St. James, Westminster, Greater London.

Sunday evening, 3 September 1854. John Snow, M.D., receives an update from a trusted source on an eruption of cholera in the parish:

The outbreak began late Thursday night or very early Friday morning, with attacks reported in streets rarely visited by cholera in this, or prior, epidemics. Attacks must number in the hundreds, deaths by the score. But the geographical extent is quite limited, only affecting streets west and north of Golden Square, centered on Broad Street, with a nubbin extending toward Soho Square. Cause so far uncertain. Some medical men suspect effluvial vapors from a rendering factory in Marshall Street. Others consider airborne miasmatic particles from mud banks along the Thames more likely. Or, perhaps, the cause was a delayed proliferation of a recent outbreak in the fever nests of Seven Dials and St. Giles. Some locals blame emanations from grates connected to sewer lines, particularly recent construction through a plague pit from the seventeenth century.

Snow thought otherwise. He walked directly to a neighborhood pump at the corner of Broad and Cambridge Streets adjacent to a public house, the Newcastle–upon–Tyne. He stood at the back of the queue. It moved slowly. Some ahead of him filled two buckets and walked away. Others quaffed a liter or more as they worked the handle whilst filling another container—must be believers that cool and effervescent Broad Street water was a cholera preventive. Snow looked westward along Broad to Marshall Street, then eastward toward Berwick. He'd never seen the like. Horse-drawn hearses followed by mourners or standing stationary in front of an open door, awaiting a coffin. Carts loaded with dead bodies or the belongings of fleeing inhabitants. When it was his turn at the pump, Snow filled several small vials with water, placed most of them in a satchel, and stepped aside. He looked at one vial and, much to his surprise, found nothing untoward. Then he returned to his house in Sackville Street.[1]

The following morning, Snow walked a mile and a half to a dentist's surgery in Fleet Street.[2] After administering chloroform to a patient for tooth extractions, he retraced his steps for a mile and then tacked northwest until he reached the Broad Street pump. He drew a sample. This time there was unmistakable evidence, visible to the naked eye, of organic impurities. Thereafter, he walked to each of four nearby pumps and took samples from each. Two of these three samples were as impure as the Broad Street pump; the fourth, three hundred yards to the northwest and at the outskirts of the cholera field, was the most impure of all, but several locals told him they always used Broad Street water. He returned to the pump in Broad Street and drew another sample. Still visible organic impurity, but the amount seemed to differ slightly from what he had seen just a short while ago. Identical results later that day, and Tuesday morning—always some organic impurity, but varying amounts. He consulted a colleague who specialized as a microscopist; he confirmed the presence of organic matter and a few animalcules that may have been feeding upon it. Snow wondered if the source of the outbreak was cholera-contaminated water pumped to cisterns by a private company? He ruled that out that possibility when learning that two companies served the affected locality; it was extremely unlikely that both had pumped contaminated water at the same time.

Time to switch tactics. Snow walked to the General Registry Office at Somerset House on the Strand. He was given access to death certificates of cholera victims from the outbreak area. Of the eighty-nine submitted so far by sub-registrars, eighty-three had occurred between the previous Thursday and Saturday, 2 September (the last day in the weekly reporting cycle). Individual deaths from these sub-districts were not scheduled for publication that week, so he received permission to make a copy. Only ten of the deceased on his list appeared to have lived closer to a pump other than the one in Broad Street. He located family members at each of these ten addresses, began inquiries about each cholera victim's drinking-water habits, but had to call it a day when receding twilight made it difficult to locate house numbers. He resumed his inquiries the following day, completing as many as scheduled chloroform administrations would permit on Wednesday before finishing Thursday afternoon. He learned that the Governors and Directors of the Poor for the parish would meet that evening, so he made arrangements to be added to their agenda and prepared a summation of his findings.

