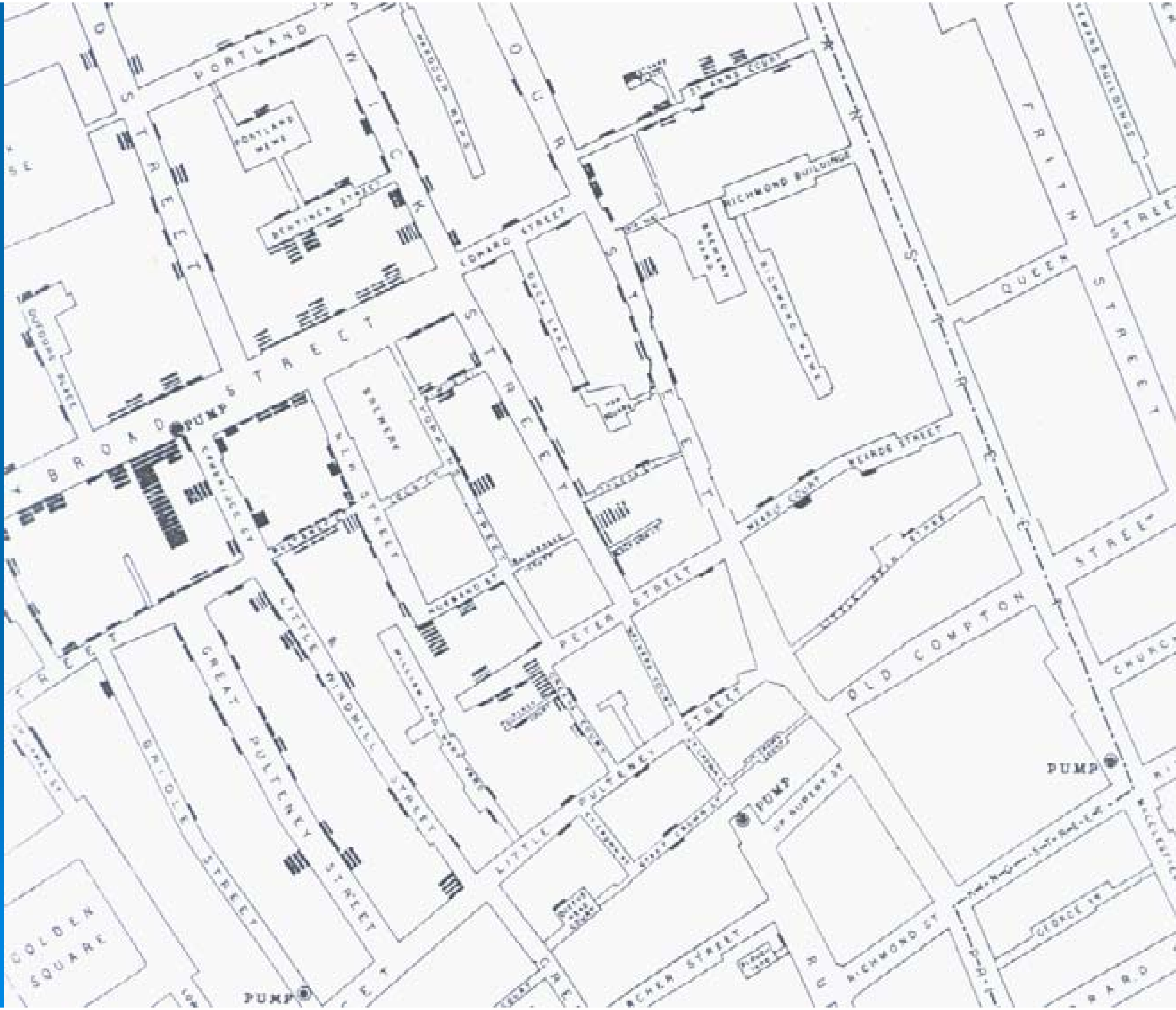
- In every street is a yawning sewer
- In every court is a gutter impure
- The river runs stinking, and all its brink
- Is a fringe of every delectable stink
- Bone-boilers and gas-workers and gut makers there
- Are poisoning earth and polluting air
- But touch them who dares, prevent them who can;
- What is the Health to the Wealth of man?

The Ghost Map

- The Story of London's Most Terrifying Epidemic—and How it Changed Science, Cities, and the Modern World.
- Author Steven Johnson, distinguished writer in residence at NYU's Department of Journalism.
- Riverhead Books, 2006.
- A *New York Times* Notable Book of the Year.
- ISBN 978-1-59448-269-4. Paperback.
- Supplemental information from Wikipedia.

Four Protagonists

- A deadly bacterium.
- A vast city.
- Two gifted but very different men.
- One dark week, 156 years ago, in the midst of great terror and human suffering, their lives collided in London's Broad Street, on the western edge of Soho.


