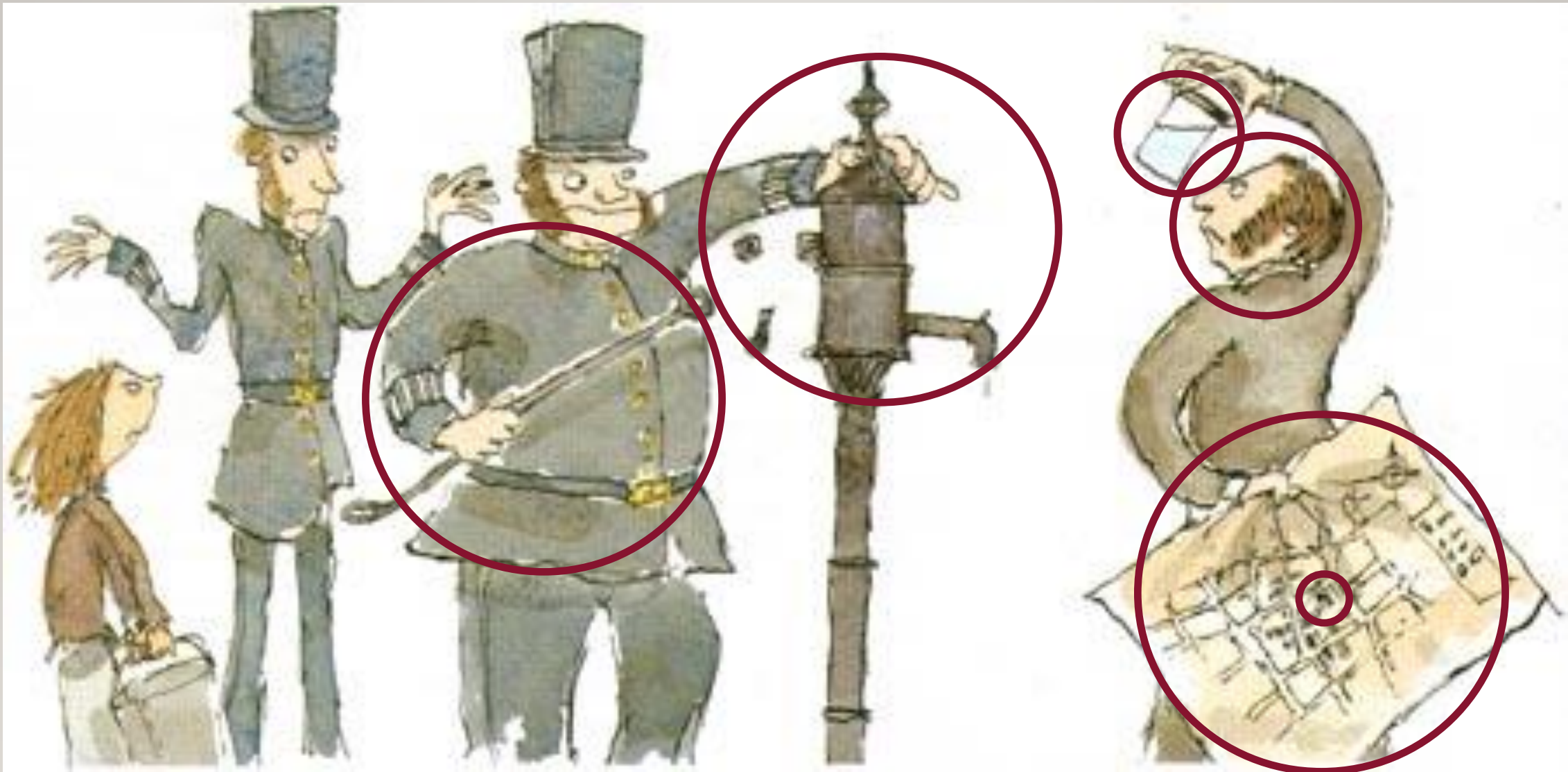


THE CHOLERA EPIDEMIC OF LONDON, 1854

THE STORY OF JOHN SNOW, HENRY WHITEHEAD, WILLIAM FARR, AND THE
PARTNERSHIPS THAT LAUNCHED THE MODERN ERA IN EPIDEMIOLOGY

SLIDES BY **MITCH STRACHAN** | **MATHEMATICS, CHAIR** | **SENIOR CLASS DEAN**
UNIVERSITY SCHOOL FOR BOYS, OHIO, USA
216.831.2200 X7474 | WWW.US.EDU



WHAT DOES IT TAKE TO MAKE YOU
WANT TO LEARN MORE ABOUT
SOMETHING?



HOW MY STORY CONNECTS TO THIS STORY...

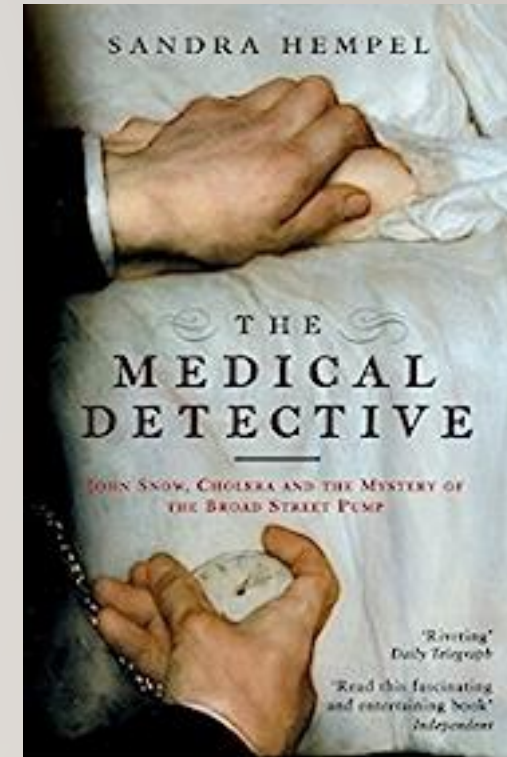
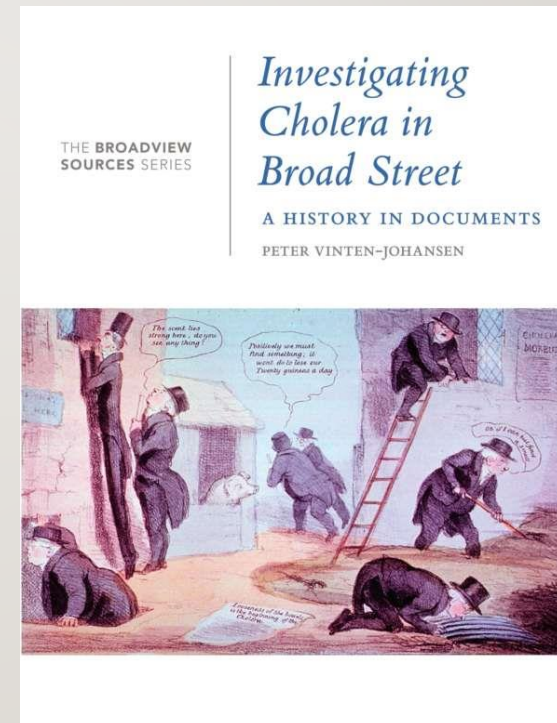
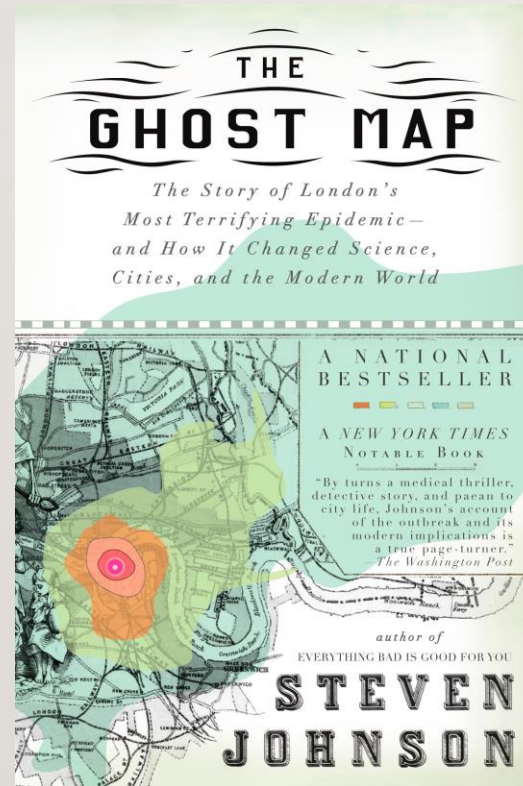
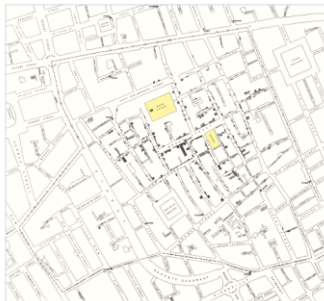
2. *Making quantitative comparisons.* The deep, fundamental question in statistical analysis is *Compared with what?* Therefore, investigating the experiences of the victims of cholera is only part of the search for credible evidence; to understand fully the cause of the epidemic also requires an analysis of those who *escaped* the disease. With great clarity, the map presented several intriguing clues for comparisons between the living and the dead, clues strikingly visible at a brewery and a workhouse (tinted yellow here). Snow wrote in his report:

There is a brewery in Broad Street, near to the pump, and on perceiving that no brewer's men were registered as having died of cholera, I called on Mr. Huggins, the proprietor. He informed me that there were above seventy workmen employed in the brewery, and that none of them had suffered from cholera—at least in severe form—only two having been indisposed, and that not seriously, at the time the disease prevailed. The men are allowed a certain quantity of malt liquor, and Mr. Huggins believes they do not drink water at all; and he is quite certain that the workmen never obtained water from the pump in the street. There is a deep well in the brewery, in addition to the New River water. (p. 42)

Saved by the beer! And at a nearby workhouse, the circumstances of non-victims of the epidemic provided important and credible evidence about the cause of the disease, as well as a quantitative calculation of an expected rate of cholera compared with the actual observed rate:

The Workhouse in Poland Street is more than three-fourths surrounded by houses in which deaths from cholera occurred, yet out of five-hundred-thirty-five inmates only five died of cholera, the other deaths which took place being those of persons admitted after they were attacked. The workhouse has a pump-well on the premises, in addition to the supply from the Grand Junction Water Works, and the inmates never sent to Broad Street for water. If the mortality in the workhouse had been equal to that in the streets immediately surrounding it on three sides, upwards of one hundred persons would have died. (p. 42)

Such clear, lucid reasoning may seem commonsensical, obvious, insufficiently technical. Yet we will soon see a tragic instance, the decision to launch the space shuttle, when this straightforward logic of statistical (and visual) comparison was abandoned by many engineers, managers, and government officials.





The John Snow Society @JohnSnowSociety · Dec 24, 2022

...