After supper, Snow walked the few blocks from his house to the Vestry Hall. There he spoke with the officials, sitting as a special Sanitary Committee, who were responsible for managing the

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1 This narrative is based on John Snow, "The cholera near Golden-square, and at Deptford," *Medical Times and Gazette* 9 (23 September 1854): 321 <http://johnsnow.matrix.msu.edu/work.php?id=15-78-45>; Snow, *On the Mode of Communication of Cholera* [*MCC2*] (London: Churchill, January 1855), 38-41 <http://johnsnow.matrix.msu.edu/work.php?id=15-78-52>; "Dr. Snow's Report," in Cholera Inquiry Committee [CIC], *Report on the Cholera Outbreak in the Parish of St. James, Westminster, during the Autumn of 1854* (London: Churchill, July 1855), 98-102 <http://johnsnow.matrix.msu.edu/work.php?id=15-78-55>; and Peter Vinten-Johansen, "Snow's multiple investigations in Broad Street" <http://johnsnow.matrix.msu.edu/BrStP-MCC2-CIC.pdf>.

2 Richard H. Ellis, *The Case Books of Dr. John Snow* (London: Wellcome Institute for the History of Medicine, 1994), 343 <http://johnsnow.matrix.msu.edu/work.php?id=15-78-AC>; street addresses were located in F. W. Watkins, *London Commercial and General Directory for 1852* (S&N Genealogy Supplies).

parish's responses to the cholera epidemic, including the current emergency. Snow told them that water samples he had taken during the first three days of the week from the pump in Broad Street had contained small, but detectable, levels of organic solids such as found in sewage contamination; that the levels varied each time he tested, which meant that the contamination could have been greater when the outbreak began; and that, based on information received from family members and neighbors of the deceased with whom he had spoken, at least 80% were habitual users of Broad Street water, another 10% probable users. In his mind, such telling numbers ruled out mere coincidence. Consequently, although it appeared from what was happening in affected streets that the outbreak had peaked a few days earlier, Snow recommended that the parish disable the suspected pump as long as Asiatic cholera was present in the metropolis and undertake an investigation of the brick lining in the well under the pump in Broad Street.

The next morning, parish authorities removed the pump handle. After a four-day interruption, John Snow resumed daily trips to South London; he needed to complete inquiries there before the commencement of the fall medical school session, when his anesthesia commitments intensified.

That's what Snow wrote about his doings the first week of September 1854.

Selected Literature Review.

You'd never know it, however, from most of what's been written about this event, beginning with Benjamin Ward Richardson's biographical sketch of Snow written shortly after Snow died in 1858 from complications of a stroke at forty-five. Richardson shepherded the posthumous publication of Snow's big book on anesthetics and used this opportunity to insert a memorial essay about his friend's life and accomplishments. Richardson believed that Snow's epidemiological investigations were grossly under-appreciated by contemporaries, so he ramped up and dramatized the significance of Snow's involvement in the St. James outbreak: "He advised the removal of the pump-handle as the grand prescription. The vestry was incredulous, but had the good sense to carry out the advice. The pump-handle was removed, and the plague was stayed. There arose hereupon much discussion amongst the learned, much sneering and jeering even; . . ."[3]

Richardson's pump-handle tale is a mixture of falsehood and half-truths. He asserts that the outbreak only ended when the pump was disabled, yet he had reviewed the second edition of *On the Communication of Cholera* (*MCC2)* in which Snow stated, "the attacks had . . . far diminished before the use of the water was stopped,"[4] and even cited *MCC2* at this point in the memoir. The second part of the tale, that Snow was ridiculed for recommending closure of the Broad Street pump, is inaccurate. Only a few close colleagues and friends even knew of Snow's involvement in the St. James outbreak until he published a letter to the editors of a medical journal toward the end of September. The parish vestry, not Snow, had been vocally attacked when angry locals were forced to find an alternative source of drinking water.