PORTLAND
PORTLAND MEWS
BROAD STREET
PUMP
PUMP
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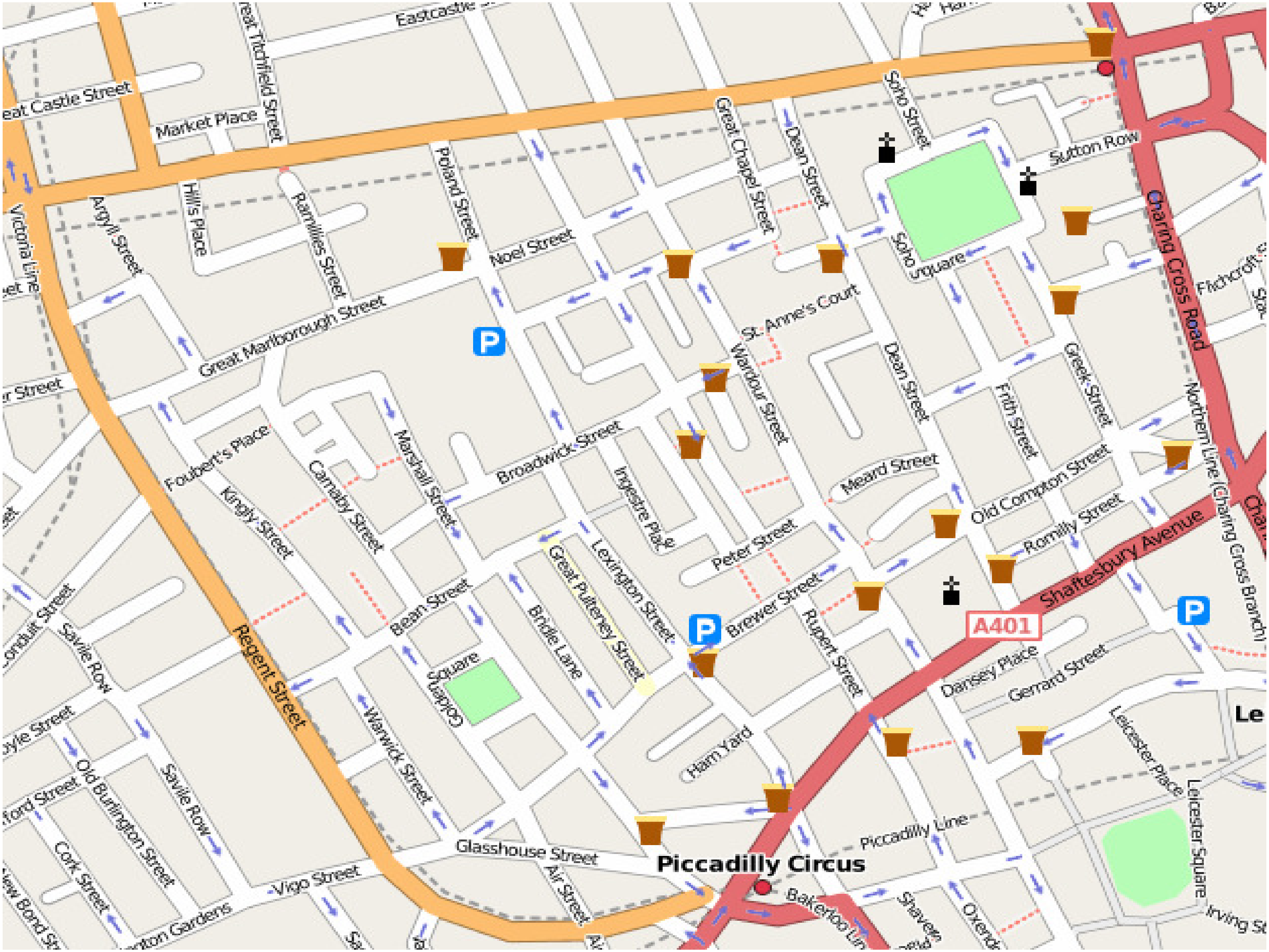
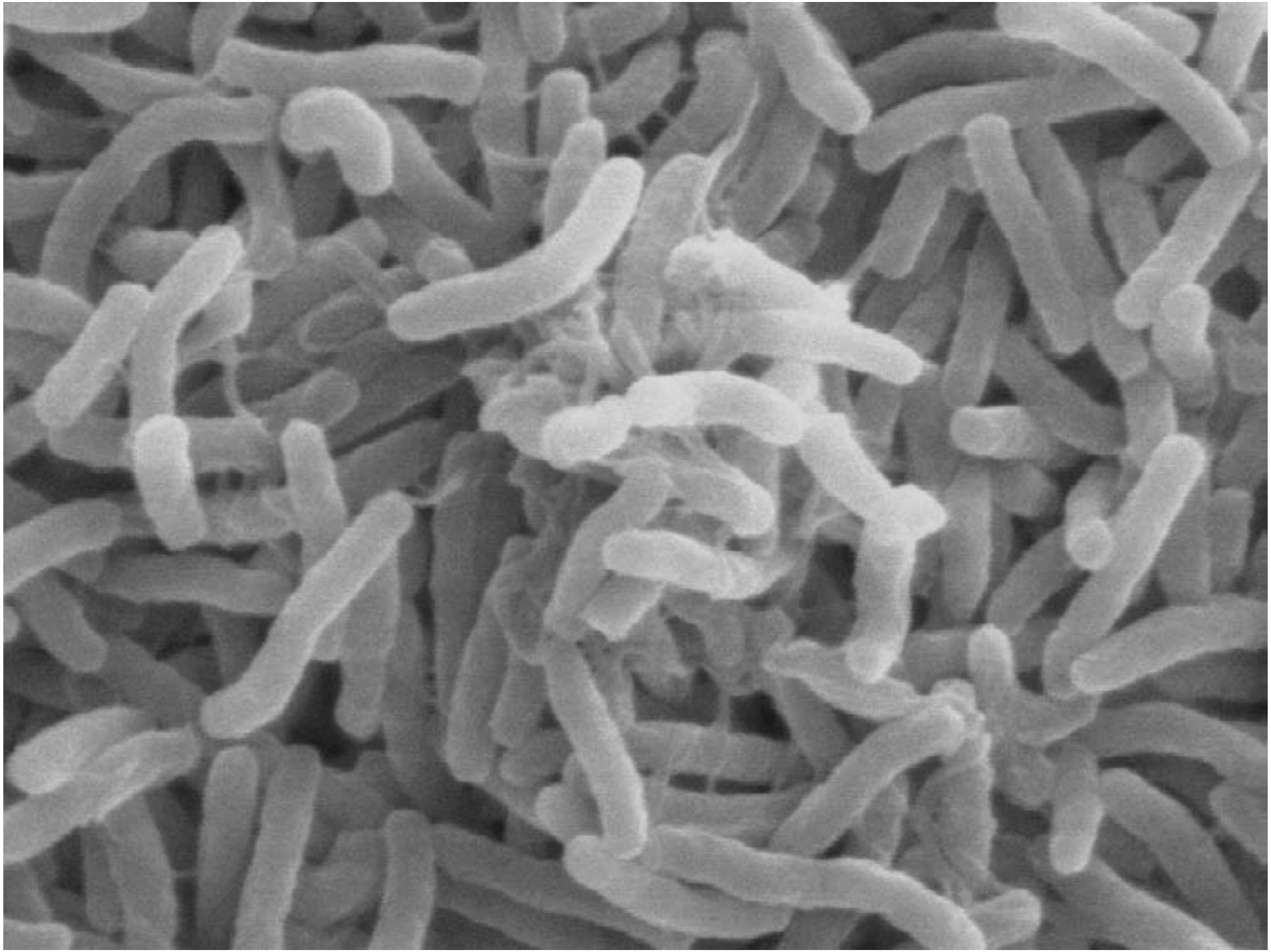
EDWARD STREET
RICHMOND BUILDINGS
QUEEN STREET
FRITH STREET
PETER STREET
OLD COMPTON
CHURCH
GREAT PULTENEY STREET
LITTLE PULTENEY
BRIDLE STREET
GOLDEN SQUARE
RICHMOND ST
BREWERY



Eastcastle Street
Market Place
Great Titchfield Street
Great Chapel Street
Dean Street
Soho Street
Sutton Row
Charing Cross Road
Victoria Line
Argyll Street
Hills Place
Ramillies Street
Poland Street
Noel Street
Soho Square
St. Anne's Court
Great Marlborough Street
Wardour Street
Frith Street
Greek Street
Broadwick Street
Foubert's Place
Kingly Street
Carnaby Street
Marshall Street
Ingestre Place
Meard Street
Old Compton Street
Romilly Street
Northern Line (Charing Cross Branch)
Peter Street
Lexington Street
Great Pulteney Street
Shaftesbury Avenue
A401
Bean Street
Brewer Street
Rupert Street
Bridle Lane
Golden Square
Regent Street
Savile Row
Dansey Place
Gerrard Street
Ham Yard
Warwick Street
Leicester Place
Leicester Square
Old Burlington Street
Cork Street
Piccadilly Line
Glasshouse Street
Piccadilly Circus
Vigo Street
Air Street
Bakerloo Line

A Deadly Bacterium

- V*ibrio cholerae.* Exhaustive diarrhea.
- You need 1-100 million organisms to contract the disease. A glass of water could easily contain 200 million *V. cholerae* without the slightest hint of cloudiness.
- In high transmission environments, the lethal strains quickly out-number the mild ones.
- In its most severe forms, cholera is **one of the most rapidly fatal illnesses known.**
- A healthy person's blood pressure may drop to hypotensive levels within an hour of the onset of symptoms; infected persons may die within three hours.
- In a common scenario, the disease progresses from the first liquid stool to shock in four to 12 hours, with death following in 18 hours to several days.



A Vast City, London, Aug. 1854

- A city of scavengers.
- Bone pickers, rag-gatherers, pure-finders, dredgermen, mud-larks, sewer hunters, dustmen, night-soil men, bunters, toshers, shoremen.
- The London underclass 100,000 strong.
- A world of excrement and death.
- Two and one-half million total population of city.
- London had over 200,000 cesspools.
- Recycling centers, public health departments and safe sewage removal had not been invented….
- The scavengers performed the recycling and waste removal functions to survive and avoid starvation.