This week we welcomed Mitch Strachan, a maths teacher from Ohio as our newest member #4400! Mitch developed a class on the 1854 cholera outbreak, and is in London as recipient of the Seelbach award @UnivSchool. The JSS Steering Committee hosted him at the @LSHTM + The JS Pub 🍷🎄



THE SETTING

Victorian London, 1837-1901





A Court for King Cholera, 1852

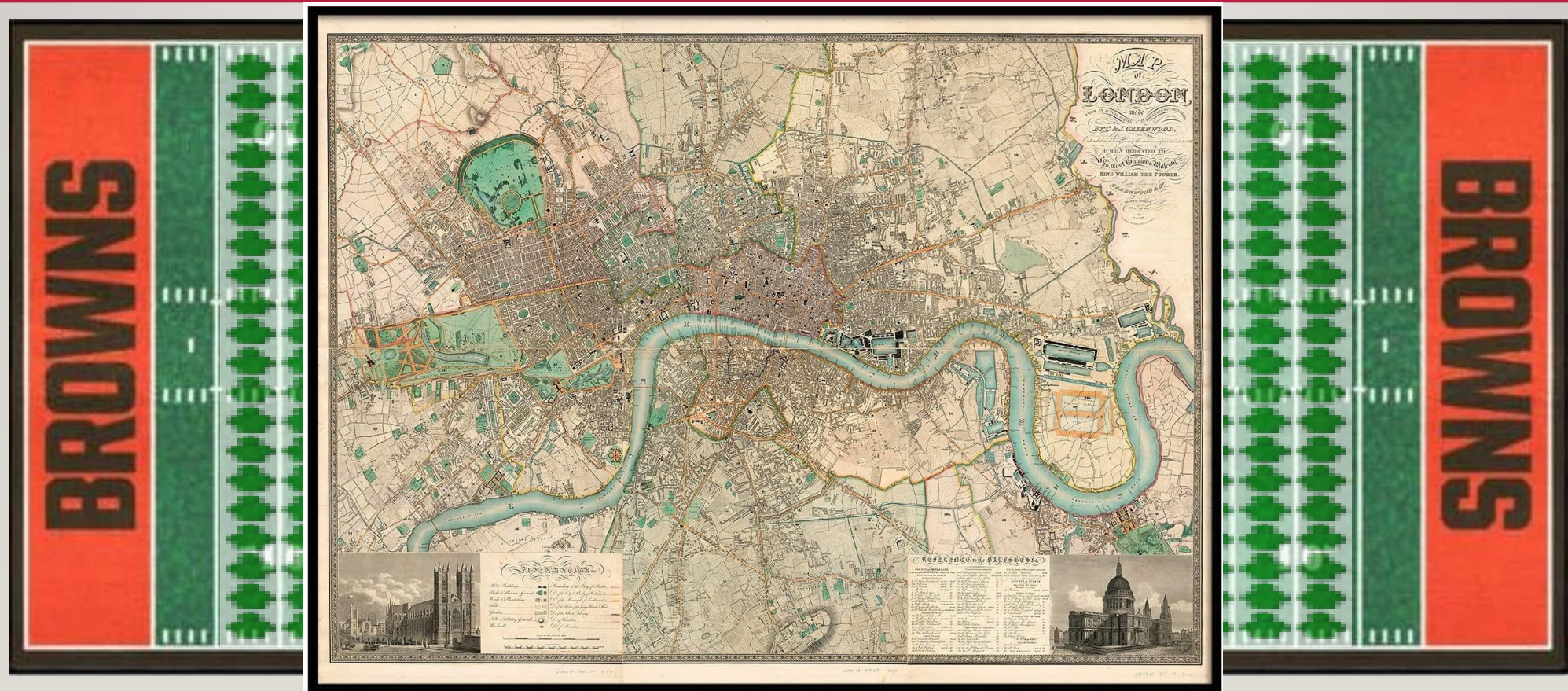
1854 LONDON: A CITY OF SCAVENGERS (OR RECYCLERS, DEPENDING ON YOUR PERSPECTIVE)

- Bone-pickers
- Rag-gatherers
- Pure-finders
- Dredgermen
- Mud-larks
- Sewer-hunters
- Dustmen
- Toshers
- Bunters
- Night-soil men

NIGHT SOIL MEN

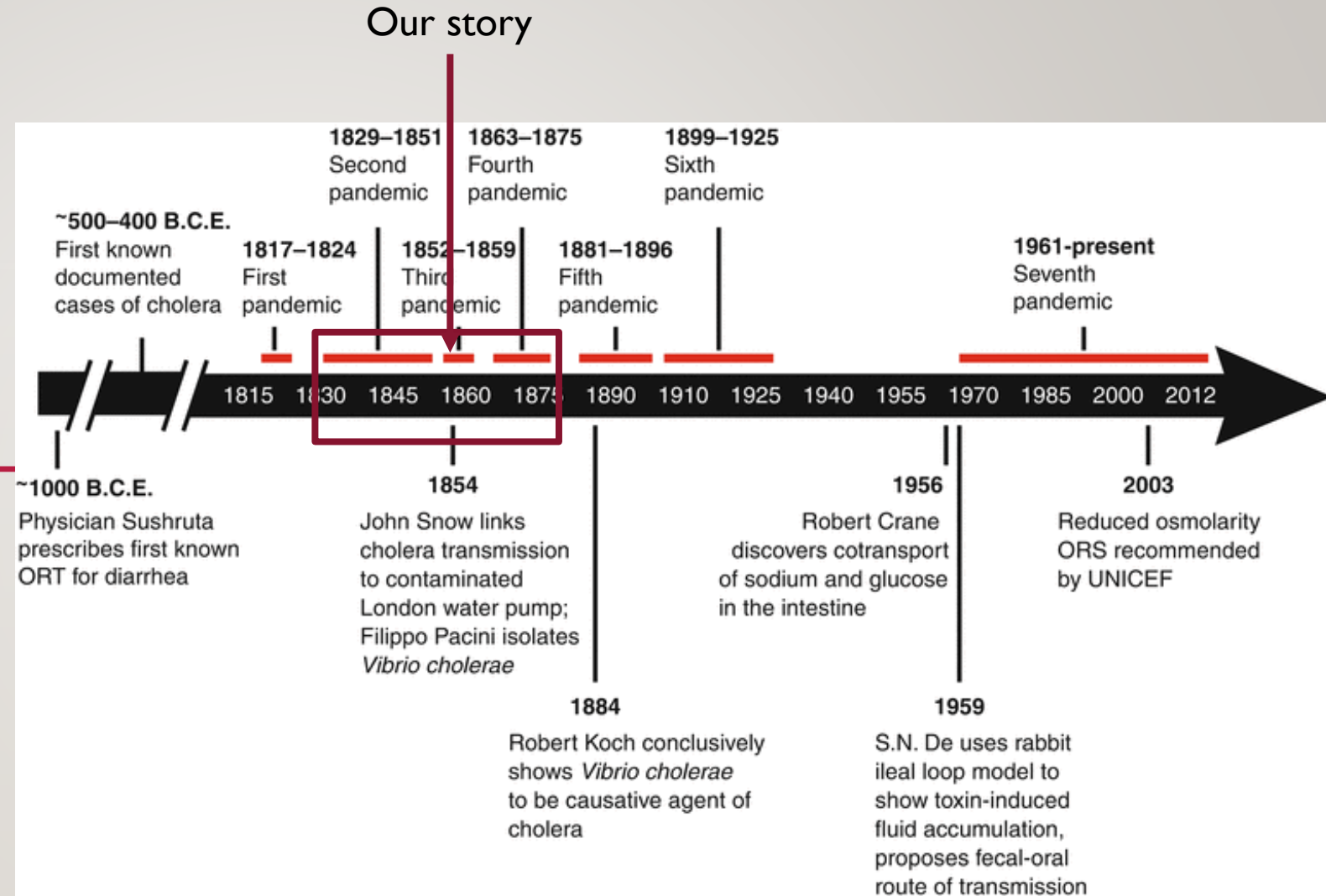


POPULATION DENSITY OF LONDON IN 1853

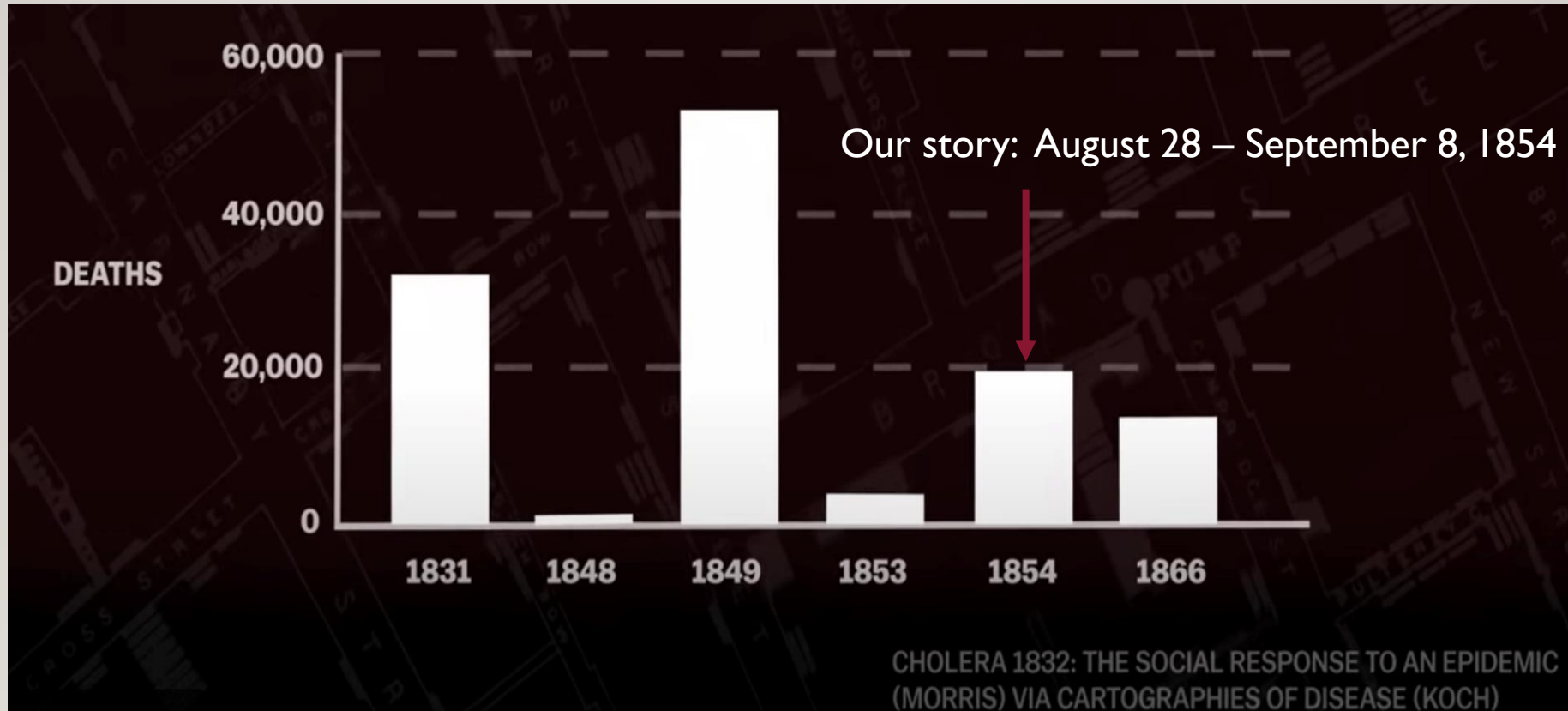


THE PROBLEM

CHOLERA TIMELINE



CHOLERA OUTBREAKS IN THE UK



AUGUST 28, 1854

40 Broad Street

Soho, London



THE REPLICA PUMP – FINALLY GETTING IT RIGHT



CHOLERA

WHAT DOES IT FEEL
LIKE TO HAVE
CHOLERA?



SWORD OF DAMOCLES

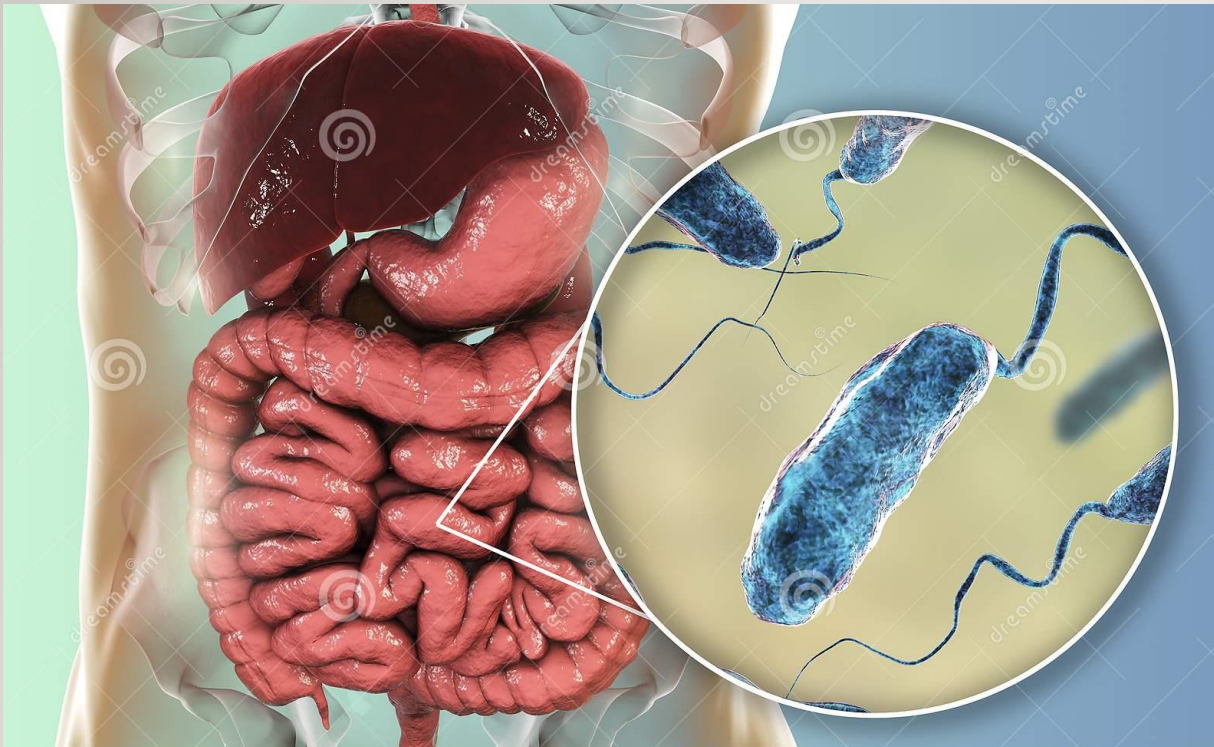
“To live in such a world was to live with the shadow of death hovering over your shoulder at every moment. To live was to be... not dead yet.”



