Cholera and Clean Water Timeline

Bob Phillips

Date	Events	Comment	Citations
from ancient times	Miasma theory	Going all the way back to the 1st century AD, the potential effects of miasma from fetid swamplands was a key influence when siting a city. The Roman architectural writer Vitruvius wrote of "the morning breezes blowing towards town at sunrise mingled with the mist and the poisonous breath of creatures of the marshes" Miasma theory – that disease was carried through the air, in foul smells and such-like, persisted right into the Victorian age, with authorities like Dr. William Farr supporting the theory until the events of our tale induced him to change his mind.	Wikipedia on Miasma Theory Hempel, p 35ff
1674	Magnified view of micro-organisms in water	Antonie Philips van Leeuwenhoek (1632 – 1723) is best known for his work on the improvement of the microscope and for his contributions towards the establishment of microbiology . Using his handcrafted microscopes, he was the first to observe and describe single celled organisms, which he originally referred to as animalcules, and which we now refer to as micro-organisms. van Leeuwenhoek is often referred to as "the Father of Microbiology" and he is considered to be the first microbiologist. He represents the beginning of our story of cholera, even though it was two centuries before "animalcules" such as the ones he observed were identified as the agents that carried diseases like cholera. van Leeuwenhoek was a cloth mercnt in Delft, in the Netherlands. He first developed lenses to enable him to look more closely at the quality of cloth.He was a self-taught scientist, and He was the first to record microscopic observations of muscle fibers, bacteria spermatazoa and blood flow in capillaries (small blood vessels). Van Leeuwenhoek did not author any books, although he did write many letters.	Wikipedia on Leeuwenhoek
early 19th C	Contagion vs Miasmatism	In the 19th century, debate raged between the Miasmatists – those who believed disease was communicated through the atmosphere and the Contagionist who saw bodily contact as the guilty party. Florence Nightingale aligned herself with the Miasmatist party, deriding the arguments about Contagion as "an adequate excuse for non-exertion to prevent its recurrence." Although Miasmatism was the wrong theory for diseases like cholera, it drove some beneficial changes. Florence Nightingale was not the only one who was driven to clean up hospital and the sinks of city streets in the hope of eradicating disease.	Wikipedia on Miasma Theory

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		John Snow appeared as an expert witness before a Committee of the House of Commons preparing for the 1846 *Nuisances Removal and Diseases Prevention Bill* (commonly known then as the Cholera Bill). He spoke on "behalf of the trades people in the south districts of London, … on a request from Mr. Knight" – one of those trades people, who he had not even met. This is a classic example of Snow's lack of attention to what might do him good, professionally, or not. He paid scant attention to the fact that in a committee of very powerful people who assumed the miasma theory was right, he might come in for undesirable criticism and even be seen as a crank. He spoke just because, rationally, he could see that however nasty these trades were, there was no causative link between them and cholera or other infectious disease. "Are the Committee to understand, taking the case of bone-boilers, that no matter how offensive to the sense of smell the effluvia that comes from bone-boiling establishments may be, yet you consider that it is not prejudicial in any way to the health of the inhabitants of the district?" *Snow* "That is my opinion." "Do you not know that the effect of breathing such tainted air often is to produce violent sickness at the time?" *Snow* "Yes, when the gases are in a very large quantity, as in a cesspool." "Do you mean to tell the Committee that when the effect is to produce violent sickness there is no injury produced to the constitution or health of the individual?" *Snow* "No fever or special disease." John Snow, from his earlier work around anaesthesiology, knew far more about the behaviour of gases than any member of the Committee, but I don't suppose they liked to recognise that! The full debate is a fun read: http://www.ph.ucla.edu/epi/snow/snows_testimony.html	
1813 ff	Snow' origins	John Snow was born on March 15, 1813 in a house on North Street in York, the first of nine	This is taken wholesale

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		children of William Snow (1783-1846) and Francis Snow (Askham) (1789-1860). His family lived on North Street, alongside the River Ouse which, prior to the advent of the railways in the late 1830s, was one of the main thoroughfares for the dispatch of heavy goods and materials to and from York. His neighbourhood in North Street was among the poorer regions of York, being always at risk of flooding from the Ouse River, and considered one of the worst drained areas in the city. At the time of Snow's birth, and during most of his early childhood, his father worked as a labourer in a coal yard, one of many poorer, unskilled, manual workers in the city. Barges on the River Ouse brought coal to the yard, situated adjacent to the family home. When he was around age 6, John Snow attended a private school in York, termed "common day schools" and intended to educate the poor. Most schools at that time were private, with the exception of Poor Law schools financed by the government or factory schools. While there is no record of his early schooling, likely he attended the Dodsworth School at Bishop Hill in central York, a school that allotted several spaces to All Saints North Street church, where the Snow family were members. The school curriculum during the eight years he attended the school (i.e., 1819-1827) included reading, writing, arithmetic and the Scriptures. He was an industrious pupil and mathematics and natural history were his favorite subjects. Exactly how his father, a poor laborer, afforded to send his son to a private school remains a mystery, although Dodsworth School was less expensive, intended as an institution to educate the poor. Most historians suggest that money to assist John Snow with his schooling came through John's mother, Frances. She was the sister of Charles Empson (1794-1861), an affluent and well-travelled man who later was a leading figure in Bath society. Later, Charles Empson probably helped finance aspects of John Snow's London education and the start of his medical practice. Before going off to London for his formal medical education, John Snow had three apprentice-ships with medical practitioners. During early 1800s, only a few organizations were allowed to grant licenses for medical practice in England. He took the route of being an apprentice with a licensed surgeon and apothecary (another name for a pharmacist), with the anticipation that he one day would pass the licensing test given by the medical group (Royal Colleges of Physicians and of Surgeons) and the pharmacy group (Worshipful Society of Apothecaries). Snow's apprenticeships began in 1827 and lasted nine years. At the age of fourteen, finishing	from the section on Snow's early years in the UCLA Faculty of Public Health Snow web-site http://www.ph.ucla.edu/epi/snow/birthearly.html I have made some minor textual amendments. We may need to seek permission for using this source in this way.