In 1866, when epidemic cholera came to metropolitan London for the fourth time in thirty-five years, Edwin Lankester thought Richardson's pump-handle tale would dissuade people from using street pumps with dodgy water. Lankester plagiarized Richardson's account in a pamphlet intended for a popular audience: "Not a member of his own profession, not an individual in the parish believed that Dr. Snow was right. But the pump was closed, nevertheless, and the plague was stayed. . . ."[5] Lankester had stooped to lying. A vestryman of the parish of St. James, Westminster, a prime mover in the creation of the parish committee to investigate the local outbreak, and the chairman of the sub-committee responsible for approving the committee's final report, he knew very well that the 1854 outbreak had peaked days before the Broad Street pump was disabled; Richardson's distortion must have seemed an acceptable means to the just end of preventing potential outbreaks of a similar kind in the current cholera epidemic.

Richardson coined this tale, but Lankester gave it legs. *On Chloroform* was a specialized subject with a limited audience, so Lankester's 1866 pamphlet seems the most likely cause of Henry

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3 Benjamin W. Richardson, "The Life of John Snow, M.D." In *On Chloroform and Other Anæsthetics* (London: Churchill, 1858), xxi <http://johnsnow.matrix.msu.edu/work.php?id=15-78-162>. Later in the same paragraph, Richardson made a disingenuous assertion: "It was my privilege, during the life of Dr. Snow, to stand on his side" (Ibid., xxii). However, in an 1855 review of *On the Mode of Communication of Cholera*, 2nd edition, he had written that "Dr. Snow and his objectors are both right in the main; and that while the specific poison of cholera (for we must presume the existence of such a poison, though we may not understand its nature), may, by accident, be carried into the intestinal canal by the medium of water, it may also be wafted into the lungs by the medium of the air [William Budd's hypothesis]. Many of Dr. Snow's objectors would, we doubt not, join us in this view of the case; which is more than we could expect from him [ie., John Snow], since it is opposed to his essential idea . . ." ("Water supply in relation to health and disease," *Journal of Public Health, and Sanitary Review* (1855): 134 <http://johnsnow.matrix.msu.edu/work.php?id=15-78-14B>.

4 Snow, *MCC2,* 51.

5 Edwin Lankester, *Cholera: What is it? And how to prevent it* (London: George Routledge & Sons, August 1866), 34–35.

Whitehead's dismay at a meeting of the London Epidemiological Society in May 1867:

> It is commonly supposed, and sometimes asserted even at meetings of Medical Societies, that the Broad Street outbreak of cholera in 1854 was arrested in mid-career by the closing of the pump in that street. That this is a mistake is sufficiently shown by the following table, which, though incomplete, proves that the outbreak had already reached its climax, and had been steadily on the decline for several days before the pump-handle was removed.[6]

But Whitehead's corrective fell on barren ground. Austin Bradford Hill noted in 1958, a hundred years after Snow's death, that Richardson's pump-handle tale "is still widespread."[7]

No smoking gun explains the pump-handle tale's persistence, although Richardson's decision in 1887 to revise his memoir of Snow and publish it in a journal of medical sciences he edited had an impact of some significance. Extensively redacted for an emerging germ-theory audience, the new essay pitched Snow as "a representative of medical science and art of the [late] Victorian era" instead of what he actually was, a typical mid-Victorian physician. Richardson left the "plague was stayed" part of the tale intact, but deleted derogatory references to sneering and jeering colleagues.[8] Toward the end of the century, D'Arcy Power compiled a short list of biographical details for a *Dictionary of National Biography* entry on Snow. Power did not mention the outbreak in St. James, Westminster, but he cited Richardson's 1858 biographical memoir and the condensed, 1887 revision as his only sources of evidence.[9]