EYES SUNK,
LIPS DARK BLUE.



HOW DOES CHOLERA WORK?



Vibrio cholerae bacteria and the small intestine

How cholera affects the body

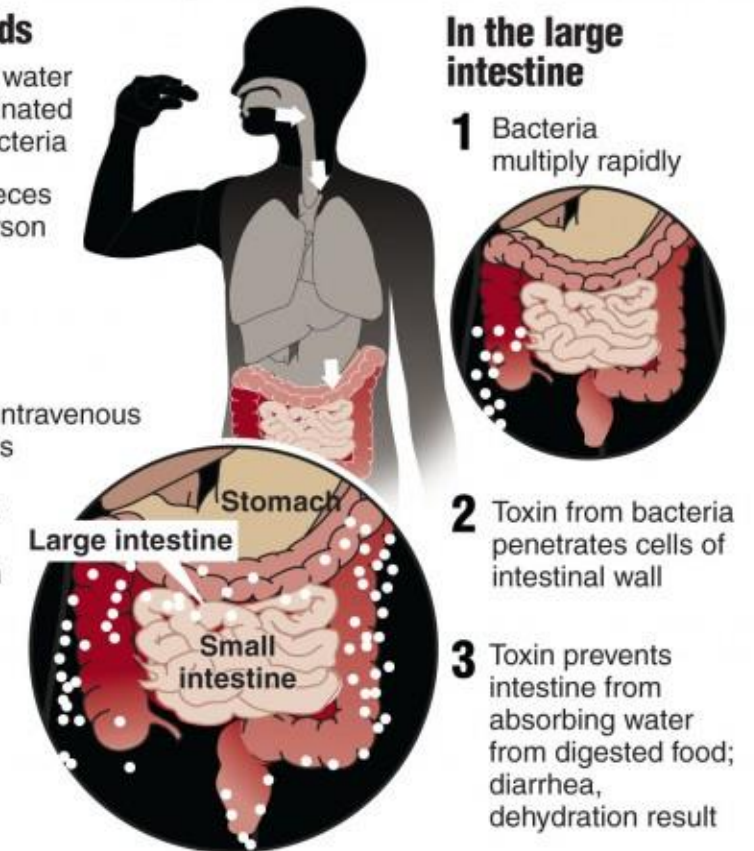
Cholera is an acute intestinal infection that causes severe diarrhea, dehydration and, if not treated promptly, death.

How it spreads

- People ingest water or food contaminated with cholera bacteria
- In epidemic, feces of diseased person is source of contamination

Treatment

- Salt solution, intravenous fluids, antibiotics
- In unprepared communities, death rates can be as high as 50 percent

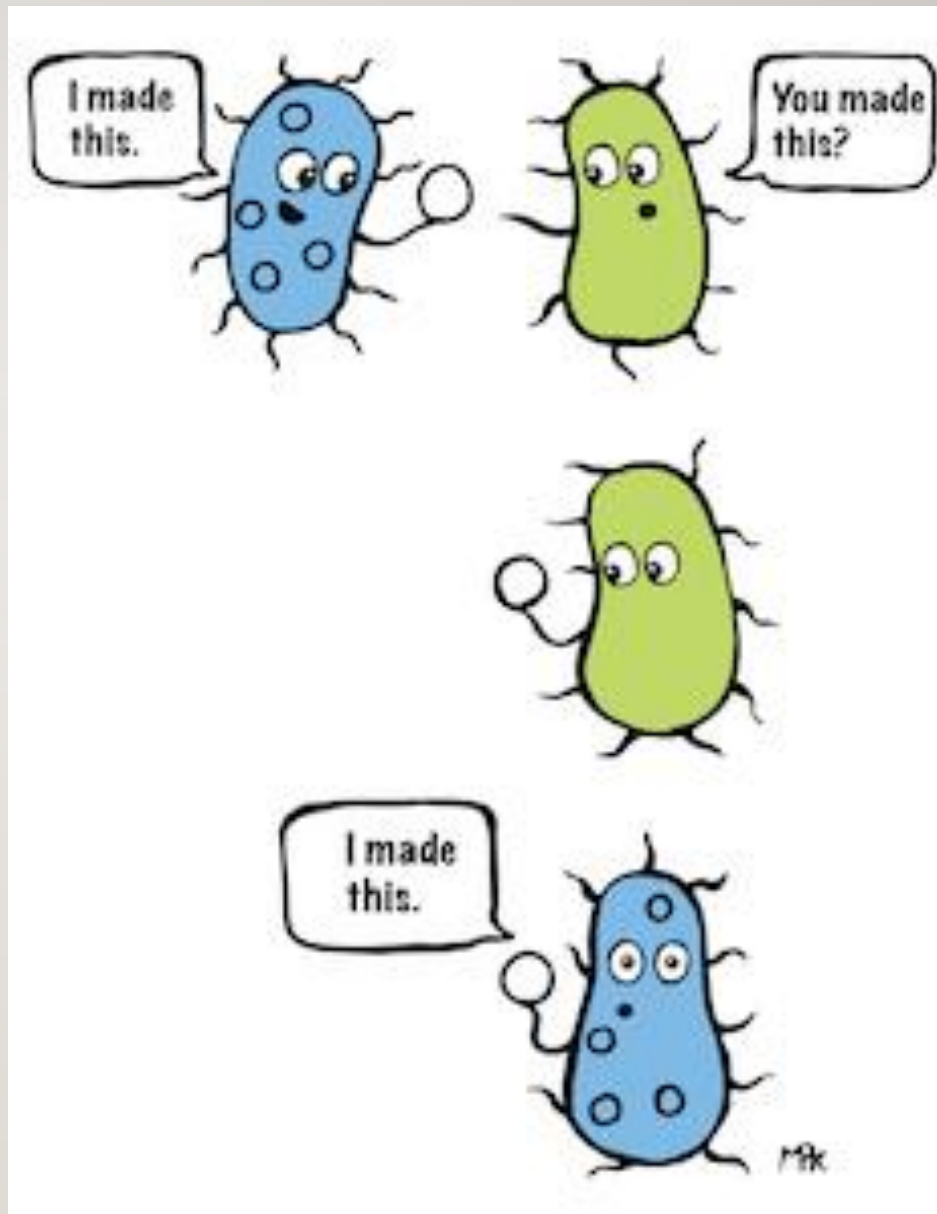


© 2010 MCT
Source: World Health Organization

MODERN DAY CHOLERA BEDS



BACTERIA'S MECHANISM FOR PASSING DNA



19TH CENTURY CHOLERA PREVENTION





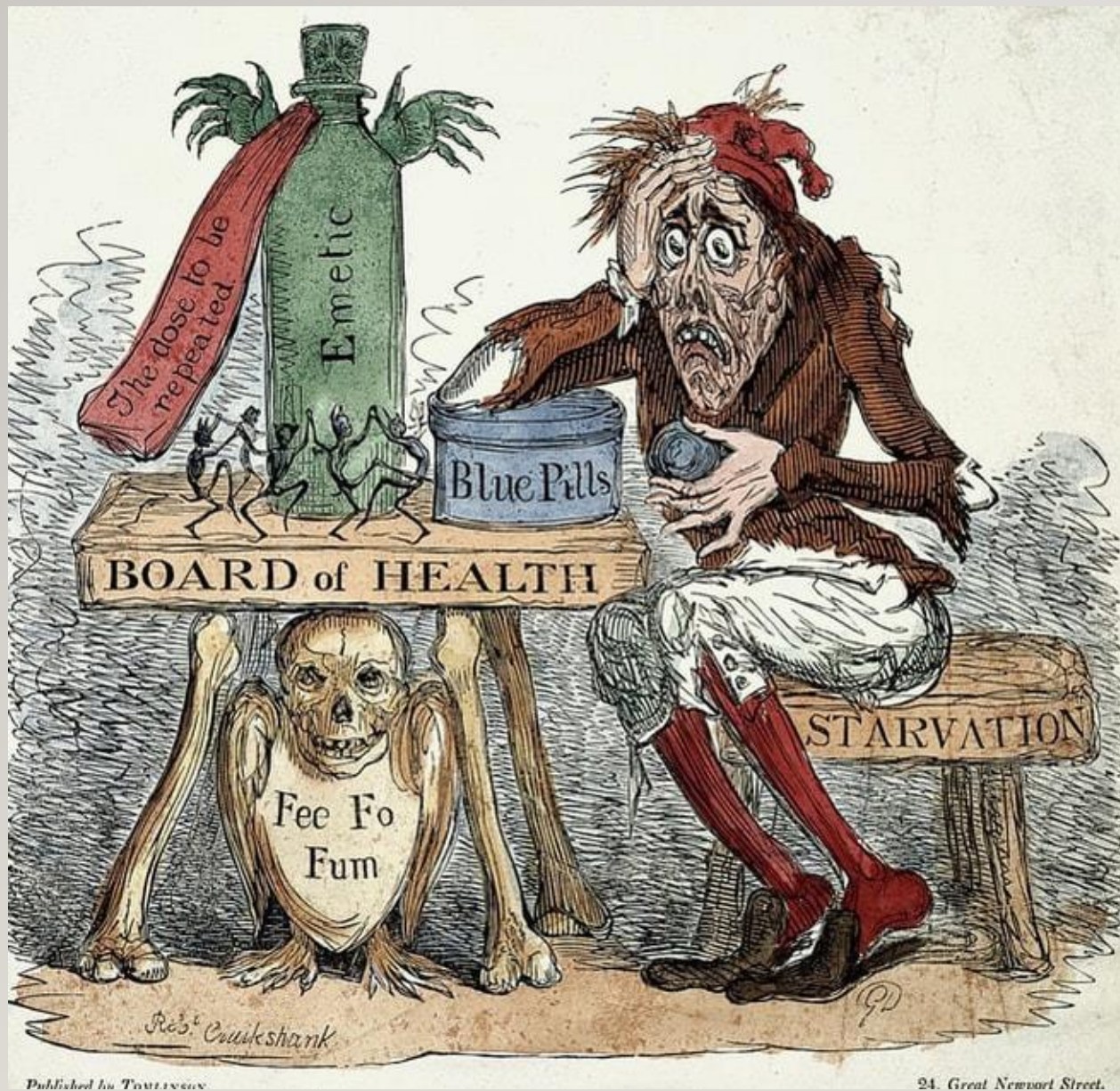
CHOLERA PREVENTIVE COSTUME.

 A full-page illustration on aged paper. A man in a blue cape, red vest, and top hat stands in a doorway. The doorway is framed by two tall, narrow structures made of stacked boxes. Above the doorway, a row of bottles is displayed on a shelf. To the left of the doorway, a red chair and a red bag are visible. The man is holding a small object in his right hand. The background shows a simple landscape with trees.

Die wohingerichtete Meier-Bauspottische für einen seine Gesundheit. bestehend

CHOLERA PRESERVATIVMANN.