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		his early education, John was sent to Long Benton, a suburb of Newcastle- upon-Tyne to be apprenticed on June 22, 1827 to William Hardcastle, a surgeon-apothecary (the term for what is now known as a general practitioner). John Snow's uncle, Charles Empson, was a friend and confidant of Mr. Hardcastle, listed as both witness at Hardcastle's wedding and executor of his will. Mr. Hardcastle was also the physician for the George Stephenson family, who earlier had lived in nearby Killingworth. Robert Stephenson had attended school in Long Benton and was a good friend of Charles Empson. Likely these friendships lead to Snow's apprenticeship so far away from his home in York. William Hardcastle was an established practitioner of good reputation in the Newcastle-upon-Tyne area who was thirty-one years old at the outset of Snow's apprenticeship. Snow's apprenticeship in Newcastle, which lasted six years, was an important time for him. Not only did it lay the foundations of his medical training but it was also the period in which he developed interests and attitudes which were to be with him for the rest of his life. During the third year of his apprenticeship when he was 17 years old, he became a vegetarian and remained so until age 25. Snow was a noted swimmer at this time, and apparently could swim longer against the tide of the River Tyne than any of his meat-eating colleagues. During the same period, he also took up the temperance cause (no alcohol), joined the ranks of the total abstinence reformers, and for many years became a powerful advocate of their principles. While working with William Hardcastle was the central focus of his apprenticeship, Snow also found time to attend classes in a pioneering venture that lead to the establishment of a modern medical school. In 1831-32 when John Snow was 18 years old, cholera first appeared in Newcastle. Mr. Hardcastle sent Snow in 1831 to provide medical assistance in Killingworth where the miners from the local colliery (a coal mine together with its physical plant) and their families were victims of a cholera outbreak. This experience likely gave him a sense of mission, which continued in his future epidemiological investigations. Years later Snow wrote of this time, "That the men [who work in coal pits] are occasionally attacked whilst at work I know, from having seen them brought up from some of the coal-pits ... after having had profuse discharges from the stomach and bowels, and when fast approaching to a state of collapse."	

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		In April 1833, at age 20, when he had completed his six years of apprenticeship with Mr. Hardcastle, John Snow went to Burnop Field, a village near Newcastle-upon-Tyne and became an assistant to Mr. John Watson, a rural apothecary. Probably his intent was to remain an assistant for a few years, saving money, before going to London for two years of medical education to become a licensed practitioner. Snow remained in Burnop Field for about a year, and then joined a medical practice in Pateley Bridge for eighteen months. He apparently had little in common with Mr. Watson, who relied more on clinical experience rather than book learning, and considered his wages to be very low. He left Burnop Field in April 1834 and returned home to York for a few months. His father at that time was becoming a landlord, renting rooms in properties he owned in York. When Snow went in the autumn of 1834 to Pateley Bridge, his medical mentor was Mr. Joseph Warburton, a licensed apothecary. Pateley Bridge is in a remote region with scattered settlements to the west of York. The town had a population of about 1,500, with most involved with agriculture, spinning and weaving of flax, quarrying, and lead mining. Snow may have been short of money, needing to earn enough to continue his medical education in London, or perhaps was aware of Warburton by reputation, more prominent than Watson in Burnop Field. He lived in a large house that served as both home and surgery to Joseph Warburton, wife Harriet, and their three children. At this time Snow was a strict vegetarian, apparently puzzling Mrs. Warburton, shocking the cook, and astonishing the children. He also attended local lectures on temperance, accepted the principles of total abstinence, and took the pledge. His teetotal address, later published in the British Temperance Advocate, was delivered in 1836. Snow viewed Warburton with great respect and friendship, later referring to him as his "old master." He remained in Pateley Bridge for 18 months. At the end of his three apprenticeships in the summer of 1836, John Snow returned home to York for a few months. During this time he and his brother Thomas played a part in creating the York Temperance Society. Thereafter he worked to establish other local temperance societies, reflecting the depth of his feelings against alcohol. Soon, however, he yearned to be a tourist and to pay his respects to his uncle, Charles Empson, who had encouraged and perhaps helped arrange his early apprenticeship. To this end, in the summer of 1836 he traveled on foot about 400 miles in 4-5 weeks from York to Liverpool then on to North and South Wales, and finally back to Bath to spend time with Uncle Charles. Snow enjoyed walking. In October 1836, seven months past his 23rd birthday, he went to London to start his formal medical education at the Hunterian School of Medicine.	