Night-Soil Economics 1854

- Scavengers had a rank system. Near the top were the night-soil men, independent contractors at the very edge of the legitimate economy.
- The collecting of human waste by the medieval “rakers” and “gong-fermors” was a venerable profession. In London by the mid-1850’s night-soil men in teams of four cleaned cesspools between midnight and 5:00 a.m. A “ropeman,” a “holeman,” and two “tubmen” did foul work, but the pay was good. A bottle of gin for their labors was a common courtesy.
- Once the cesspool was emptied the cart was destined for one of the city’s dust stall yards, laystalls, or manure wharves that accepted deposits of human waste. There was a market for waste as fertilizer with farmers located outside the city.

Night-Soil Economics 1854 (2)

- London, due to geographic protection from invasion, was the most sprawling of European cities extending well beyond its Roman walls. That meant longer transport times for the manure to get to the farms. Wages increased for night-soil men to twice that of the average skilled laborer. The financial cost of removing waste exceeded the environmental cost of just letting it accumulate—especially for landlords who were not living over cesspools and not directly affected.

- Cesspools frequently were not properly maintained and infrequently cleaned if revenue from agricultural manure was insufficient to cover removal costs. Cellars full of several years nightsoil to a depth of three feet were not uncommon in the worst cases.

- A 1849 survey of 15,000 homes found that almost 3,000 had offensive smells from bad drainage, while a thousand had “privities” and water closets in a very offensive state. One in twenty had human waste piling up in the cellar.

Night-Soil Economics 1854 (3)

- In addition, America was shipping solidified bird droppings (guano) to England starting in 1847 at a price far below cesspool manure, which cut revenue.

- Thousands of privies and daily buckets of waste all added to the problems of open sewers and filth along city streets. And a new invention--the water closet with a flushing device all added to the likelihood of cesspools overflowing. Liquids the color of strong green tea flowed along drains, sewers and slips of streams, often the only water supply of wretched locals.

Problems 1854 London

- The number of people generating waste had almost tripled in the space of 50 years, from 1800 to 1850, making London the most populous city on the planet.
- By 1851 the sub-district of Berwick St. on the west side of Soho was the most densely populated of all the 135 sub-districts that made up Greater London. Soho had 432 people per acre compared to Manhattan Borough of New York City today, which houses around 100 people per acre.
- In one two-room flat without one good piece of solid furniture lived a Prussian family of seven. Everything was broken, tattered and torn, finger-thick dust everywhere and everything in the greatest disorder. The immigrant couple, their four children and a maid managed to survive. The husband's productivity somehow was not hindered but Karl Marx did spend a lot of time at the British Museum.

Soho and Environs

- By the time Karl Marx arrived in Soho in the 1850's it was a classic mixed-use economically diverse neighborhood. There were two-to-four story residential buildings with storefronts at nearly every address, interlaced with occasional larger commercial space. Industry included slaughterhouses, manufacturing plants and tripe boilers. Residents were poor, almost destitute.
-
- Soho was an anomaly in the otherwise prosperous West End of the city. It was an island of working poor and foul smelling industry surrounded by opulent town-houses of Mayfair and Kensington. The social topography would play a pivotal role in the late summer of 1854, when a terrible scourge struck Soho but left the surrounding neighborhoods utterly unharmed.

The Drama Begins

- A London policeman named Thomas Lewis and his wife lived at 40 Broad St., a 11-room house with 20 occupants. These were spacious accommodations for a part of the city where most houses averaged five occupants per room. Sarah Lewis gave birth to a girl in March, 1854, name unknown to history. The infant thrived over the summer and was in good health. Sarah had been unable to breast-feed the infant due to her own health problems, but had fed her daughter ground rice and milk from a bottle.

- Unexpectedly at 6:00 a.m. on Monday, August 28, at the end of an oppressively hot summer night the Lewis infant began vomiting with a green watery stool. While waiting for the doctor's arrival, Sarah Lewis soaked the diaper and crept down to the street and tossed the fouled water into the cesspool that lay at the front of the house.

- The next day or two, life in Berwick proceeded on its crowded path.

Berwick

- Berwick had plenty of horses, pets, people and manure. The local slaughterhouse killed an average of five oxen and seven sheep per day and discarded entrails into the gully holes on the street.

- The Broad Street pump, a few yards away from number 40, had long enjoyed a reputation as a reliable source of clean well water. It extended 25 feet below the surface of the street, reaching down past the ten feet of accumulated rubbish and debris that artificially elevated most of London, through a bed of gravel down to the veins of sand and clay saturated with groundwater. It was colder then the water found in rival pumps; it had a pleasant hint of carbonation. As a result the pump insinuated itself into a complex web of local drinking habits.

- History has recorded remarkable detail about the drinking habits of the inhabitants of the local neighborhood. The minutiae of ordinary lives in a seemingly ordinary week proved fateful or fortuitous for the Berwick residents who lived near the Broad Street pump.

Mr. G.

- On late Wednesday, August 30, the tailor at 40 Broad Street, Mr. G. began to feel ill at ease with a slightly upset stomach. He likely began vomiting during the night with muscle spasms and sharp abdominal pains. He would have been overtaken by a crushing thirst, vast quantities of water being evacuated from his body. His bowels were strangely absent of smell and color, harboring only tiny white particles or "rice water stool." Once this occurred, the odds were that he would be dead in a matter of hours. He would have remained mentally alert until the very last. By Friday his pulse would be barely detectable and a rough mask of blue leathery skin would have covered his face and his nails likely were livid.

- On Friday at 1:00 p.m., with baby Lewis next door, Mr. G.'s heart stopped beating barely 24 hours after he showed the first symptoms.