In the next century, Richardson's pump-handle tale found legs yet again from an unexpected source—Wade Hampton Frost, chair of the Department of Epidemiology at Johns Hopkins. Frost had long admired Snow's cholera writings and understood them for what they were: promising explorations of a horrific disease within the mid-century Victorian medical worldview. He and an editorial team from the Commonwealth Club decided to put together a source book entitled *Snow on Cholera*, featuring complete reprints of *MCC2* and *On Continuous Molecular Changes* (an oration Snow delivered in 1853).[10] This pairing, odd as it may seem, made perfect sense to Frost because Snow had cautioned in *MCC2* that "the writer . . . does not wish to be misunderstood . . . that cholera depends on veritable animals, or even animalcules, but rather to appeal to that general tendency to the continuity of molecular changes, by which combustion, putrefaction, fermentation, and the various processes in organized beings, are kept up." However, Frost negated this astute insight into Snow's manner of thinking with two mind-boggling decisions: First, in an introduction that's generally accurate about historical context and even-handed in its treatment of conflicting points of view about cholera causation, Frost portrayed Snow as a germ-theory epidemiologist;[11] and second, he positioned Richardson's 1887 biographical essay (in which Snow is sanitized of mid-century influences) immediately after his introduction and ahead of Snow's actual work. *Snow on Cholera* appeared in 1936, was reprinted in 1965, and remained the only, readily accessible example of Snow's writings until the new millennium. Snow is no easy read in his longer pieces, so it's understandable if generations of aspiring and experienced public health workers rarely ventured much beyond Frost's introduction and Richardson's biographical essay. I can think of no better explanation for the fact that

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6 Rev. Henry Whitehead, "Remarks on the outbreak of cholera in Broad Street, Golden Square, London, 1854 ," *Transactions of the Epidemiological Society of London* 3 (1868): 99. Whitehead had also been a member of the parish investigative committee and written a special report on the impact of the outbreak in Broad Street. The table he mentions shows, like those of Snow and the parish investigative committee, that the greatest number of fatal attacks occurred on 1 and 2 September, after which the drop-off was dramatic.

7 A. Bradford Hill, "Snow—an appreciation," *Proceedings of the Royal Society of Medicine* 48 (1955): 1009.

8 Benjamin Ward Richardson, "John Snow, M.D. A representative of medical science and art of the Victorian era," *The Asclepiad* 4 (1887): 274-300 <http://johnsnow.matrix.msu.edu/work.php?id=15-78-F5>. My introductory remarks to the transcription highlight Richardson's major sanitizing efforts; the pump-handle tale occurs on page 286. Mary Stella reprinted this version in a 1900, post-mortem edition of her father's writings.

9 D'Arcy Power, "Snow, John (1813–1858)," in Sir Sidney Lee, ed., *Dictionary of National Biography* 53 (Macmillan 1898): 207–08 <http://johnsnow.matrix.msu.edu/work.php?id=15-78-1A3>. Power erroneously identifies the *Asclepiad* version as a reprint of the 1858 memoir.

10 Commonwealth Club Publication Committee, *Snow on Cholera, being a reprint of two papers by John Snow, M.D., together with a biographical memoir by B. W. Richardson and an Introduction by Wade Hampton Frost*. Cambridge, MA: Harvard University Press, 1936. Reprinted by Hafner, 1965. See <http://johnsnow.matrix.msu.edu/work.php?id=15-78-F9>, which contains my interpretation of Frost's introduction.

11 Ibid., xvi-xvii. Snow's comment appears in *MCC2*, 9.

Richardson's pump-handle tale remains the cardinal metaphor (with teflon resistance to contrary historical evidence) for the noble minded, shoe-leather epidemiologist to the present day.

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In October 2010, Joe Palca introduced a segment of National Public Radio's "Science Friday" in the following manner:

> Over 600 people died of cholera in London during the outbreak of 1854, and it was a pretty mysterious disease back then. The prevailing medical theory of the day blamed it on contaminated vapors, but the English physician, John Snow, had his own theory. To prove it he mapped out the cholera deaths during the outbreak, and he noticed that many of the deaths were concentrated around one particular water pump on Broad Street. Snow recommended disabling the pump; and sure enough, the outbreak was contained, so they knew it had something to do with water.[12]

The quote ends with a variation of Richardson's pump-handle tale ("the outbreak was contained"/"the plague was stayed"). But Palca repeated another apocryphal assertion about Snow's investigative methodology for which neither Richardson nor Lankester may be blamed—the disease mapping tale, which seems to have appeared in the second half of the twentieth century and retains considerable currency now in the twenty-first.[13]