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1829	Filtration for Chelsea Water Co. at Pimlico	At the same time as the medical establishment raged about theory, the Victorian engineers were celebrating practical triumphs. "Our own" James Simpson, the engineer who built the Seething Wells establishment, was growing into the role of Chief Engineer of the Lambeth Water Company, following his father Thomas who was Chief Engineer of the Chelsea Water Company, was exploring the possibilities of filtering water for consumption by humans. James Simpson, in the late 1820s, invented the technology for filtering water through sand that has substantially not been improved to this day: even though the existence of bacteria was way ahead in the future when James Simpsom was experimenting with filtration, he still invented a technique that was so successful in clearing water of every impurity held in suspension that it removed not only most of the odour, flavour and discolouration of the water, but also the bacteria. Simpson's new slow sand filter bed made him famous. It employed readily available, cheap materials: an undulating layer of pebbles dredged from the river, constructed by laying them over earthenware drainpipes pierced with hole,; secondly: a layer of fine gravel; thirdly: a layer of seashells imported from Harwich; fourthly: a layer of coarse sand; and fifthly: one of fine sand. The shells overlapping prevent the sand from sinking into the pipes. This practical engineering genius features again and again in our Surbiton story, because James Simpson becomes Chief Engineer to the Lambeth Water Co. that builds the first water inlet system in Seething Wells, playing a key role in the detective story around cholera; and continues to sell engineering know-how to the Chelsea Water Co., which becomes the second at the Seething Wells site. (The first installation of James Simpson's revolutionary new slow sand filtration technology has disappeared – under what is now Victoria Station.)	Onocm Community web site Liz Pearson
1831-2	Epidemic 1: Sunderland	England's first experience of the dreaded epidemic disease, Asiatic cholera came into the country from the north, through the ports. The first outbreak was in Newcastle. John Snow's master, William Hardcastle, had to send his apprentice to tackle one outbreak, in the mining village of Killingworth while he did what he could in Newcastle itself – this raging new disease	Vinten-Johansen, p 41ff

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		was so overwhelming. It was a new disease in England - never on our shores before 1831. But it had raged around the world before, seeming to have its origins in India. British doctors in India, in Russia, and a few other places had seen cholera and dealt with it first hand, but there were few of these. John Snow was one of a very small band of doctors who had direct experience of tackling cholera, with the woefully inadequate means available in a world of Victorian medicine that speculated about the miasma on which cholera infection was borne.	
1836-8	Snow's professional training	In the meantime, John Snow had made an arduous journey on foot from Newcastle-upon-Tyne to London and attained his qualifications at the Hunterian School of Medicine, in Soho, and carried out practical work in Westminster Hospital and in the Royal Lying-in Hospital on Queen Street. He lodged in Soho, and first set up in practice, in 1836, in Soho – in Frith Street. Soho was to feature very large in Snow's life (and long after his death: there is a John Snow pub in Broadwick Street in Soho – more of that later). John Snow became engaged with issues of public health while he was still studying: he pursued two issues in which a wider group of people were being affected by arsenic. One issue was the use of arsenite of potash in the preparation of cadavers for dissection, which was affecting other medical students. The other wsa the use by some manufactures of arsenic in candles to enhance brightness, which was affecting theatregoers in particular. In the investigation of the latter issue, we first see Snow using Francis Bacon's idea of the *experimentum cruces* which took such a prominent place in his work on cholera.	Vinten-Johansen, Chapter 3
1843-8	Snow's other line - anaesthesiology	Once John Snow had established himself as a practitioner, he began to crave out a line for himself. He had already established scientific credentials – he was a respected and published experimental scientist within medicine. His enquiring mind turned to the newly discovered properties of ether,\and then chloroform, and within a few years he was recognised as one of the expert practitioners in a field that was just emerging: anaesthesiology. He started providing this service to some of the most distinguished patients of his fellow physicians and surgeons – he provided chloroform to assist Queen Victoria in the birth of Prince Leopold, 7th April 1843, her eighth confinement. Throughout Snow's years of working on cholera, he continued his general and anaesthesiology practice – that was what paid the bills. In fact,\it was a side-line from anaesthesiology that drew	Vinten-Johansen, pp 97-164 Vinten-Johansen, p 242 Vinten-Johansen,

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		him into cholera research: In late 1848, articles began appearing in the professional journals advocating the use of chloroform in the treatment of cholera.	p 165
1847	Lambeth Water Company takes The Decision	On July 27 1847 the Chief Engineer of Lambeth Water Company tabled for the Board a report he had written "on the Conduit Pipe in the River Thames, and on the purchase of land for a site for the erection of New Works" – summarising work he had been pursuing for a couple of years proposing that LWC develop a new inlet for cleaner water, above the tidal basin of the Thames, pumping the water down a new main to the reservoir at Brixton. The Board appointed a sub-committee of just two of its members – James Peach and James Noble – to investigate this recommendation for the Board. The subcommittee was asked to report to the next meeting of the Board, in less than a month. On August 24 the Board received the report of the subcommittee – we have is as just over 3 pages of beautiful copper-plate writing in the LWC Minute Books. The subcommittee recommend the venture, the Booard decides to think about it: they give themselves a week. On August 31 the Board decides – the Lambeth Water Company will undertake a hugely adventurous project, estimating that it will cost the huge sum of £125,000. They have the courage to "bet the farm". In subsequent minutes we read of meetings to convince "the Proprietors" (the shareholders), to petition the commons, for Metropolitan water companies require a bill in Parliament for actions like these; and we read of the other water companies putting thei heads together in what looks like a flap.	LWC Board of Management Minute Books
1848	City Sewers Act - the power to conduct epidemiological surveys	In terms of governance, London of the 1840's was still a city divided, the wider Metropolitan area distinct from the "Square Mile " of the old City. Former Poor Law Commissioner, dominating the Royal Commission on the Health of Towns, Edwin Chadwick was urging the Metropolis to clean up the rapidly declining environment of London – the air water and river systems especially. His efforts did not affect the City but it did cause the City Commissioners to pay attention to the dramatic engineering solutions he was putting in place – flushing sewers for example and to compare the innovations under way with the essentially mediaeval character of the City which was an unreconstructed city of cesspools and pollution of every kind. Chadwick, like almost	Lambert, p 176