THE RACIALIZATION OF DISEASE



CHOLERA TRANSMISSION

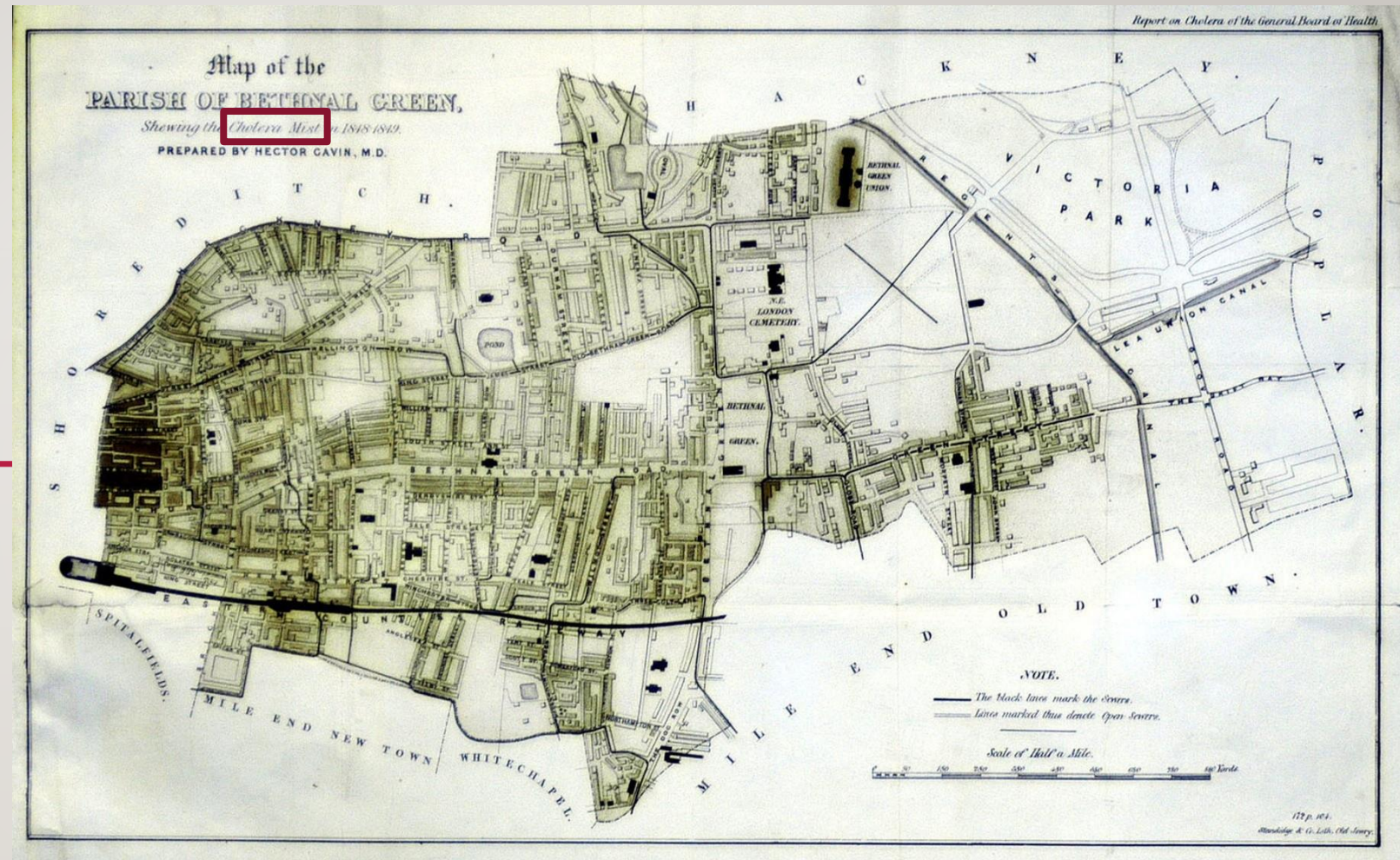


COMPETING THEORIES ABOUT THE TRANSMISSION OF CHOLERA

The Miasma Theory



CHOLERA MIST



COMPETING THEORIES ABOUT THE TRANSMISSION OF CHOLERA

Contagion/Waterborne Theory



ON THE MODE OF
COMMUNICATION OF
CHOLERA – 1849

Deaths from Sept.	ON THE MODE OF COMMUNICATION OF CHOLERA. BY JOHN SNOW, M.D. LONDON: JOHN CHURCHILL, PRINCES STREET, SOHO. MDCCCXLIX.	from Cholera Deaths in 1,000 inhabitants.
Districts of London.		
West .		77
North .		10
Central .		48
East . .		06
South .		95
Total .		83

MONSTER SOUP

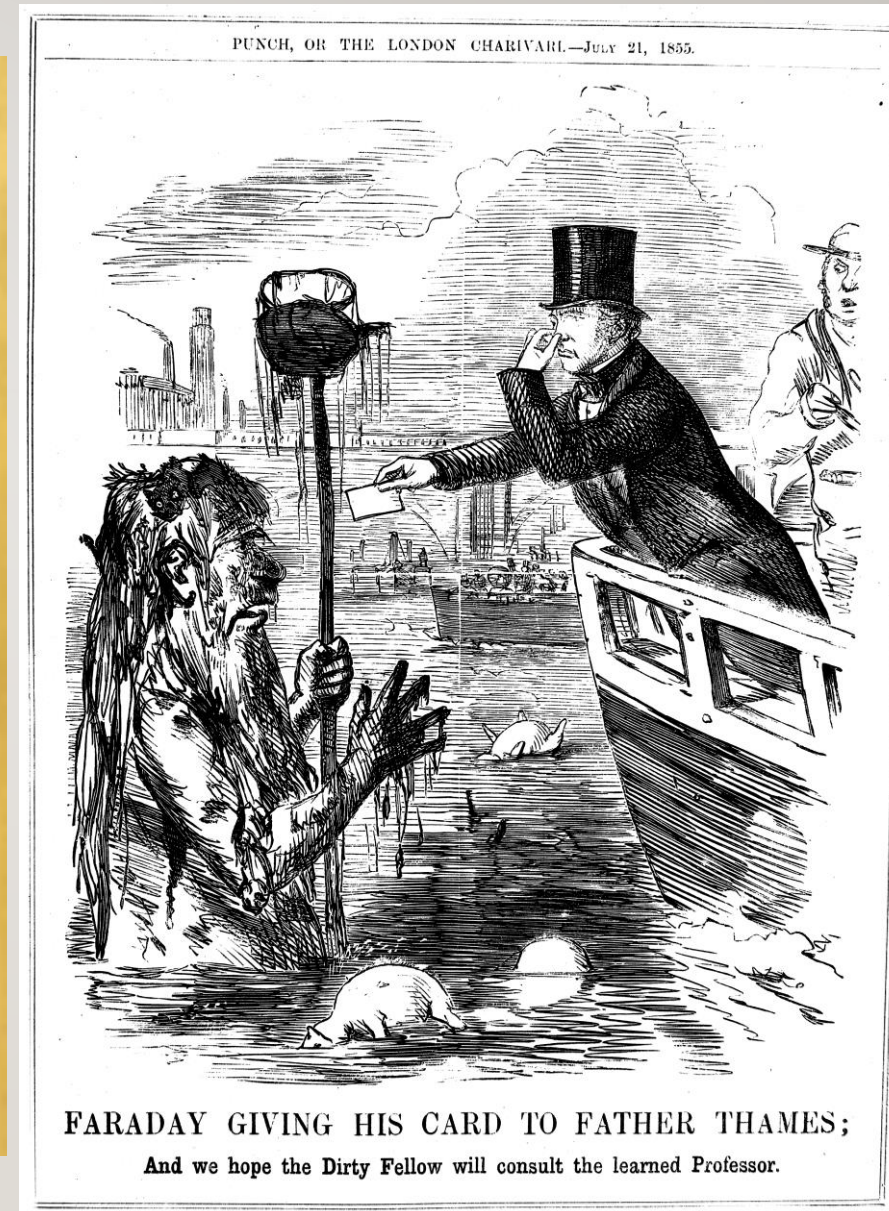
Commonly called
Thames water.



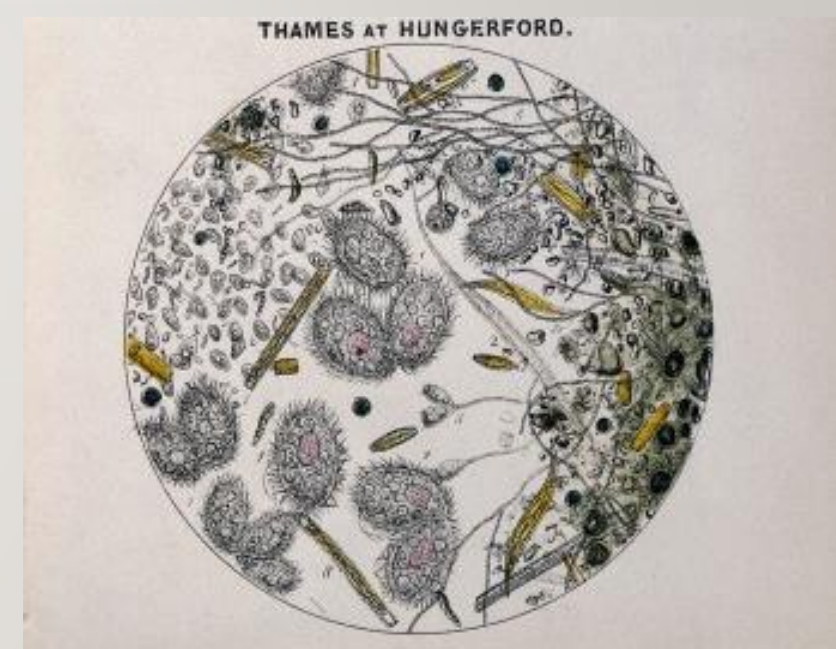
A DROP OF THAMES WATER



PUBLIC HEALTH ACT OF 1848 AND NUISANCE REMOVAL AND DISEASE PREVENTION ACT OF 1846



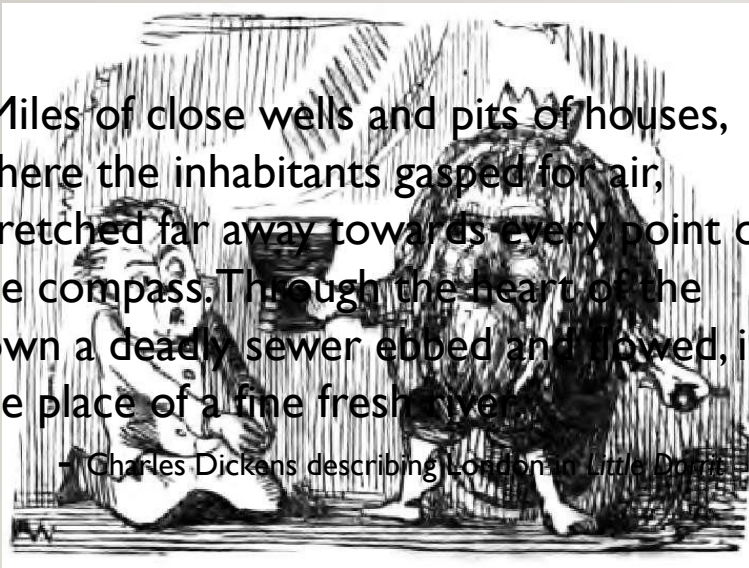
MICROSCOPIC EXAMINATION OF THE WATER SUPPLIED TO THE INHABITANTS OF LONDON, 1850



FATHER THAMES INTRODUCING HIS OFFSPRING TO THE FAIR CITY OF LONDON

“Miles of close wells and pits of houses, where the inhabitants gasped for air, stretched far away towards every point of the compass. Through the heart of the town a deadly sewer ebbbed and flowed, in the place of a fine fresh river.”