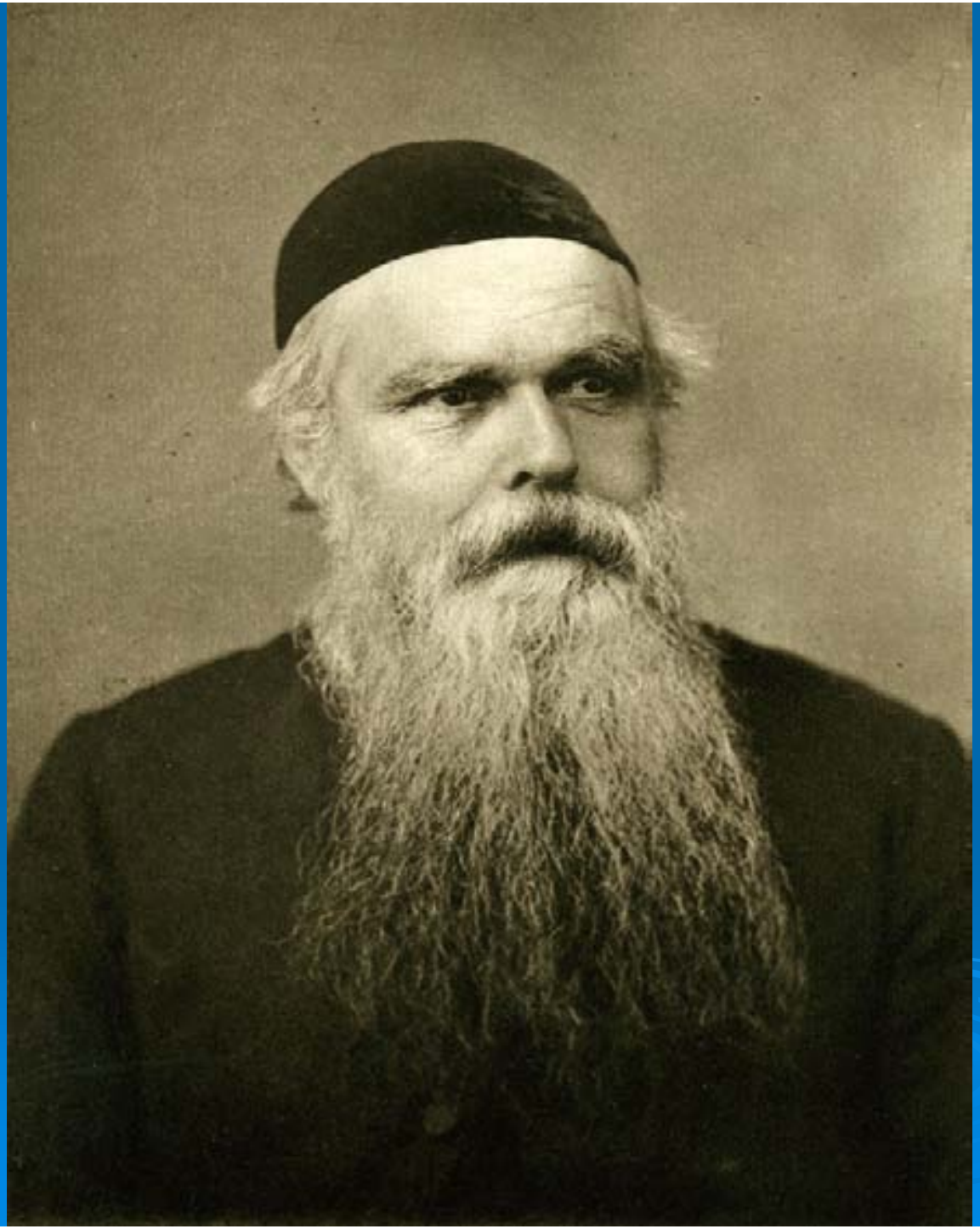
- **Within a few hours, another dozen Soho residents were dead.**

Reverend Henry Whitehead

- Whitehead became the assistant curate (junior priest) to the vicar of St. Luke's Church, Berwick Street in Soho. Following his ordination as a deacon in 1851, Whitehead became a welcome visitor to parishioner's homes in the crowded slums of Berwick Street. Overnight his normal sociable rounds became a death vigil on Friday, Sept. 1, 1854. The Lewis baby died. The dead were being wheeled down the street by the cartload.

- Henry was an observer, was composed and had probing intelligence and was willing to challenge popular opinion. He knew the houses and he knew the people.

- Henry observed that some of the slightly better and more sanitary households were in chaos with the disease while other filthy and grimy households were doing fine. Conditions varied and sanitary conditions seemed to have no predictive power where the disease was concerned.



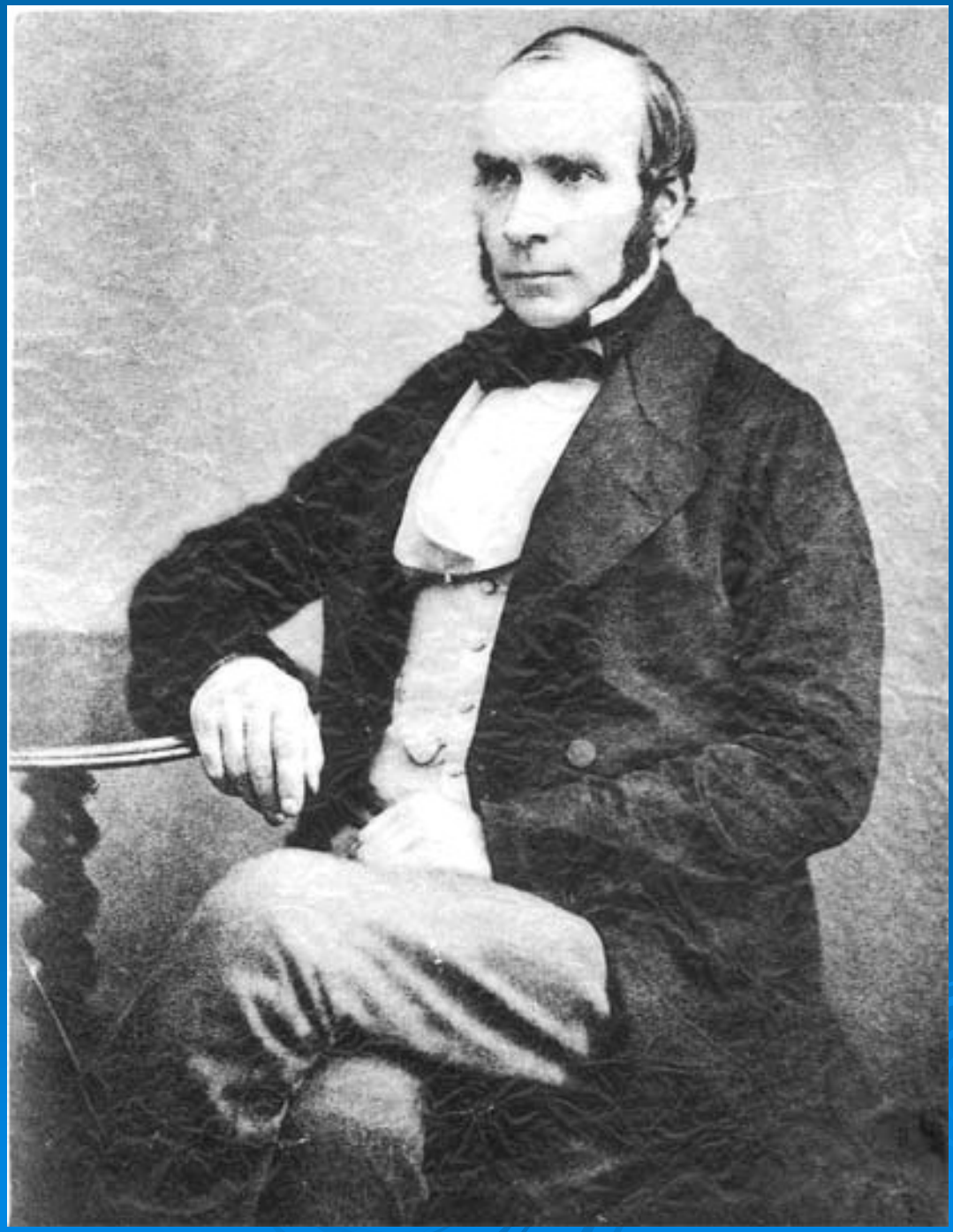
Dr. John Snow, The Investigator

- Sunday, Sept 3. A strange quiet existed on the streets of Soho. The usual chaos of street vendors had disappeared. Residents had evacuated or were suffering behind their doors. Seventy had perished over the preceding 24 hours, hundreds more were on the edge of death. Priests and doctors made frantic rounds. **Dr. John Snow, a Soho regular from the southwestern edge of the neighborhood stopped at the 40 Broad Street pump and examined the pump in the fading evening light.**

- Dr. John Snow, 42, from a family of modest means, had treated cholera victims as an apprentice in Newcastle in 1831 at the Killingworth Colliery (mine). The idea that cholera was rooted in the social conditions of those workers eating and defecating in the same dark stifling quarters lodged in the back of his mind.

- He was a superb doctor: observant and quick-witted and possessed an exceptional memory. He was as free from superstition and dogma as it was possible to be in those days.