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		every other "informed person" of his time, "knew" that the miasma emanating from these piles of pollution were the primary causes of a range of illnesses.Following a fresh series of inspections in 1848, the City of London acted as well; the Commissioners were forced to recognise the filthy water supply, the overcrowded burial grounds, streets overflowing with human and industrial refuse and astonishing levels of overcrowded housing. Their response was to drive through the City Sewers Act of 1848. This was designed to provide powers to effect a programme of widespread clean up in the Square Mile. When John Simon took on the job of first Medical Officer of Health for the City he developed a wide reaching system of investigation and statistical survey based on his conviction that medical research would yield up the solutions more effectively than Chadwick's engineering initiatives. Simon also discovered that the Act gave him substantial powers to intrude upon the domestic lives of the poorest of the City's inhabitant (those living in lodging houses at a rent of 3/6d (17½p) per room per week, or less). He was thus enabled to carry out investigations on an unprecedented scale, and he created systematice data collection forms and procedures to exploit this opportunity. Thus modern epidemiological methods were born.	
1848 *ff*	Flushing out the cess-pits … into the Thames	Edwin Chadwick was one of the advocates of Miasma theory, and he had the power and the personality to put his convictions into practice. He had done work with the Poor Law Commission in the 1830s and 40s that had made him very well known. He was appointed to both the Metropolitan commission of Sewers and to the General Board of Health in 1848 – near the beginning of the effort in Victorian times to bring the power of the State to bear on public health. Chadwick was not a doctor – he was a lawyer. He gained a reputation for being inflexible and domineering. He was convinced that miasma – smell – was the cause of disease, without anything that we would call scientific evidence to support this. He determined that the cess pits in London should be cleared, and made this happen with extraordinary efficiency – thousands of sewer lines were built in the 1840s to clear the cess pits in the centre of London – into the Thames. This executive action had two unintended effects. First of all, it increased the prevalence of all sorts of fecal-borne infections, including cholera, in Thames water, setting the scene for John	Lambert, p 80

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		Snow's later discoveries. Secondly, it provided all the lateral sewers feeding towards the Thames which David Bazalgette later linked together into a sewage main in the feat of engineering that in late Victorian times did solve London's sewage problem. But Edwin Chadwick had not intended either of these results. Despite his zeal, he has removed from his post, mostly because nobody could stand him. The next person to be appointed to the chief state medical role was John Simon, who features later in our story.	Inwood, p 427
1848-9	Epidemic 2: S. London – Albion Terrace	What was experienced as a second epidemic of cholera in England and Wales in 1848-9 was in fact a second wave of a pandemic of cholera that had travelled from India to Russia in 1830, and had travelled through Finland and Poland to create the first,1831-2, epidemic in England. That pandemic went on from the British isles to ravage the US and Canada, moving into South America in 1834. It came back to England in 1848 and killed 52,000 Britons over two years Snow was an established practitioner by 1848, and he had had his early experience of cholera when he had been an apprentice. He was ready to turn this experience into theories of the communication of cholera, and he proposed a different line from almost all of his contemporaries: he believed that cholera was "communicated by something that acts directly on the alimentary canal" Snow investigated an outbreak of cholera at Albion Terrace, Wandsworth Road, in July-Aug 1849 in which cesspools and drains with leaky joints were positioned higher than pipes serving drinking water and storage tanks and it could be shown that polluted water from the former had infiltrated the latter. Snow's manner of investigation house to house showed all the characteristics that later came to full development as the techniques of epidemiology. Another researcher, John Grant, provided more data from Surrey Court in Horsleydown that supported Snow's emerging hypotheses,(even though Grant drew entirely different, miasmatist, inferences from his data).	CBS News Cholera's Seven Pandemics, 22/10/2010 http://www.cbc.ca/news/ealth/story/2008/05/09/f-cholera-outbreaks.html MCC1, p 8-9 Vinten-Johansen pp 206-10
1849	Initial publication MCC1	By 1848, Snow was convinced that cholera was transmitted by at least two means: by ingesting water contaminated in some way by a prior sufferer and by hand to mouth contact between family members. He did not rule out other means but he could claim from his evidence that these two means existed. When in 1849 he published his first edition of On the Mode of	Vinten-Johansen pp 199 - 212

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		Communication of Cholera (MCC) he used evidence gathered from two local outbreaks south of the River Thames during the 1848 – 9 epidemic. Snow was spurred to hasten publication because of a report published on Aug 9th 1849 by John Grant, assistant Commissioner of Sewers who wrote of broken sewers and the stench of cesspools being the likely cause of a local outbreak of cholera at Surrey Court, Horsley Down, during this second epidemic. Additionally, at that moment, another outbreak in Albion Terrace, Wandsworth Road, caused Snow to go checking for details of the order of events to establish cause and effect – to establish that contaminated water, not miasma, was the cause of this outbreak. In both cases cholera was brought to the neighbourhood by one or two individuals. John Snow was certain that the speed of the spread of the disease could only have occurred through waterborne contamination. Snow found the focus of the epidemic contamination: drains, pipes and tanks were found to have leaky joints and the water tanks had been installed at a lower level than the cesspools and drains. Contaminated water leaking into the drains was the culprit. Snow set down his findings and privately published MCC before the end of August 1849. In the last paragraphs of this report he offered precautionary measures to reduce passing on the disease: scrupulous hand washing when tending a sufferer and the avoidance of any water which had not been filtered and boiled. He recommended no quarantine procedures, indicating that he saw no danger from normal human intercourse. As he had been advocating for years before this date, Snow recommended that the long term solution to the problem was that the city's water supplies must come from sources uncontaminated by the city's sewers.	
1852	LWC Opens at Seething Wells		
1852	Filtration at Seething Wells	[***Connection****:* The Lambeth Water Company had acted ahead of all the other water companies, and ahead of legislation, and moved the source of its supply out of the filthy tidal Thames into clean water above the Teddington Weir.]	