— Charles Dickens describing London in *Little Dorrit*



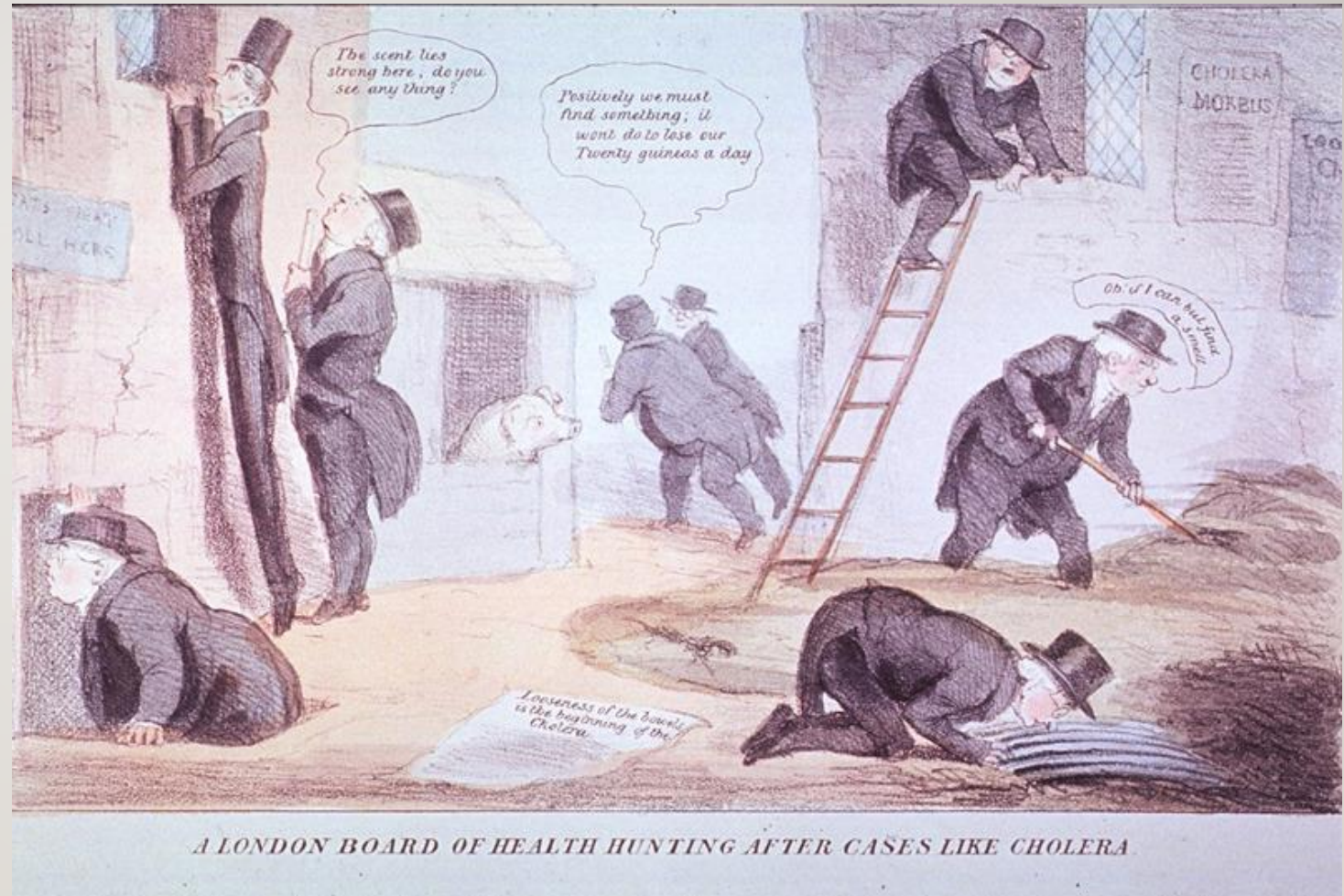
THE SILENT HIGHWAYMAN

Death rows on the Thames, claiming the lives of victims who have not paid to have the river cleaned up.



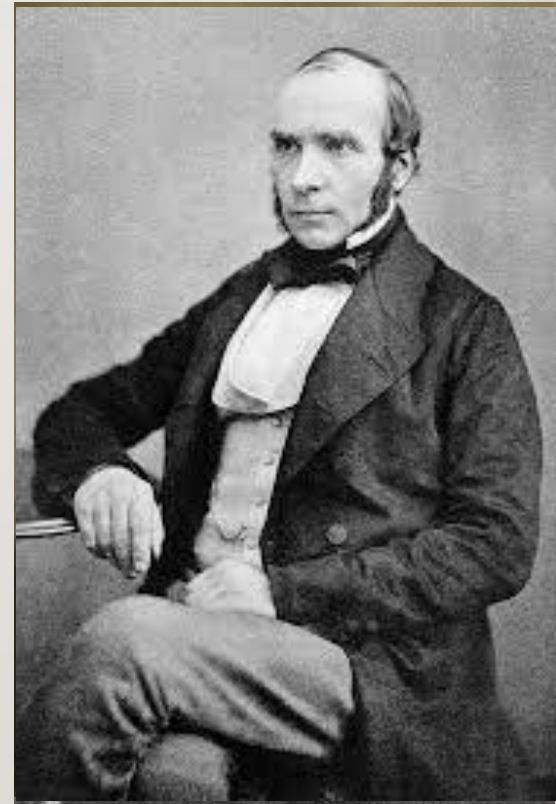
A LONDON BOARD OF HEALTH HUNTING AFTER CASES LIKE CHOLERA

“All smell is disease.”

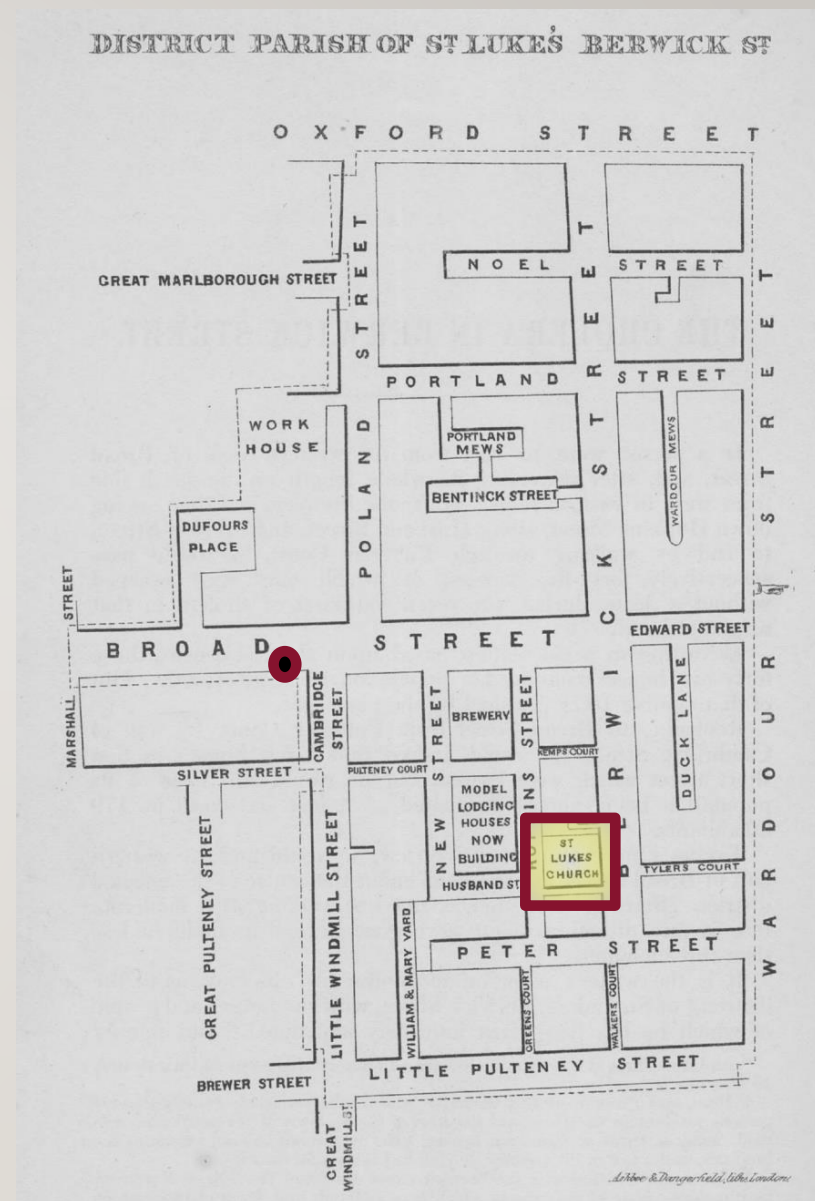
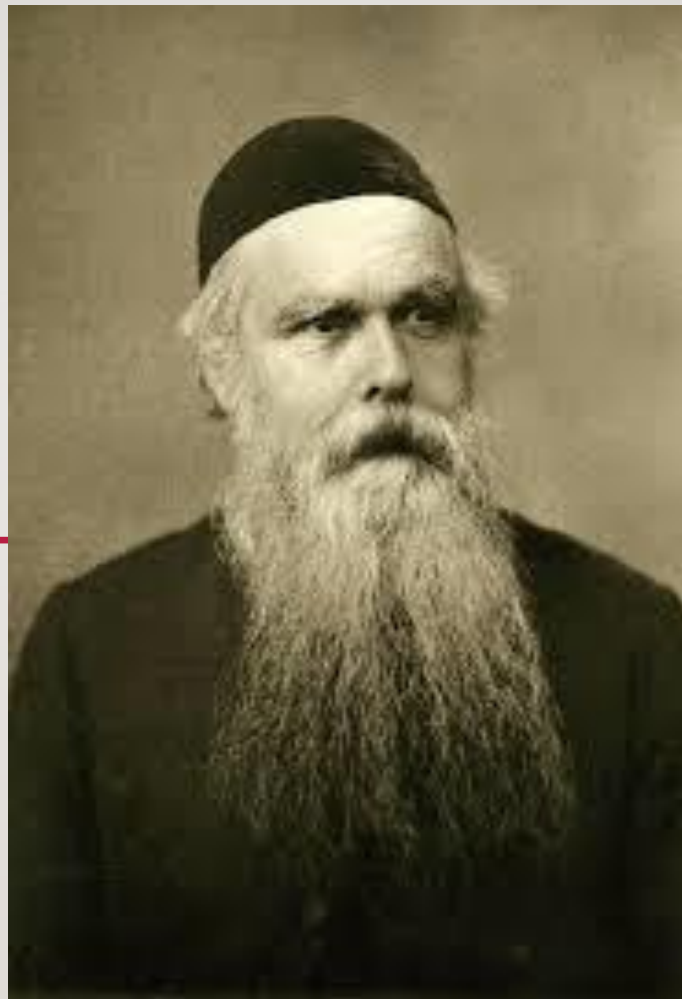


THE CHARACTERS

- John Snow
- Henry Whitehead
- William Farr
- Edwin Chadwick



HENRY WHITEHEAD



CHOLERA IN BERWICK STREET BY HENRY WHITEHEAD OCTOBER, 1854

Population of
September 1st,
fortnight, and 18
BROAD STREET
49; population,
burst, 84;† dea
side. Eleven h
were the six co

ence to the ma
side, 36.