- In Victorian times the idea of microscopic germs spreading disease was not even a fairy tale. The Victorian medical refrain was, essentially: take a few hits of opium and call me in the morning.



Dr. John Snow (Continued)

- Snow was the son of a Yorkshire laborer and did well in receiving his apothecary and surgeon's license. He soon established a successful practice, liked to work on side projects growing out of his surgeon's practice and published journal articles on medical and health-related issues of the day (lead poisoning, scarlet fever, smallpox and sloppy science). He was first in his class and earned an advanced degree, bachelor of medicine, from the University of London in 1843 and passed the M.D. exams a year later.

- Surgery in Victorian times was sheer brutality indistinguishable from the most grievous forms of torture. Cut fast, give the patient some alcohol or opium and hopefully finish in two or three minutes.

- In October, 1846 ether, as an anesthetic emerged, and the word spread rapidly to England. In December a London dentist had begun using ether which was observed by Dr. Snow. But it was unreliable in practice. Some patients would nod off, others would fail to go under or return to consciousness abruptly in the middle of a delicate operation. Many never woke up at all.

John Snow (Continued)

- Snow quickly hypothesized that the unreliability of ether was a matter of dosage. By mid-January 1847 he had compiled a "Table for Calculating the Strength of Ether Vapor" that was immediately published by the *Medical Times*. In the meantime Snow, working with a surgeon's instrument maker, developed a medical inhaler that would allow maximum control of the dosage. In a matter of a month he detected the fundamental properties of the gas and engineered a state-of-the-art medical device to deliver it.

- He became the most sought-after anesthesiologist in London and in 1853 assisted Queen Victoria in the birth of her eighth child. But his real talent was as a researcher, capable of linking chains and networks of causality from molecules to cells to brains to machines.

Cholera Theories

- Cholera in the 1800s was an increasing problem. Outbreaks occurred over wide geographic areas and affected a high proportion of the population (pandemics). Outbreaks began in Bengal, India, in 1816 and by 1850 had left million of deaths in India, Russia, China, Eastern and Western Europe, the Americas, the Middle East and Asia. Cities impacted by serious outbreaks included Paris, London, New York, Quebec, Liverpool, St. Louis and New Orleans, just to name a few. The California Gold rush and the California, Mormon and Oregon trails had many victims. It is believed that over 150,000 Americans died during the two pandemics between 1832 and 1849.

- There were as many theories about cholera as there were cases of the disease. The two main camps were **contagionists and miasmatists**. Either cholera was some kind of agent that passed from person to person like the flu, or it somehow lingered as a “miasma” of unsanitary spaces. Most physicians and scientists believed that cholera was a disease spread via the poisoned atmosphere and not by personal contact. In London the foul inner city air was widely felt to be the source of most disease.

Cholera Theories (Continued)

- Snow noted newspaper accounts of the **1848 European cholera outbreaks, including Hamburg.** A few days later the German steamer *Elbe* arrived from Hamburg and a crewman died after checking into a London waterfront lodging house. Days later another lodger took over the room and was seized with cholera. Within a week, the cholera began to spread throughout the surrounding neighborhood and eventually through England. By the time the epidemic wound down 50,000 people were dead.

- Snow recognized the weakness of the contagonist arguments. The same doctor attended both the crewman and the second lodger, spending multiple hours with them during the rice-water phase of the disease. And yet he remained free of the disease.

- Clearly cholera was not communicated through sheer proximity. A most puzzling element of the disease was that it seemed capable of traveling across city blocks, skipping entire houses in the process.

- Snow consulted with chemists and water and sewer authorities and drew upon his past experience with the dying miners in Killingworth.

Dr. Snow (Continued)

- Snow followed up with research on a couple of outbreaks drawing upon data tables of cholera deaths compiled by London's Register-General. By the summer of 1849 John Snow felt confident enough to go public with his theory. Cholera, he argued, was caused by some as-yet-unidentified agent that victims ingested, either through direct contact with the waste matter of other sufferers or, more likely, through their **drinking water** that had been contaminated with that waste matter. Cholera was contagious but not in the same way as was smallpox. Sanitary conditions were crucial to fighting the disease, but foul air had nothing to do with its transmission. It was not something you inhaled but something you swallowed.

- Dr. Snow developed and self-published a 31-page monograph for the medical profession and then submitted an article that was published in the *London Medical Gazette.* The reaction was positive but skeptical. The *Gazette* suggested one scenario that might settle the matter convincingly:

  - The ***experimentum crucis*** would be that the water conveyed to a distant locality, where cholera had been hitherto unknown, produced the disease in all who used it, while those who did not use it, escaped.

Experimentum crusis

- Unbeknown to Dr. Snow, the test suggested by the Gazette five years previous unfolded. Susannah Eley in **Hampstead** had fallen ill earlier the week of August 28th after drinking her regular supply of Broad Street water, dutifully shipped to her by her children in Soho. By **Saturday she was dead**, followed on Sunday by her niece, who had returned to her home in Soho. **Not one other case of cholera in Hampstead would be recorded for weeks.**

- On Sunday night, Sept. 3, 1854, Dr. Snow walked to his home in Soho with a sample of the water from the pump at 40 Broad Street.

- In the meantime, Rev. Whitehead was mulling over the rumor that far more victims of cholera lived on the upper floors of residences than on the ground floor. The owners tended to live downstairs, the poor upstairs; cholera may be correlated with class. However, Whitehead also knew that more people overall lived upstairs than downstairs. Whitehead went to bed with a glass of the Broad Street water mixed with a thimble of brandy.