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		Section here about the engineers' contribution to cleaning water: improving the source, and continuing developments in filtration: filtration at Seething Wells (and Brixton Reservoir?)	
1853	The Grand Experiment	When the second cholera epidemic started ravaging London, John Snow started systematically collecting data to execute on what he called his "Grand Experiment". Circumstances had provided him with the conditions for this perfect natural experiment – a means to establish the effect of different qualities of water on people in the same population, to establish whether it is one source of water that carries the cholera. There was a population across South London who received water from the Lambeth Water Company and the Southwark & Vauxhall Water Company. The Lambeth had in 1852 started drawing water from Seething Wells, above the Teddington Weir that defines the limit of the tidal Thames, and therefore clean water very different from that sloshing back and forth in the Thames basin. Snow could contrast this with the customers of Southwark & Vauxhall, drinking water drawn from Battersea, in the midst of the Thames soup. The natural experiment was nigh perfect because all the other variables were the same across both populations of customers. They lived in the same street, but the alternating houses took water from the two different companies. They were the same kind of people – largely the relatively poor folk of London. In the perfect experiment – the *experimentum crucis*, a term Snow borrowed from the philosopher Francis Bacon in describing an earlier piece of work – all the variables bar one are evenly distributed across the two populations being tested; only one variable is different. If the two populations behave differently, then the cause must lie with this one crucial variable. John Snow knew he had this almost perfect natural experimental set-up given to him by the circumstance of the Lambeth Company moving to Seething Wells. Snow needed to establish which house was served by which water company, and he worked incredibly hard, walking door to door to ask. He was dismayed to find that many tenants either wouldn't answer of didn't know. He devised a clever work-around. He took to asking for a sample of water from each house. When he took the water back to his surgery and laboratory, he could apply a simple test – establish the level of salt in the sample. The Battersea water, drawn from the tidal Thames, was salty; the Seething Wells water was not. The results were not perfect, but they provided John Snow with the data that he needed. The results of the Grand Experiment were published in the 2nd edition of John Snow's famous work On the Mode of Communication of Cholera, but this did not happen immediately. Snow's	Vinten-Johansen p 199 - 212

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		systematic experimental work was interrupted by the epidemic – it arrived on his doorstep in Soho, forcing him into more immediate work and a parallel, more direct detective enquiry into the cause of cholera.	
1853-4	Epidemic 3: London The Broad Street outbreak The pump Baby Leiws	John Snow moved house as his medical practice started to prosper, but he stayed in the same neighbourhood, Soho, where he practise was based. Cholera followed him there – he was right on its doorstep when England was struck by its third epidemic, in 1853. The first sign of the illness around Golden Square, Soho, was when Sarah Lewis's five month old daughter fell ill with bad diarrhoea. The family lived in the back parlour of 40 Broad Street. The baby died on the 2nd September, and by then there was a stream of cholera cases being notified in the neighbourhood. Florence Nightingale, then superintending nurses at the Middlesex Hospital, had cholera patients "brought in every half hour from the Soho District, Broad Street, etc., … chiefly fallen women of the district." (in a letter from Mrs. Gaskell, quoted in Cecil Woodham-Smith Florence Nightingale, Penguin, 1955). John Snow became aware of the situation on Sunday September 3, and stepped in to determine what might be going on. He arrived with a prior hypothesis of what was likely to have been going on, based on his hands-on knowledge of cholera and the analysis he had done and published in MCC1. He looked at the pattern of death and disease that was already evident, and went straight to the Broad Street pump that evening and took samples of its water. In the succeeding days, the death toll in and around Broad Street climbed dramatically, and Snow started systematically visiting houses and asking about the source of water used for drinking in each house. He also obtained from the General Register Office, where William Farr presided – one of the first government statisticians – a list of cholera deaths that the Office was compiling weekly. Snow's other cholera researches in his "Grand Experiment" had to take a back seat for a while. Snow's new Broad Street researches broadly supported his initial hypothesis. 89 deaths from cholera were reported on the first list that Snow obtained, on September 5. Snow determined that 73 of those deaths were of people who lived nearer to the Broad Street pump than any other pump; 8 more were people who had special reasons to drink from that pump – children passing it on the way from school, people who liked the taste of this particular water, etc. Snow continued to build evidence to back his conviction that the Broad Street Pump was the	Vinten-Johansen Chapter 11 283 – 317 Vinten-Johansen 331

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		source, and this emboldened him to do something that seems a little out of character for this quiet man. He realised that the Board of Governors and Directors of the Poor of St. James' Parish was due to meet on Thursday 7th September, and, without introduction or summons, he insists on addressing their meeting. He told the startled gentlemen to take the handle off the pump at Broad Street. This was a group of men, at their wit's end with the cholera raging around them, whoneeded to do something, so they did what Dr. Snow proposed, even though it is unlikely that any one of them knew why it was a good thing to do. For John Snow, this was just a step on the way – his careful collection of data continues. At the same time as Snow was undertaking his one-man scientific study, Henry Whitehead, the local curate, was equally busy. His parishioners were dying all around him, and he was run ragged trying to help them but more or less powerless in the face of this devastation. Whitehead came to hear of Snow's researches, and initially formed an aversion to the man and his studies. He considered it unlikely that a doctor not known in many of the households would be getting either accurate or complete information, and Whitehead decided that with his intimate knowledge of his parish he could do better. He set out to show that Snow's obsession with the water supply was a red herring, and to draft his own pamphlet The Cholera in Berwick Street There were others active in researching this terrible outbreak. Edmund Cooper was working for the Commission of Sewers, keen to show that a rumour of cholera emanating from badly kept sewers was false. He produced a fine map showing that the drains belonging to houses tended to be bad; the sewers belonging to the Commission tended to be good. The Paving Board – employing a Mr. Farell – was commissioned by the Parish to examine to Broad Street Pump. He looked down the pump well and found no problem. Whitehead did, indeed have greater access to the residents than Snow, and was able to obtain fuller information. He also found himself working with Snow and the Parish Cholera Inquiry Commission. Whitehead found that his more detailed information was all pointing in exactly the direction of Snow's hypothesis. The two men became allies. They began to discover facts about the outlying data that confirmed the hypothesis. The widow Eley who died as a lone case in Hampstead had been drinking water from the Broad Street pump because her attentive sons brought it to her: she used to live there, and she like the taste. The family who thought they had always drunkdrank this pump water realized that they had not done so at the crucial time, because their daughter had had a cold and was unable to fetch it. And so	