DUFOUR'S P
houses without
mortality in thi

The streets

CAMBRIDGE

16; deaths on

house. Five h

LITTLE WIN

been expected

such was not

26; deaths on

escaped; east,

PULTENEY C

Street), 9; pop

a very small o

NEW STREET

deaths, 10. C

HUSBAND ST

HOPKINS ST

deaths, 13, of

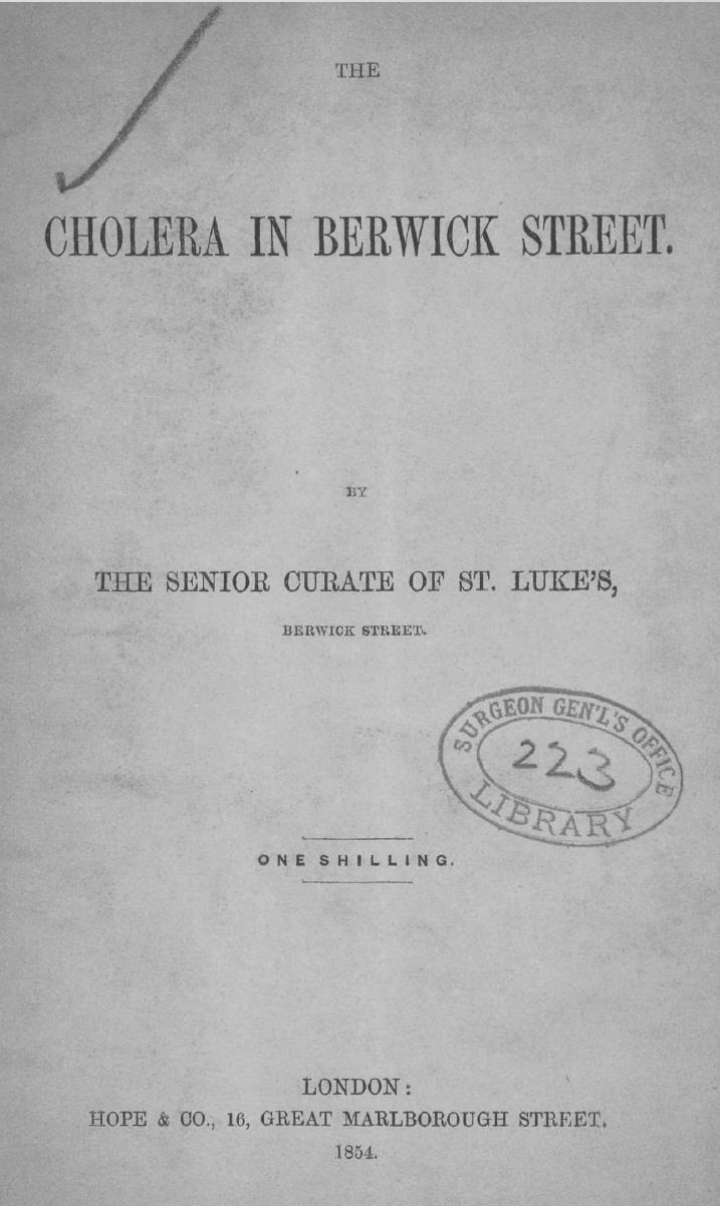


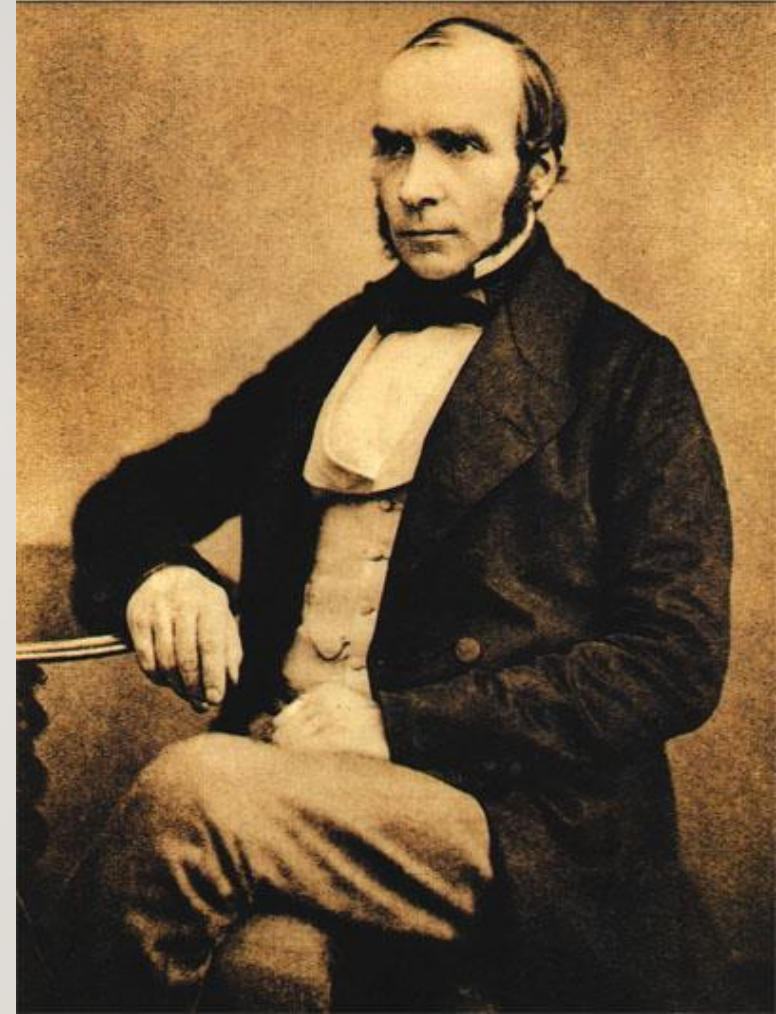
TABLE OF DURATION OF ILLNESS.											
Hours.	SEPT. 2nd.	Deaths.	Hours.	SEPT. 3rd.	Deaths.	Hours.	SEPT. 4th.	Deaths.	Hours.	SEPT. 5th.	Deaths.
10 & under	—9		10 & under	—1		10 & under	—2		10 & under	—4	
10 to 20	—23		10 to 20	—14		10 to 20	—11		10 to 20	—8	
20 to 30	—6		20 to 30	—8		20 to 30	—4		20 to 30	—2	
30 to 40	—2		30 to 40	—1		30 to 40	—2		30 to 40	—0	
40 to 48	—7		40 to 50	—4		40 to 50	—3		40 to 50	—1	
			50 to 80	—3		50 to 80	—3		50 to 80	—2	
									80 to 100	—1	
Average			Average			Average			Average		
20 hours.			28 hours.			37 hours.			Average 28 hrs.		

Following table of the daily rate of mortality among the inhabitants of St. Luke's is made from the Registrar's

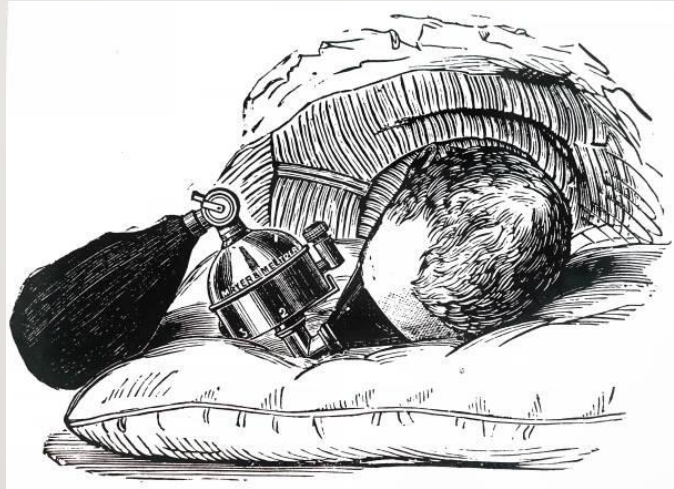
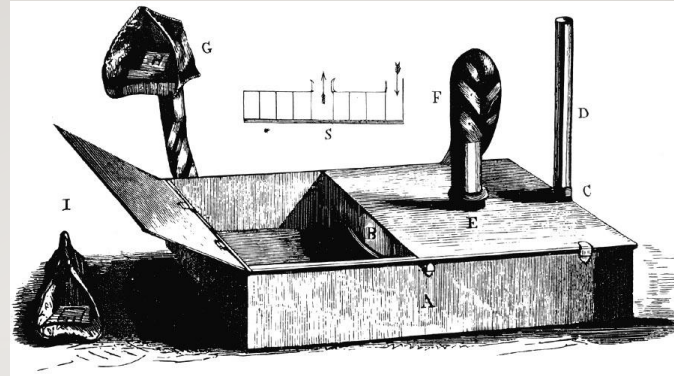
	Deaths.	Date.	Deaths
9th to 30th)	. 0	September 4th	. 43
30th	. 1	„ 5th	. 23
31st	. 1	„ 6th	. 21
1st	. 42	„ 7th	. 17
2nd*	. 63	„ 8th	. 16
3rd	. 41	„	

s in or from Kitchens	. . .	13
„ Houses and Cottages, with no floor above the 1st	. . .	9
„ Ground floor	. . .	60
„ First floor	. . .	100
„ Second floor	. . .	114
„ Third floor	. . .	73
„ Workhouse	. . .	4
Total	. . .	373

JOHN SNOW



A PIONEER IN ANESTHESIA



A FATHER OF MODERN EPIDEMIOLOGY

Who gets sick and why.

“upon”
epi*dem*iology
“people”

“study”



ON THE MODE OF COMMUNICATION OF CHOLERA

ON THE
MODE OF COMMUNICATION
OF
CHOLERA.

BY
JOHN SNOW, M.D.

LONDON:
JOHN CHURCHILL, PRINCES STREET, SOHO.
MDCCCXLIX.

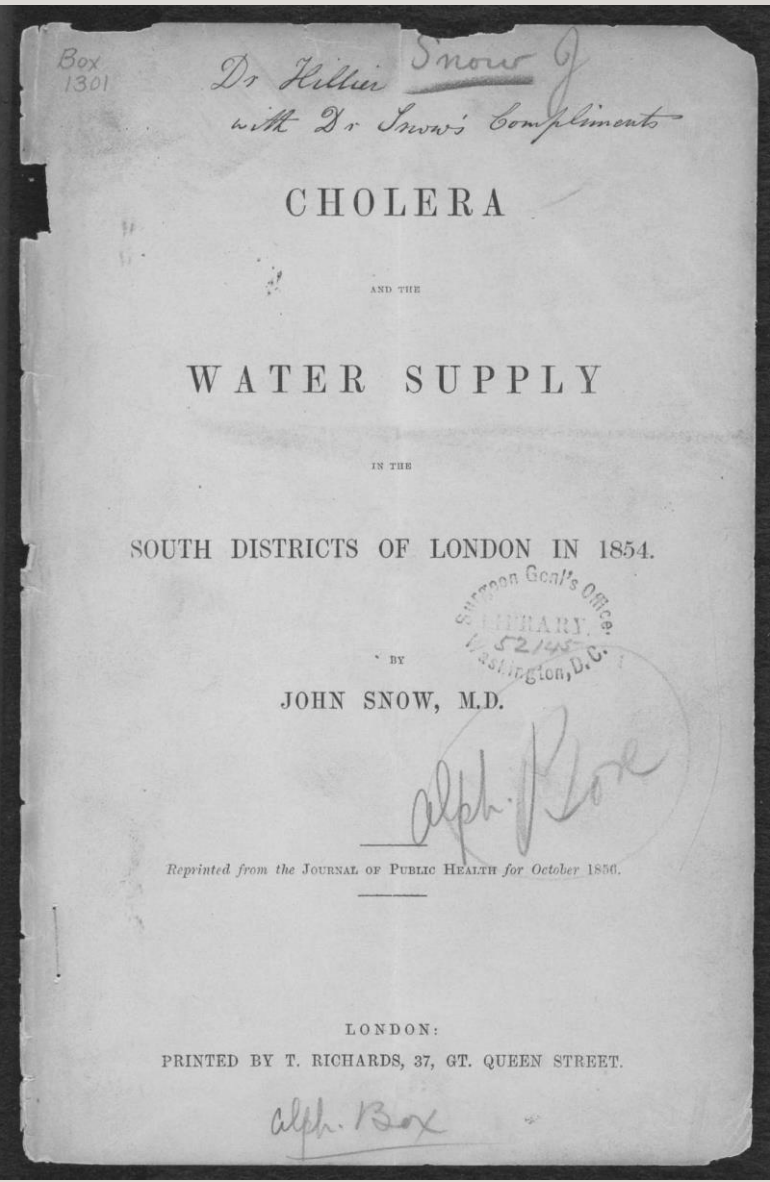
ON THE
MODE OF COMMUNICATION
OF
CHOLERA.

It is not the intention of the writer to go over the much debated question of the contagion of cholera. An examination of the history of that malady, from its first appearance, or at least recognition, in India in 1817, has convinced him, in common with a great portion of the medical profession, that it is propagated by human intercourse. Its progress along the great channels of that intercourse, and the very numerous instances, both in this country and abroad, in which cholera dates its commencement in a town or village previously free from it to the arrival and illness of a person coming from a place in which the disease was prevalent, seem to leave no room for doubting its communicability.

It is quite true that a great deal of argument has

SNOW'S "GRAND EXPERIMENT"

Who supplies your water?