Snow, himself, did not mention anything about mapping locations of the eighty-three cholera deaths registered at the General Register Office for the week ending 2 September 1854 (the only deaths Snow investigated prior to the pump closure). Instead, he used an indeterminate verb: "On proceeding to the spot, I *found* that nearly all the deaths had taken place within a short distance of the pump."[14] Sandra Hempel appears to have interpreted "found" to mean mapped, although she somehow missed the preceding prepositional phrase; and, like Palca, she invests the mapping exercise with an exploratory dimension. According to Hemphill, Snow ostensibly

> marked the deaths, house by house, on a street plan, a line for each fatality. And as he did so, a distinct pattern began to emerge. . . . To Snow's keen eye, something else stood out, both figuratively on the map and physically in Broad Street, right at the heart of the outbreak and, to his way of thinking, as obvious a culprit as could be . . . the Broad Street pump.[15]

Another journalist, John Noble Wilford, rounds out my triptych of mapping-tale examples:

> a turning point in prevention came in 1854, when a London physician, Dr. John Snow, established the connection between contaminated water and cholera. Dr. Snow tested the idea by plotting cholera cases on a map of SoHo [*sic.*]. This showed that most of the victims drew their water from a public pump on Broad (now Broadwick) Street. An infected baby's diapers had been dumped into a cesspool near the well. A recent book, "Ghost Map," by Steven Johnson, recounts the discovery.[16]

And, I would add, offers a fascinating narrative of Snow's initial mode of inquiry.[17] Johnson explains in *The Ghost Map* that Snow had been accumulating evidence since 1849 about point-source outbreaks that may have been caused by cholera-contaminated wells. Whatever he was told on Sunday 3

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12 Episode on October 29, 2010. It's listed on <www.sciencefriday.com/episodes/page/30>, but the link did not permit me to listen to it the last time I checked. The home page for that episode at one time listed three sources as recommended readings.

13 Vinten-Johansen, et al., *Cholera, Chloroform, and the Science of Medicine: A Life of John Snow*, 396–99, suggest two possible origins of the mapping tale: the appearance of Snow's *MCC2* map of the local outbreak, usually in the form of altered and simplified recreations, in scores of books and articles after 1952; and the advent of geographic information system (GIS) technology in the 1990s.

14 Italics mine. Otherwise, the sentence is identical in all three of Snow's descriptions of his investigative procedures that week: "Cholera near Golden-square," 321; *MCC2*, 39; "Dr. Snow's Report," 101.

15 Sandra Hempel, *The Strange Case of the Broad Street Pump* (Berkeley and Los Angeles: University of California Press, 2007), 212–13. Citations are to the US reprint, which uses a title that's misleadingly narrow, given the scope of the book; Granta's title is *The Medical Detective: John Snow and the Mystery of Cholera*. A bit later Hempel dismisses the pump-handle tale as a "myth": "By the time Snow had finished his enquiries and put his case to the guardians [sic], the epidemic had peaked of its own accord" (223). She's obviously unaware that the mapping tale is equally mythological.

16 *NYT* (15 April 2008): D4. Wilford adds a GIS angle to his interpretation: "The cholera research was an early application of mapping in medical investigations, a technique that has become widespread now that computers facilitate the display and analysis of such data." Henry Whitehead, not Snow, proposed the index case in April 1855, seven months after the outbreak.

17 Full disclosure time: I read and commented on a galley draft of *The Ghost Map* in July 2006 at Johnson's request.

September about the nature of the St. James, Westminster outbreak seemed to fit that bill. Moreover, Snow knew from having lived and practiced in the affected neighborhoods that the pump in Broad Street was favored by locals. Johnson's account, therefore, matches what Snow wrote in letter published three weeks later: he immediately walked to the pump, took water samples then and again the following two days, after which he made a list of certified cholera deaths at the GRO. With that list in hand, according to Johnson, Snow:

> returned to Broad Street to continue sleuthing. He stood at the base of the pump, and ran through the addresses on the list. From time to time, he gazed out at the empty streets around him, imagining the paths the residents might take to find their way to water.