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		on – there are lots of stories. On the 22nd April, Whitehead reopened the issue of the physical integrity of the pump. Farrell's investigations had seemed to give it a clean bill of health. But Henry Whitehead had been back to Sarah Lewis at 40 Broad Street, and listened to her tale of sluicing the baby's nappies into the cespit. Whitehead ordered a more thorough investigation – using Jehosaphat York, a surveyor. This time, they dug around the outside of the pump well, and found that the drain from the Lewis' cess pit ran less than three feet from the wall of the pump well. The brickwork of the drain was rotten; the drain leaked and the brick wall of the pump well was porous. Filthy water was seeping from cess pit to the pump well – here was "the smoking gun". The Broad Street episode added a whole new line of empirical weight to Snow's demonstration in On the Mode of Communicating Cholera (MCC2). Snow had another edition in preparation. In this edition, is the incredibly powerful map that shows the pattern of distribution of cholera deaths around the source of water-borne contamination – the Broad Street Pump. This map, often called the "Ghost Map" for its traces of the ghosts of cholera victims, is an early example of a very powerful tool in the armoury of the profession that John Snow more or less invented – the profession of epidemiology. But John Snow is not the inventor of the disease map; he is one of its early and powerful exponents. The line of reasoning generated from the experience of the cholera outbreak in Broad Street, and the dramatic exposure of the contaminating agent, is secondary to the major scientific innovation in MCC2: the systematic statistical analysis of two populations similar in all respects excepting in one crucial variable. That main scientific revelation was Snow's "Grand Experiment"	
1855	Publication: MCC2	The second edition of Snow's On the Mode of Communicating Cholera is the book on which Snow's claims on posterity rest. In this book he produces proof sufficient to any reasonable scientific standard of the fact that cholera infection is borne by some agent in fecalised water. This proof was not recognised at the time, but those people who overlooked Snow's scientific achievement in 1855, when they later came to recant and credit Snow with the pioneering work, went back to MCC2 as the moment of proof. In this book there are three separate strands of proof that Snow is able to weave together: • The direct identification of "the smoking gun" – the physical evidence of transport from the infected cesspit at 40 Broad Street to the well of the pump.	Vinten-Johansen 271-77

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		• One kind of demonstration that we would now call "epidemiological" – the pattern of infections raging across Golden Square. • Larger scale "epidemiology" that demonstrates that the difference between ingesting clean water (from Seething Wells) and fecalised water (from Battersea) is the crucial variable that delivers the argument about causation It is primarily this third line of argument on which Snow's lasting fame rests – he created the science of epidemiology.	
1855	Report to Parliament	In 1855 John Simon was offered the new post of Medical Officer to the Government. It was required that he relinquish his lucrative private medical practice. To this he agreed but retained his pathology and surgical positions at St. Thomas's Hospital. His mission from the first day was to turn the Government's full attention on the plight of the urban poor. His duties covered the full spectrum of Public Health, cholera being one part of a very wide responsibility. He needed to create a single Health Authority with considerable powers to make it effective in the face of daunting challenges. In 1854, even before entering the national administration, Simon had already formulated an extensive legislative plan. Under Simon's direction, there was developed a sophisticated discipline for data collection to support public health legislation over the key issues of Victorian city life. Simon was extremely effective in using official reports to change government legislation, as he was for most of his professional life in gaining the the ear of the Minister under whose direction he worked. On the topic of cholera, in 1856 Simon embarked on a report which would provide confirmation for the series of investigations started by Snow and followed later by Farr, using the statistical and investigative techniques devised by both these men and himself. Simon made the scope of his investigation deaths in both the 1848-9 and 1853-4 cholera epidemics. It covered a population of half a million South Londoners and it made the same comparison between households drawing water from Lambeth and Southwark & Vauxhall Water Companies as did Snow's pioneering study. Except for their water supplies, these communities experienced identical living environments. In 1848 both companies were drawing unfiltered water from the tidal Thames but by 1852,	Royston Lambert Sir John Simon pp 231-6, 244-8

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		Lambeth had moved its operations to the new site at Seething Wells. When the deaths from cholera were calculated and correlated with the sources of water from which those victims drank, the results strikingly demonstrated that when the Seething Wells water was consumed, the inhabitants no longer fell victim to cholera in anything like the same numbers. Comparing the water sources in the 1848 outbreak, there was little difference in the two water supplies' effect on death rates: in fact the Lambeth water, then drawn from by Westminster Bridge, was rather more dangerous than the S&V water. In the 1852 outbreak the difference was striking - S&V water was 3½ times more dangerous than the Lambeth water from Seething Wells (and Snow later pointed out that Simon's figures were actually even more damning than that). Thus Simon's 1856 Report of the last Two Cholera Epidemics of London, as Affected by the Consumption of Impure Water monumentally confirmed what Snow had argued from restricted evidence. The Report was confident and persuasive and drew considerable accolades from across Europe. Simon expressed embarrassment at this personalisation of praise. However, at the time Simon failed to mention Snow's groundbreaking work, replicated at scale in this study, Simon received accusations of arrogance and even plagiarism, and since. Simon did not address these complaints until 1861, when he made a statement in his annual report to the Privy Council handsomely acknowledging Snow's leadership in this field – sadly, after Snow's death..	
1856	Chelsea Water Company opens at SW site		
1856	Controversy at BMA	John Snow could be said to be a doctor's doctor: dedicated, quiet, not pushing himself forward. He pushed the arguments – and evidence – for the contagionist stance, as against the prevailing orthodoxy of miasmatism steadily and with scientific calm and detachment. The second edition of his famous work On the Means of Communication of Cholera was published by himself and did not make a big splash. But among a group of dedicated medical men in the 1850s it was hailed as a ground-breaking piece of work, pointing to the long-sought cause of cholera with overwhelming objective evidence. When the Government's Medical Officer, John Simon – a very different, urbane, polished, successful man – carried out a study on exactly the same lines, and did not mention Snow's work at all, Snow's colleagues were irate. This fury broke out in public, in the year after Simon's Report was laid before Parliament, in the normally staid setting of the Annual General Meeting of	Hempel, p 271 Association Medical Journal, archived with the BMJ, August 9, 1856, p 683 AMJ/BMJ Aug 23,1856