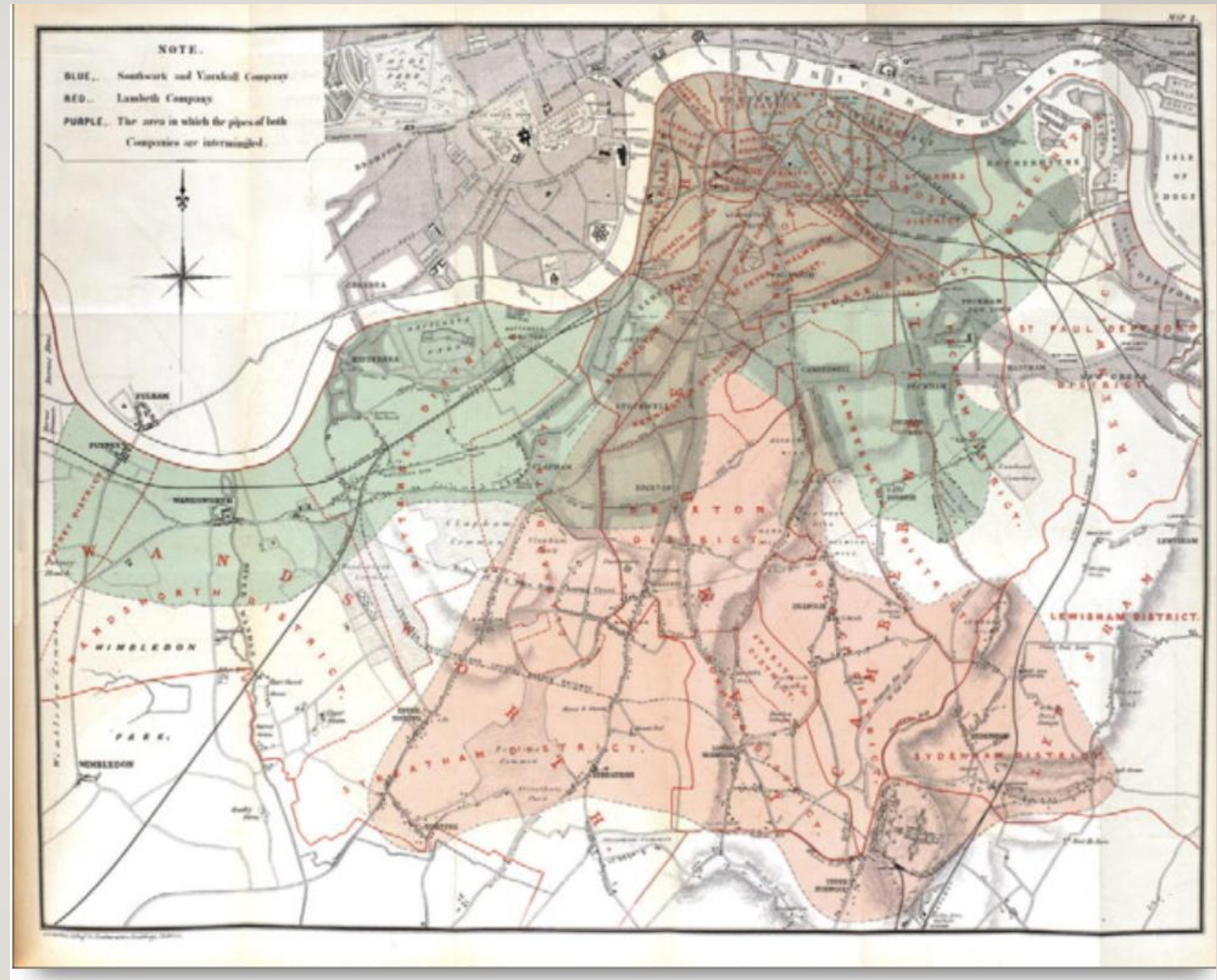


IN THE SOUTH DISTRICTS OF LONDON.													13
Registration Districts.	Registration Sub-Districts.	Population in 1851.	Population in 1854.	Estimated constant population per house.	Number of inhabited houses in 1851.	Number of houses supplied in 1854 with water as under.		Deaths from cholera in first seven weeks of epidemic of 1854.		Mortality per 1000 supplied with water as under.	Southwark and Vauxhall Co.	Lambeth Co.	
						By the Lambeth Waterworks Co.	By the Southwark and Vauxhall Co.	Population.	No. of houses.				Population.
Newington	1. Christchurch	16,022	16,022	85	1,887	343	2,015	1,557	13,354	11	13	377	99
	2. Kent Road	18,126	18,126	71	2,558	1,779	12,030	563	3,907	52	7	37	125
	3. Berong Road	17,802	17,802	77	2,309	1,176	8,397	878	6,072	91	7	37	125
	4. London Road	17,802	17,802	77	2,309	1,176	8,397	878	6,072	91	7	37	125
	5. Trinity	20,922	20,922	65	3,265	1,539	3,872	1,539	11,407	52	0	29	73
	6. St. Peter, Waltham	29,861	29,861	01	3,461	1,032	1,372	1,372	11,407	52	0	29	73
	7. St. Peter, Waltham	29,861	29,861	01	3,461	1,032	1,372	1,372	11,407	52	0	29	73
	8. St. Mary	16,083	16,083	01	2,369	1,183	1,183	1,183	10,754	84	4	0	38
	9. Waterloo, part 1	17,298	17,298	81	1,729	1,468	81	489	2,953	899	5,454	19	64
	10. Waterloo, part 2	17,298	17,298	81	1,729	1,468	81	489	2,953	899	5,454	19	64
Lambeth	1. Lambeth church, pt 1	24,541	24,541	75	4,341	18,348	84	804	7,171	1,510	12,593	25	8
	2. Lambeth church, pt 2	24,541	24,541	75	4,341	18,348	84	804	7,171	1,510	12,593	25	8
	3. Lambeth church, pt 3	24,541	24,541	75	4,341	18,348	84	804	7,171	1,510	12,593	25	8
	4. Kennington, part 1	3,977	3,977	01	3,977	3,977	444	1,154	7,868	2,589	10,623	34	13
	5. Kennington, part 2	3,977	3,977	01	3,977	3,977	444	1,154	7,868	2,589	10,623	34	13
	6. Kennington, part 3	3,977	3,977	01	3,977	3,977	444	1,154	7,868	2,589	10,623	34	13
	7. Brixton	3,902	3,902	01	3,902	3,902	1,410	310	1,922	1,000	5,555	2	5
	8. Norwood	3,902	3,902	01	3,902	3,902	1,410	310	1,922	1,000	5,555	2	5
	9. Wandsworth	3,902	3,902	01	3,902	3,902	1,410	310	1,922	1,000	5,555	2	5
	10. Wandsworth	3,902	3,902	01	3,902	3,902	1,410	310	1,922	1,000	5,555	2	5
Camberwell	1. Putney	9,118	9,118	63	1,322	9,611	63	144	907	15	94	1	0
	2. Streatham	9,118	9,118	63	1,322	9,611	63	144	907	15	94	1	0
	3. Dulwich	9,118	9,118	63	1,322	9,611	63	144	907	15	94	1	0
	4. St. George	9,118	9,118	63	1,322	9,611	63	144	907	15	94	1	0
Lewisham	1. Sydenham	15,849	15,849	56	2,945	15,849	56	707	4,293	971	5,437	30	9
	2. Sydenham	15,849	15,849	56	2,945	15,849	56	707	4,293	971	5,437	30	9
Totals		47,348	47,348	686	16,088	107,290	20,554	141,901	507	98	10	20	7

LONDON WATER SUPPLY

“It is beyond dispute that...a portion of the inhabitants of the metropolis are made to consume in some form or other, a portion of their own excrement and, moreover, to pay for the privilege.”

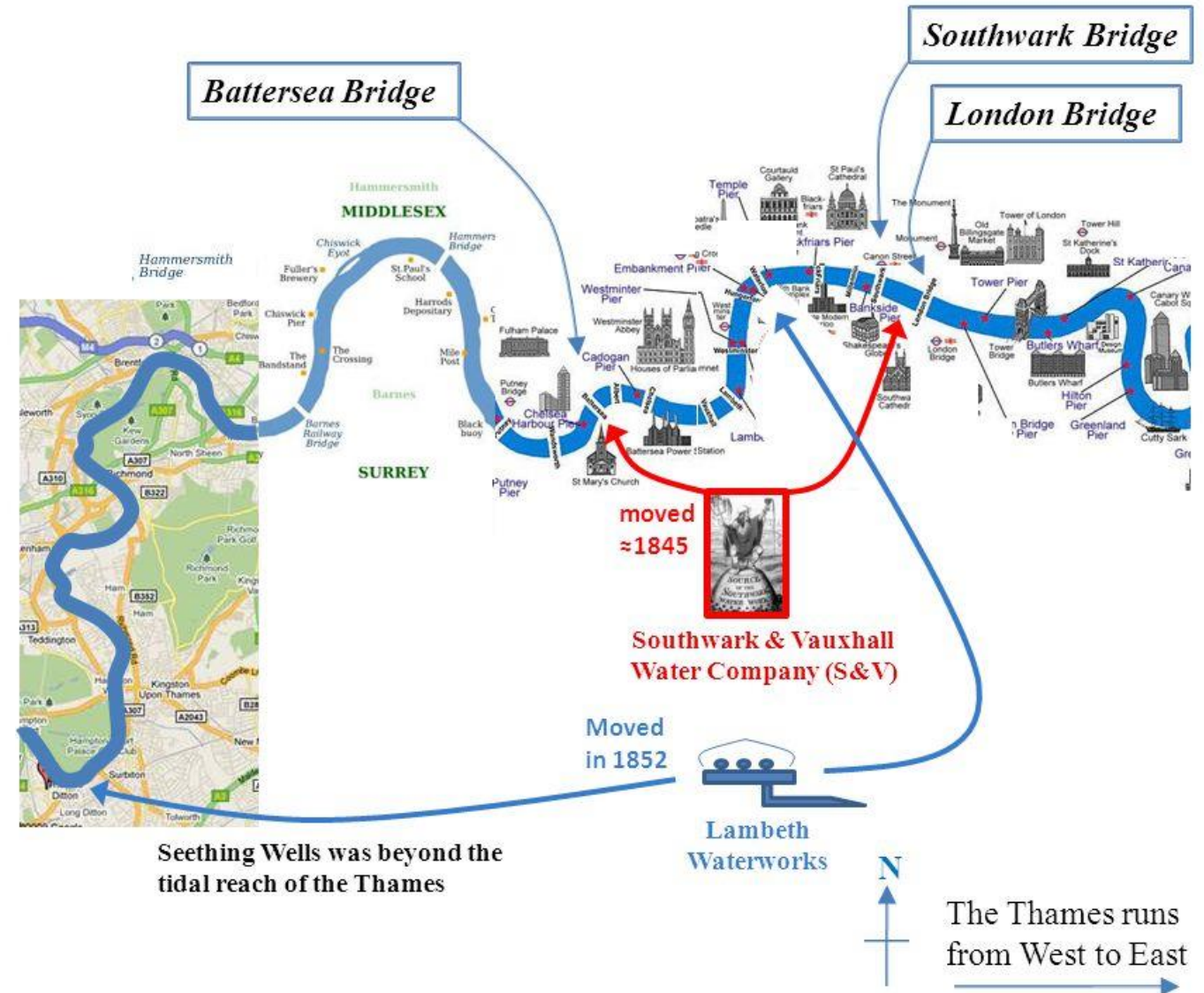
- Arthur Hill Hassall, microscopist, 1850



SOUTHWARK & VAUXHALL WATER COMPANY VS. LAMBETH WATERWORKS

TABLE IX.