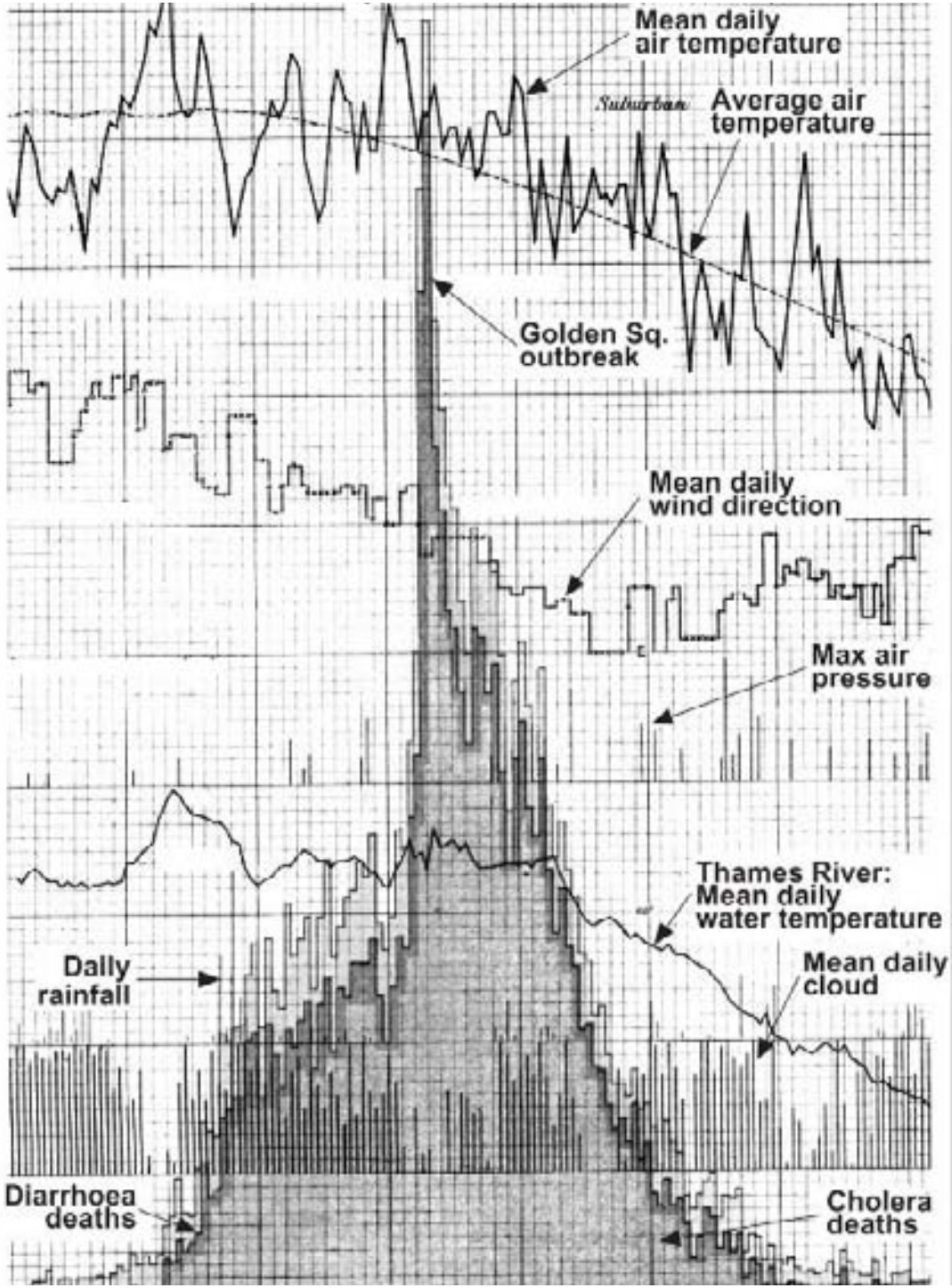
Background

- The London Epidemiological Society had been formed in 1850 with Dr. Snow as a founding member. The basic concept of population statistics and measuring the incidence of given phenomenon—disease, crime, poverty—had entered the mainstream of scientific and medical thought only a decade or two earlier.

- A scientist, Dr. Farr, joined the newly created Register-Generals office in 1838 and started a report **"Weekly Returns of Births and Deaths" at the end of the 1840s.** Demographics and public health information included deaths tallied not only by 27 fatal diseases but also by parish, age, sex and occupation. Farr was intrigued enough by Snow's research in 1849 that he began to report the elevation of districts and the source of drinking water of cholera victims.

- Snow was an avid reader of Farr's reports and became versed on the numerous water companies and did tests on their water. His interest and research on cholera deaths continued. Suddenly Soho was the perfect testing ground.

- Snow was convinced that water was the culprit on the Berwick cholera outbreak, but was unsure how to prove it. A second sample of Broad Street water revealed small white particles and a quick chemistry experiment in his lab revealed a high presence of chlorides. A friend of Snow's with microscope skills indicated that the particles had no "organized structure," indicating that they might be the remnants of decomposed organic matter.


Mean daily
air temperature
Suburban
Average air
temperature
Golden Sq.
outbreak
Mean daily
wind direction
Max air
pressure
Thames River:
Mean daily
water temperature
Mean daily
cloud
Daily
rainfall
Diarrhoea
deaths
Cholera
deaths

Monday-Tuesday, Sept. 4-5, 1854

- The *Observer* noted, “In Broad Street, on Monday evening when the hearses came around to remove the dead, the coffins were so numerous that they had to be put on top of the hearses as well as inside. Such an incident has not been witnessed in London since the time of the plague.”

- John Snow spent most of Tuesday searching for patterns. In the morning he knocked on doors, interrogated strangers in the street and collected anecdotal information. By midday he visited the Registrar-Generals Office where Farr gave him an early look at the numbers being calculated for the week. Eighty-three deaths had been recorded for Soho between Thursday and Saturday. Snow asked for a complete list, including addresses. He returned to Broad Street and stood at the base of the pump, and ran through the addresses on the list. He gazed at the empty streets and imagined the paths to the pump. He needed more then body counts, he needed footprints of the dead and the living.

The Investigation 1

- Standing at the pump, Snow could see the addresses of almost half of the dead. Half of the remaining addresses of the dead were residences that were a matter of steps from Broad Street itself. At a glance he would be able to show the outbreak was clustered around the pump. However, from experience he knew this kind of evidence would not satisfy the miasmatist. It could be a pocket of poisoned air from the pump or the gully holes or cesspools. What he needed was deviations from the norm. In his mind he was already drawing maps and an irregular border around the pump. Everyone inside the border lived closer to the poisoned well; everyone outside would have had a reason to draw water from an outside source.

- Snow knew that his case would also revolve around the inverse situation: **residents who lived near the pump who survived**. They survived because for some reason, they had opted not to drink from the poisoned well.

The Investigation 2

- In summary, Snow discovered:
  - Nearby St. James Workhouse, home of 535 people, had only a handful of deaths. Where commonly one in five persons died in nearby households, the numbers for the Workhouse should have been much higher. The Workhouse directors indicated they had a private supply of water from the Grand Junction Water Works and also their own well on the premises. **They had no reason to use the Broad Street pump**.

  - With 70 workers, the Lion Brewery at 50 Broad Street was the second largest employer in the vicinity. Yet not a single death was recorded for that address on Farr's list. When Snow inquired about the water supply, the owners indicated they had a private pipeline and a well. Also, their men rarely drink water at all. **Their daily rations of malt liquor usually satisfied their thirst.**

  - At the Eley Brothers factory the situation was much worse. Dozens of employees had fallen ill, many dying in their homes over the first few days of the epidemic. They had two large tubs of water from the Broad Street pump for their employees. Snow had heard through the grapevine that the brothers' mother and their cousin had recently perished of cholera as well, both far removed from the immediate vicinity of Broad Street. On delicately inquiring, Snow learned of the mother's death in far off Hampstead and the description of the regular delivery of Broad Street pump water to her residence.

The Investigation 3

- Of the 83 deaths recorded on Farr's list, 73 lived in houses that were closer to the Broad Street pump than to any other public water source. Of the those 73, Snow learned 61 were habitual drinkers of Broad Street water, six of the dead were definitively not Broad Street drinkers and the final six remained a mystery "owing to the death of or departure of everyone connected with the deceased individuals."
- On Cross Street, much closer to the Little Marlborough Street pump, a family of a tailor often walked over after dark to get the cool well water from Broad Street. Five children and their father died in four days.
- Of the ten cases that fell outside of Snow's imaginary border, eight appeared to have a connection with the Broad Street pump. The proprietor of the coffeehouse who often sold sherbet mixed with Broad Street water told Snow that nine of her customers had died since the outbreak began.

- In retrospect, Snow's success depended on tenacity, his knowledge of the way gases disperse that tended to rule out the popular miasma theory, his doctor's training as an observer of physical symptoms and the social connection he had to the subjects he observed. He had a genuine local knowledge of the Broad Street case. It gave him both an awareness of how the neighborhood actually worked and it gave him credibility with the residents. His roots as a son of a rural laborer left him free of moral or class preconceptions regarding illness.

Rev. Whitehead's Information

- When Henry Whitehead traced the week's events, he found cases of survivors drinking copious amounts of Broad Street water. One boy drank ten quarts; he found a girl who consumed 17 during her (ultimately successful) attempt to fight off the disease. But he also found that almost all the survivors who had consumed Broad Street water did their drinking after Saturday. It was much harder to find anyone who would report drinking the pump water earlier in the week—because most of the people were dead.