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		the British Medical Association, in response to a completely innocent presentation by a Dr. T. Bell Salter, on "A summary of our present knowledge of the laws of epidemics", which included a reference to the previous year's Report by the Medical Officer. Dr. Richardson is asked to give the vote of thanks, and he launches into an attack: "the discovery of the connection between water supply and cholera in no way belonged to the Board of Health, but exclusively to one of our own associates – Dr. John Snow*" [Hear, hear]* Drs. Lankester and Budd rise in their seats to add to the vociferous protest, and Dr. Budd is moved to write to the editor of the Association Medical Journal (precursor of the BMJ) a fortnight later to continue the battle.	
1861	Recognition of Snow - Simon's apology	It took John Simon several years to give a public acknowledgement of the priority of the work of Snow. This was in his Annual Report to the Privy Council of 1974, and when it came it was a fulsome tribute: "the late Dr John Snow, twenty-five years ago, had the great merit of forcing medical attention : an attention at first quite incredulous ...." The Lancet got in quicker with a, still belated, recognition of Snow's contribution; "the researches of Dr. Snow are among the most fruitful in modern medicine. He traced the history of cholera. We owe to him chiefly the severe induction by which the influence of the poisoning of water-supplies was proved. No greater service could be rendered to humanity than this; it has enabled us to meet and combat the disease, where alone it is to be vanquished, in its sources or channels of propagation .... Dr. Snow was a great public benefactor." There is, of course, a recognition here too of the contribution of the water supply from Seething Wells, without which neither Snow nor Simon could have carried out the work as they did.	Vinten-Johansen, p 394
1864	It is established that specific diseases are caused by specific microbes	Louis Pasteur (1822 -1895) was among the first to propose germ theory – the theory that individual germs cause individual diseases. He was the first to conduct defining experiments which proved that micro-organisms existed and could only grow if permitted access to a suitable growth medium. The medium, if isolated, could not generate micro organisms. Pasteur's discovery is the beginning of the end of the arc that spans from van Leeuwenhoek first seeing "animalcules" under a microscope to the end where the particular micro-organism that carries cholera is identified. Bracketed within that arc is the whole of our story of the discovery of	

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		the origins of cholera and of the vital importance of clean water such as the Lambeth Water Company secured at Seething Wells. Pasteur was a chemist who wrote his doctoral thesis on crystallography but his understanding of germs is what made him one of the most famous scientists in history. He did not just make scientific discoveries – he also developed practical medical procedures that benefited the world. Through his work on chicken cholera he developed immunisation, and vaccines .	
1867	Epidemic 4: East London – Old Ford Reservoir	The epidemic of 1866-67 was the last major invasion of the disease in the UK. It took place after Pasteur's new germ theory, which changed the scientific context dramatically, and it took place after John Snow's early death. Nevertheless,John Snow's name was almost more prominent in the response to this epidemic than had been the case in the earlier epidemics when he was alive. William Farr, the statistician and, hitherto, supporter of miasmatism and opponent of Snow's theories, became prominent in the investigation of causes in this epidemic, and he was assisted by Henry Whitehead. "It was the failure of the East London water company to protect its water supply, combined with the fact that its directors attempted to conceal its failure, that finally convinced Farr the campaigner of the critical role of polluted water in the propagation of cholera. On 27 June 1866, a laborer called Hedges and his wife both died of cholera, aged 46. The Hedges' water closet discharged into the River Lea at Bow Bridge, near the East London water company's reservoir at Old Ford. This should not have mattered, since the company had installed filter beds for its new covered reservoirs and supposedly isolated these reservoirs from its older uncovered reservoirs, which had pervious bottoms. Nevertheless, Farr observed the degree to which the outbreak was concentrated in the area served by the East London company, commenting that "The mortality is terrible just in the area of East London supply". The engine-eer of the company, Greaves, wrote to The Times on 2 August 1866 to refute the suggestion that contaminated water had been allowed to enter the drinking water supply: "not a drop of unfiltered water has for several years past been supplied by the company for any purpose". On 3 August Farr visited Old Ford and requested an analysis of the company's water. He observed that, though Greaves's letter to The Times had claimed that all its water was filtered, two customers of the East London company claimed that they had found eels in their water pipes. Farr also wrote to Joseph Bazalgette the same week about the possibility of waste	This is taken wholesale from the section on William Farr in the UCLA Faculty of Public Health Snow web-site http://www.ph.ucla.edu/epi/snow/farr/farr_eastlondon_a.html I have made some minor textual amendments. We may need to seek permission for using this source in this way.