In short, according to Johnson and in line with extant evidence, Snow undertook no mapping whatsoever during the inquiry phases of his researches.[18] He never "tested the idea by plotting cholera cases on a map," as Wilford put it. Instead, Johnson writes that Snow waited nearly three months after the Broad Street pump had been disabled to devise a map for *MCC2* that would illustrate the totality of his findings.

Why, then, would Wilford recite the mapping tale and recommend *The Ghost Map* when Johnson had explicitly described an alternative scenario? Why would Palca and the Science Friday team of writers recite the mapping tale during a radio broadcast when it doesn't appear in the three books, including *The Ghost Map*, originally listed as recommended readings on the home page for that episode? Why did Hempel, who was generally careful in her use of sources in other instances, mess with Snow's chronology to make it appear that he had visited the GRO and mapped the outbreak in order to suspect the Broad Street pump in the first place?

My hunch? All too often, we impose our notions and how we would act upon figures in the past. I can happen to any of us, including historians trained to do otherwise. It's understandable that someone today would assume that Snow used a map to establish that most of the eighty-three cholera victims on his list of addresses had died within close proximity to the Broad Street pump. It's equally understandable that someone in the twentieth or twenty-first century might assume that Snow had access to a street map depicting individual house numbers in the cholera field. It's up to historians to provide the interpretations and information required to indwell different situations and worldviews. If Palca, Wilford, and Hempel had made additional inquiries on this matter, they would have learned that no map depicting individual house numbers existed for St. James, Westminster until the Metropolitan Commission of Sewers created a partial one the third week of September 1854 to accompany an investigative report on the cholera outbreak.[19] Johnson discussed this map, although he did not indicate that it was the first frontage plan for the area as it existed at mid-century.

But there is no reason that he should have done so. *The Ghost Map* is creative non-fiction, not history. Johnson asked me to send him comments because he wanted to "get it right," factually, even though there was little time to make changes, given a looming production deadline.[20] "We know a remarkable amount" about the 1854 cholera epidemic, and he had selected a time-tested device, dramatic irony, to deploy what he had learned about the horrific outbreak in St. James, Westminster: the story begins with the dodgy sewer drain at 40 Broad Street filled with choleraic dejections and then follows Snow and Henry Whitehead as they struggle to discover what Johnson's readers are told from the outset. The two intrepid investigators are brilliant; miasmatists are "blinded . . . by an idea." At times, Johnson believed "the historical record comes up wanting. We have to use our imagination."[21] That's true for historians as well as creative non-fiction writers. The difference is that the former must constrain their imaginations from wandering beyond the known documentary evidence, whereas the latter do not.

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18 Steven Johnson, *The Ghost Map. The Story of London's Most Terrifying Epidemic—and How It Changed Science, Cities, and the Modern World* (New York: Riverhead Books, 2006). See discussion of the point-source outbreak in Thomas Street, Horsleydown, 72; and "imagining the paths" quote, 136.

19 Vinten-Johansen, "In Fairness to Snow" <http://johnsnow.matrix.msu.edu/work.php?id=15-78-162>, 8–9.

20 "Got all my changes in this afternoon . . . . I agreed with about 90% of what you suggested, though I think I only ended up changing about 60%"; Steven Johnson, e-mail to author, 31 July 2006. Ironically, given the book's title, one of Johnson's most glaring factual errors is the following: "The second version of the map—the one that made it into both Snow's monograph [*MCC2*] and the Vestry [CIC] report—included a slightly odd, wandering [Voronoi-like] line . . ." (Ibid., 196). The map in *MCC2* was the version miasmatists argued depicted an aerial dispersion of cholera matter; the map with the Voronoi-like equidistant walking lines appeared only in the CIC report, which had a very limited distribution and is unlikely to have had the impact Johnson claims.

21 Johnson, *Ghost Map*, 184; 31–32. But his criticism that Sir Benjamin Hall's instructions to the GBoH inspectors displayed confirmation bias is spot-on.