- So perhaps the *V. cholerae* had largely abandoned the pump by the weekend, or another microbial organism had vanquished the killer on its own. Or perhaps the natural flow of groundwater had slowly cleansed the pump supply and the initial colony of *V. cholerae* had dispersed through the gravel, sand and clay beneath the streets of Soho.

The Pump Handle is Removed

- On Thursday night, Sept. 7, the Board of Governors of St. James Parish held an emergency meeting. Halfway through the meeting Dr. Snow asked to speak and discussed the patterns of life and death that had been occurring in the vicinity of the pump. The Board was skeptical, yet Snow's argument was persuasive for disabling the pump--they had few other options. If Snow was wrong, the neighborhood might go thirsty for a few weeks. If he was right, how many lives might be saved. After relatively quick consultation the Board voted that the **Broad Street well should be closed down**.

- The following morning, Sept. 8, one week after the outbreak, **the pump handle was removed**. Deaths would continue for another week but clearly the worst was over.

The Final Tally

- When the final numbers were tallied, the severity of the outbreak shocked even those who lived through it.
  - Nearly 700 people living within 250 yards (one-seventh of a mile) of Broad Street had died in a period of less than two weeks.
  - Broad Street's population had literally been decimated and 90 of 896 residents had perished (10 percent).
  - Among the 45 houses extending in all directions from the intersection of Broad and Cambridge Streets, only four managed to survive without losing a single inhabitant.
  - "Such a mortality in so short a time is almost unparalleled in this country," the *Observer* noted. Past **epidemics** had produced higher body counts citywide, but **none killed so many in so small an area with such devastating speed**.

The Authors Note

- Steven Johnson argues that the removal of the pump handle was a historical turning point, and not just because it marked the end of London's most explosive outbreak. **History has its epic thresholds** where the world is transformed in matter of minutes. Some unknown person unscrews the handle of a pump on a side street in a bustling city—and in the years and decades that follow, a thousand changes ripple out from that simple act. The change itself takes many years to become visible. But the change is no less momentous for its quiet revolution.

- The removal of the handle marks a turning point between man and *Vibrio cholerae*, because **for the first time a public institution has made an informed intervention into a cholera outbreak on a scientifically sound theory of the disease**. For the first time, *V.cholerae's* growing dominion over the city would be challenged by reason, not superstition.

A Doubting Reverend

- News of the pump handle's removal had struck Rev. Whitehead as being a particularly foolish act. Snow's two-day analysis and waterborne theory did not square with the neighborhood that Henry knew. Snow had not seen a girl drink 17 quarts of pump water and survive. Henry had drank the well water with his brandy days prior. It would take some additional research but Whitehead was confident the pump would be exonerated in time. The foul air was the issue and miasmatists would be proven right in time. Snow's primary nemesis would be Henry Whitehead. The two protagonists explored Broad Street on separate but parallel tracks.

- Whitehead would end up pursuing details of the Broad Street outbreak further than he ever imagined—further indeed than John Snow would venture.

- **In the days following, a Board of Health committee investigated** the epidemic but then would not share the results with the local citizens, arguing "principally on the grounds that investigations of this kind were more valuable when independent."

- So St. James formed a vestry committee of their own and asked Whitehead to join. They studied Snow's survey of the neighborhood but recognized he had not investigated the drinking habits of the neighborhood residents who had *survived* the epidemic. If that group used the pump, then the whole basis for Snow's theory would dissolve. Whitehead would track down more than 500 residents of Broad Street, more than half the population that lived there before the outbreak.

Whitehead Investigates

- As Whitehead visited and investigated, the more he felt his resistance to the pump-contamination theory fade. Links to the Broad Street water were recalled by family members of the deceased.
- The reason for the unusual survival of many of the old and infirm was that they did not have children to fetch water from the pump for them.
- As Whitehead tabulated his data it squared with Snow that pump-water infection rates were three out of five Broad Street pump drinkers and one out of ten at other pumps.
- If Snow was right there had to be an "**index case**" of an original cholera victim whose evacuations had somehow found their way into the Broad Street well. **Snow and Whitehead became colleagues on the Vestry Committee** and discussed inconsistencies. Whitehead, in reviewing the *Weekly Returns* report for just prior to the outbreak, noticed, "At 40 Broad Street, 2d Sept., a daughter, aged five months: exhaustion, after an attack of diarrhea four days previous to death." He was already familiar with the sad story of baby Lewis. In visiting with Mrs. Lewis he discovered the illness came upon the baby a day earlier than reported and that Mrs. Lewis had indeed disposed of the waste water from rinsing the diaper in the cesspool. A perfect match for an index case: an attack of cholera that occurred three days before the first wave of the general outbreak.

Whitehead (Continued)

- Whitehead contacted the Vestry Committee immediately and the men reached an easy agreement. The Broad Street well would be examined once again and the cesspool would also be checked.. The original investigation based on City Health Department dictates only focused on the inside of the well and had not checked for leaks.

- The Vestry Committee contractor reported that the walls of the Broad Street cesspool were lined with bricks that were so decayed that they could be "lifted from their beds without using the least force." **Two feet and eight inches from the outer edge of the brickwork lay the Broad Street well.** At the time of the excavation, **the water line in the well was eight feet below the cesspool**. The contractor reported finding "swampy soil" saturated with human filth between the cesspool and the well.

- As Whitehead shared his discoveries with Snow over those early months in 1855, a quiet but profound friendship of respect developed between the two men. The doubting Reverend turned out to be Snow's star witness.