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		entering the water supply. Since 1859 Bazalgette had been constructing the main drainage system which intercepted the sewage before it reached the Thames and conducted it to treatment works and outfalls at Barking and Plumstead, well beyond the metropolitan boundary. Most of the system was now in operation but Bazalgette replied to Farr: 'It is unfortunately just the locality where our main drainage works are not complete. The low-level sewer is constructed through the locality, but the pumping station at Abbey Mills will not be completed until next summer.... I shall recommend the Board to erect a temporary pumping station at Abbey Mill to lift this district sewage into the Northern outfall sewer. This can be accomplished in about 3 weeks.' In the same week that he wrote this letter, Bazalgette began to install a temporary pumping station to lift the sewage into the outfall and thereby protect the area from its own waste. In September, the number of deaths from cholera rapidly fell, but 29 customers of the East London company signed a "memorial" to the Board of Trade in which they alleged that their water supplies were being contaminated by water from the River Lea [41]. A Captain Tyler, who was appointed to report upon the matter, questioned the company's employees and discovered that on three occasions, in March, June and July 1866, a 24-year-old carpenter had admitted water to the company's closed reservoir (from which drinking water was drawn) from an old, uncovered reservoir which was vulnerable to contamination, in breach of the 1851 and 1852 Metropolis Water Acts. Tyler wrote: "a case of grave suspicion exists against the water supplied by the East London company from Old Ford". He estimated that 4363 deaths had occurred between 1 July and 1 September, of which 3797 had occurred in areas supplied only by the East London company and a further 264 in an area which it shared with the New River company. Thus 93% of deaths had occurred in areas supplied wholly or in part by the East London company [42]. Farr, whose own enquiries had been instrumental in exposing the company's attempts to conceal the truth, concluded that this was the means by which the infection had spread to other houses in the area and his anger, partly at the deaths which resulted and partly at the company's attempted deception, is reflected in the "Report on the cholera epidemic in England", which he appended as a supplement to the Registrar-General's 1866 annual report. Farr tabulated the death rates per thousand population in the three cholera outbreaks of 1849, 1854, and 1866, and drew attention to the fact that, in most of London's parishes, the 1866 epidemic had been by far the least deadly, the marked exceptions to this trend falling in seven East End parishes, all of which were supplied by the East London company, while three also received supplies from the New River	

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		company In the same report, he wrote of the debate on the roles of air and water in disease propagation and gave much more favorable consideration to Snow's theory than he had in the past	The last sentence comes from the follow-on web page in the ucla site farr_airworst
1883	The cholera bacillus is isolated	Germ theory, at last, provided scientists with a tangible agent and a mechanism to explain the patterns of infection that John Snow had, so long before, recognised as undoubtedly true, against the scepticism of almost the whole of his contemporary professional world. Robert Koch took Pasteur's germ theory into the particular world of cholera and isolated the cholera baccilus in 1884. John Snow made his deductions from epidemiological data, and was one of the first to do that. He knew there would be a mechanism, but the science did not exist in his day to isolate it. Robert Koch identified that mechanism. Koch was one of the most important and influential bacteriologists in history. He is credited with developing many innovative and fundamental laboratory techniques—some of which are still used today — and proving that micro-organisms caused anthrax, cholera, and tuberculosis. His work was essential in proving the germ theory of disease and that such diseases were contagious. Koch was also instrumental in applying the germ theory to public health and hygiene practices in order to prevent disease in his native Germany and elsewhere. He won the Nobel Prize for Physiology or Medicine in 1905, and received many other medals and honours during his lifetime and after his death. Koch developed many fundamental laboratory techniques that are still used today. One of his most important innovations was the use of solid media instead of liquid to prepare pure cultures of bacteria. Liquid media was easily contaminated by other germs, and colonies of bacteria became mixed up with each other. With solid media, colonies could be kept isolated. Koch first used ordinary sliced potatoes to grow his germs on, but later developed techniques using agar gelatine in Petri dishes. Koch also introduced microphotography of bacteria, made important	Wikipedia site on Robert Koch

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		strides in the techniques of bacterial staining. An Italian scientist Filippo Pacini discovered the cholera bacillus independently of and prior to Koch. He identified *Vibrio Cholerae* in 1854, but the scientific community ignored him, and it was not until Koch's (re)discovery that science really embraced the new understanding.	http://www.comfsm.fm/socscie/histchol.htm
1895	Vaccination developed	Waldemar Mordecai Wolff Haffkine (born 1860 in Odessa; died 1930, Switzerland) was a Russian Jewish bacteriologist, whose career was blighted in Russia because "he refused to convert to Russian Orthodoxy." He was also,in his youth, a member of a revolutionary organisation, Narodnaya Vola. Haffkine emigrated from Russia and worked at the Pasteur Institute in Paris, where he focussed his research on developing cholera vaccine. He produced an attenuated form of the bacterium. Risking his own life, on July 18, 1892, Haffkine performed the first human test on himself and reported his findings on July 30 to the Biological Society. Even though his discovery caused an enthusiastic stir in the press, it was not widely accepted by his senior colleagues, including both Mechnikov and Pasteur, nor by European official medical establishment in France, Germany and Russia. He decided to move to India where hundreds of thousands died from ongoing epidemics. At first, he was met with deep suspicion and survived an assassination attempt by Islamic extremists during the first year there (1893), but he managed to vaccinate about 25,000 volunteers, most of whom survived. After contracting malaria, Haffkine had to return to France. In his August 1895 report to Royal College of Physicians in London about the results of his Indian expedition, Haffkine dedicated his successes to Pasteur, who recently had died. In March 1896, against his doctor's advice, Haffkine returned to India and performed 30,000 vaccinations in	Wikipedia on Haffkine

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		seven months..	
?	Modern filtration techniques for clean water	*If there is a tale to tell on this topic, especially one that links into the technology used in the sewage treatment site in Berrylands, then this might be a nice way to rounds the timeline out.*	