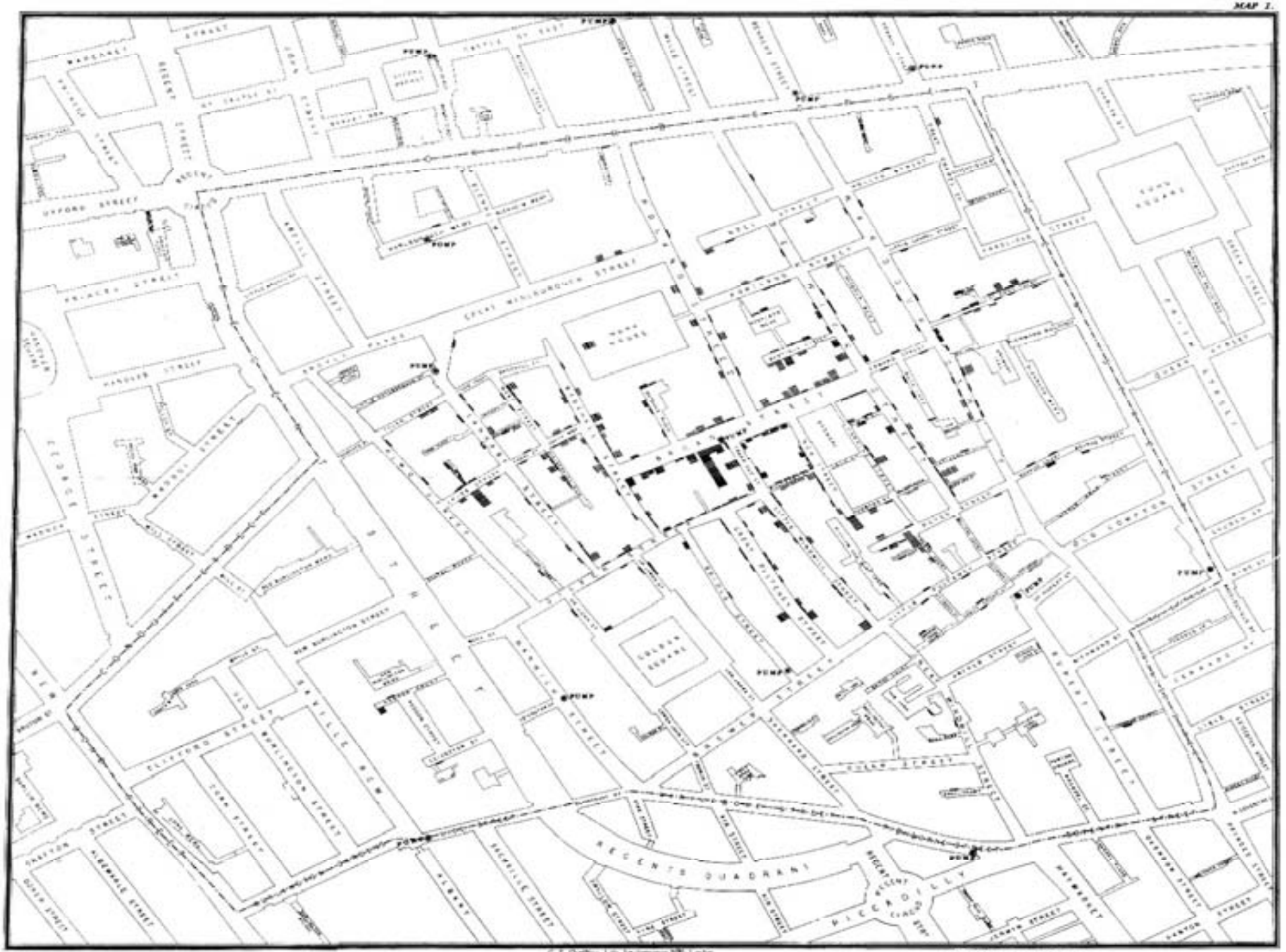
Public Works

- The removal of the Broad Street pump handle generally stopped the cholera outbreak. **The Vestry Committee's report in early 1855 unanimously attributing the cholera deaths to the use of impure water from the Broad Street well should have closed the case** and led to major reforms and investments in public sanitation projects.

- However, the fog of miasma did not lift easily for science to overcome superstition and popular opinion. The Board of Health saw no reason to accept Snow's theory and the Vestry Committee report in contrast to their own investigation. Prominent leaders including Dr. Farr; Edwin Chadwick, pioneering but controversial chair of the General Board of Health until August 1854; and influential medical figure Florence Nightingale were traditional and tenacious in their support of miasma. Social prejudice, convention, religious tradition, instinct and the technological limitations in microscopy all led to continuing to blame noxious pollution or "bad air" (miasma) for the cholera outbreak.

- Dr. Snow began working on his **first map in the fall of 1854 and presented it to the Epidemiological Society in December.** The map didn't solve the mystery of the outbreak. It didn't lead to the pump handle's removal thus bringing an end to the epidemic. It failed to sell the Board of Health on the merits of the waterborne theory. Yet despite those reservations, **Snow's map deserves its iconic status**. The case for the map's importance rests on two primary branches: its **originality and its influence.**


50 0 50 100 150 200 Yards
× Pump
• Deaths from cholera
OXFORD STREET
GT MARLBOROUGH ST
REGENT STREET
LITTLE MARLBOROUGH STREET
BROAD STREET
WARDOUR STREET
DEAN STREET
CONDUIT STREET
GOLDEN SQUARE
SAVILLE ROW
BREWER STREET
NEW BOND STREET
REGENTS QUADRANT
PICCADILLY



C. F. Cheffins, Lith. Southampton Bldgs. London.

SCALE 30 INCHES TO A MILE.

The Ghost Map

- The real innovation lay in the data that generated the diagram and in the investigation that compiled the data in the first place. **Snow's Broad Street map was a bird's eye view, but it was drawn from street-level knowledge.** In time something about the map reverberated in the culture. It had a certain quality that made people inclined to reproduce it and through that reproduction **the map spread the waterborne theory more broadly.** In the long run it was a triumph of marketing as much as empirical science.

- Our author Stewart Johnson argues that Snow and Whitehead solved a local mystery that led, ultimately, to a series of global solutions—solutions that transformed metropolitan living into a sustainable practice and turned it from the collective death drive that it threatened to become. The Broad Street case was a triumph of urbanism.

Miasmatists and the Great Stink

- After the fall of 1854 the battle with the miasmatists versus those supporting the waterborne theory continued. Hearings were held before Parliament in 1855 and arguments over sanitation and air pollution continued. In 1858 pollution on the Thames reached a point of the "Great Stink" in June after relentless early-summer heat. But rates of death from epidemic disease remained normal.

- Dr. John Snow would have been delighted, but he died of a stroke in his office on June 10, 1858, at 45 years of age while revising his monograph on chloroform.

The “Big Stink” and Progress

- After years of bureaucratic waffling, the “Big Stink” motivated public authorities to deal with contamination of the Thames water from sewer lines emptying directly into the river. The city embarked on one of the most ambitious engineering projects of the nineteenth century: a system of sewer lines that would carry both waste and surface water to the East away from Central London. The construction of the new sewers was every bit as epic and enduring as the building of the Brooklyn Bridge or the Eiffel Tower. The visionary engineer, Joseph Bazzalgette, proved you could do something about a massive health crisis.

- Between 1858 and 1865 the city constructed 82 miles of sewers. Tourists may marvel at Big Ben or the London Tower, but beneath their feet lies the most impressive engineering wonder of all. The major sewer lines discharge at high tide into the Thames, after which the seaward pull of low tide flushes the city’s waste out into the ocean

Post-Scripts

- In 1866 while construction was not yet complete in East London there were cholera deaths. **Since 1866 London has not experienced an outbreak of cholera.**
- With the completion of the sewer systems, fish returned to the Thames, the stench abated and the drinking water became markedly more appetizing.
- At the time of the London epidemic less than 10 percent of the world's population lived in cities; the totals today are well over half. Ironically cities, because of their density, are by far the most economical way to deal with major environmental issues including sewage. Modern urbanization thus far offers up more solutions than problems. According to the coordinator of the UN Global Report on Human Settlements, **"Urban areas offer a higher life expectancy and lower absolute poverty and can provide essential services more cheaply and on a larger scale than rural areas."**
- Three incidental notes:
  - Cholera claimed 5.5 percent of Chicago's population (about 3,500 people) in 1854.
  - Someone, somewhere, died of cholera in the world today. Deaths in the past two years have been recorded in Iraq, India, Vietnam, the Democratic Republic of the Congo, South Africa, and in the thousands in Zimbabwe.
  - **If you get a case of cholera, in most cases it can be successfully treated with oral rehydration therapy (drink plenty of fresh clean water). If cholera patients are treated quickly and properly the mortality rate is less then 1%, if untreated the mortality rate increases to 50-60%....**


JOHN SNOW

Finale

- The forces of reason won out.
- The pump handle was removed.
- The map was drawn.
- The miasma theory was put to rest.
- The sewers were built.
- The water ran clean.
- The last cholera death in England was in 1866.

2008

- The World Health Organization noted a total of 190,130 cases in 56 countries including 5,143 deaths.
- Many more cases were unaccounted for due to limitations on surveillance systems and fear of trade and travel restrictions.
- The true burden of the disease is estimated to be 3-5 million cases and 100,000 – 120,000 deaths annually.
- Drinking Gatorade (administration of oral hydration salts) will easily treat 80% of all cases. Severely dehydrated patients may require IV's and antibiotics to rapidly bring about recovery. With proper treatment the case fatality rate should remain below 1%.