	Number of houses.	Deaths from Cholera.	Deaths in each 10,000 houses.
Southwark and Vauxhall Company	40,046	1,263	315
Lambeth Company	26,107	98	37
Rest of London	256,423	1,422	59



SOURCE OF THE SOUTHWARK WATER WORKS



THE LANCET – JUNE 23, 1855

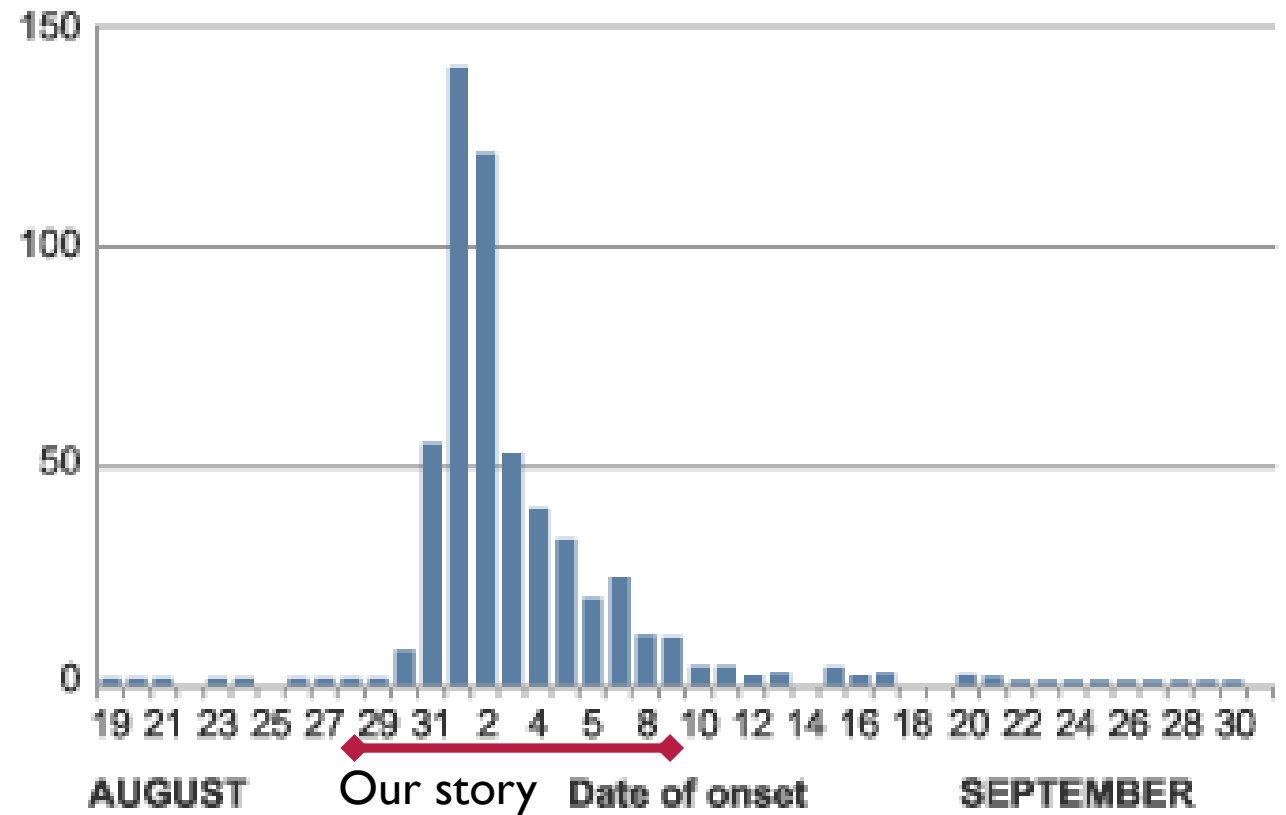
The fact is, that the well whence Dr. SNOW draws all sanitary truth is the main sewer. His den is a drain. In riding his hobby very hard, he has fallen down through a gully-hole and has never since been able to get out again. And so there we leave him.

TIMELINE OF EVENTS

August 29 – September 8, 1854

DAILY FATAL CASES OF CHOLERA NEAR GOLDEN SQUARE

August 19 – September 30, 1854



AUGUST 28, 1854

40 Broad Street

Soho, London



THURSDAY,
AUGUST 31

- 98 degrees F
- 200 people died of cholera within hours

FRIDAY,
SEPTEMBER 1

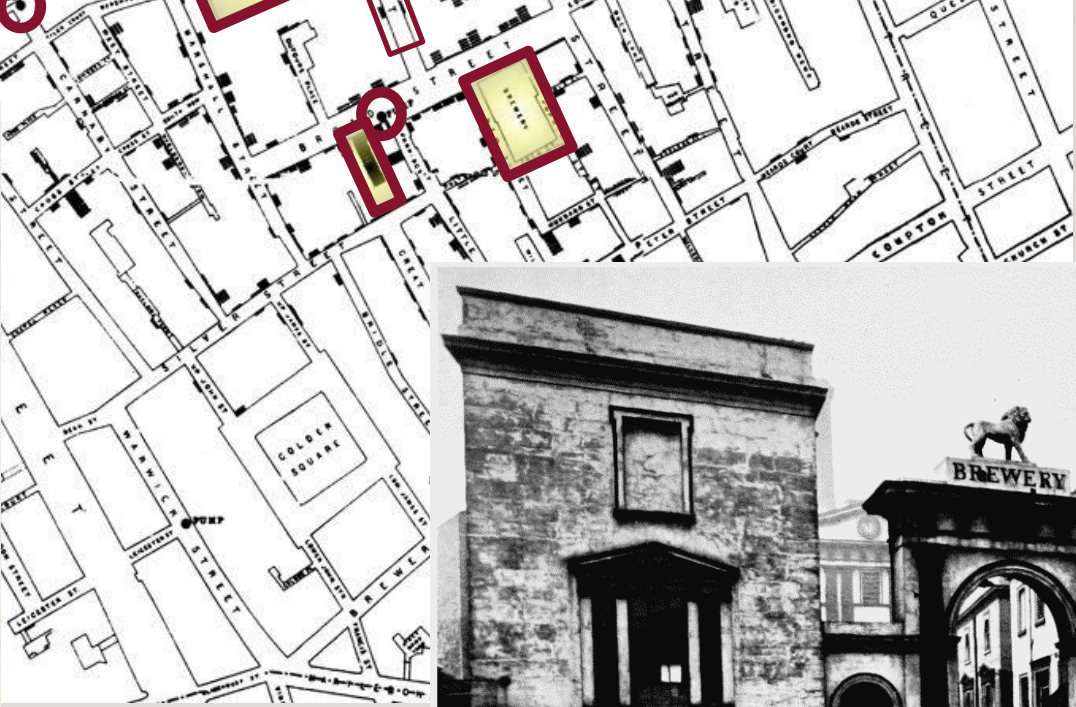
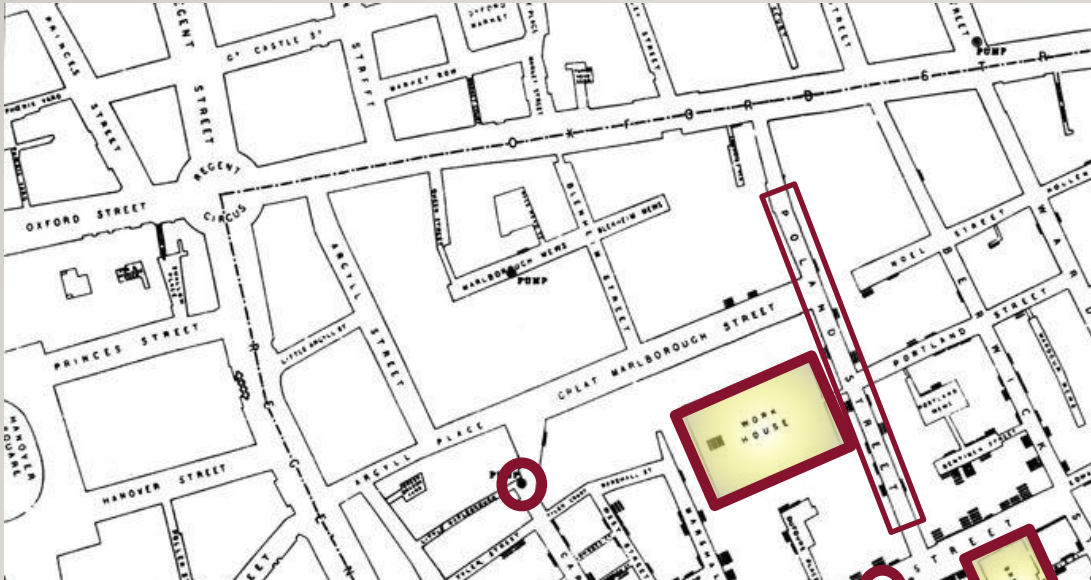
- 127 people died
- Outbreaks occurred all over the immediate area, but nothing compared to Broad Street

SUNDAY,
SEPTEMBER 3

- John Snow studies samples of Broad Street pump water
- Expected to find large quantities of rotting organic material, but water looked pure and clear
- Went back to the streets trusting in epidemiology (what was happening on the ground) over microbiology (what he saw in the microscope)

MONDAY,
SEPTEMBER 4

“A few odd islands
appeared in this sea
of devastation.”



WORKHOUSE
ST. JAMES'S PARISH.

London: Pub. Dec. 1790 at R. Adersman's Repository of Arts 20 Strand



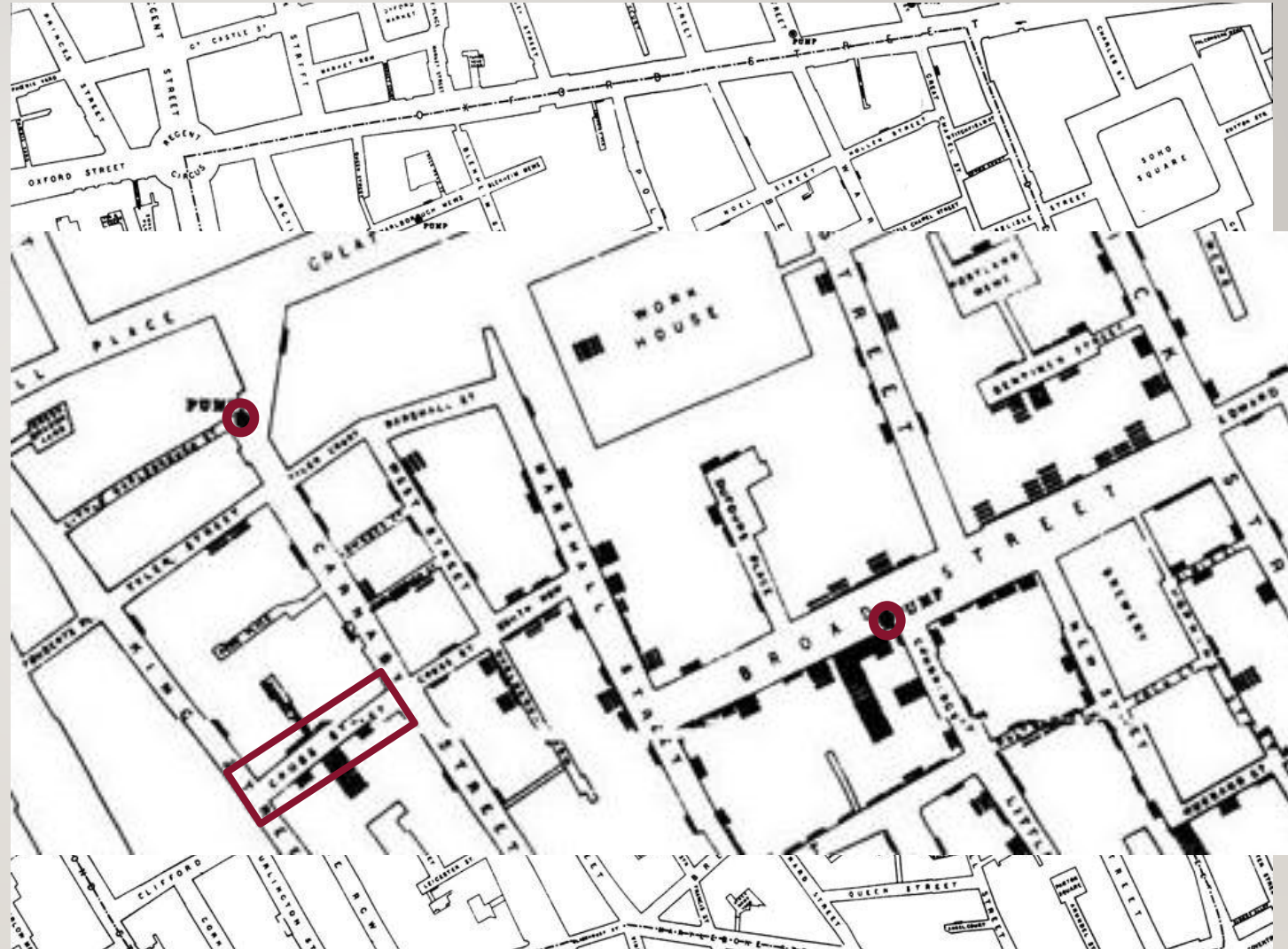
TUESDAY,
SEPTEMBER 5

Body counts and footprints



WEDNESDAY,
SEPTEMBER 6

Cross Street Outbreak

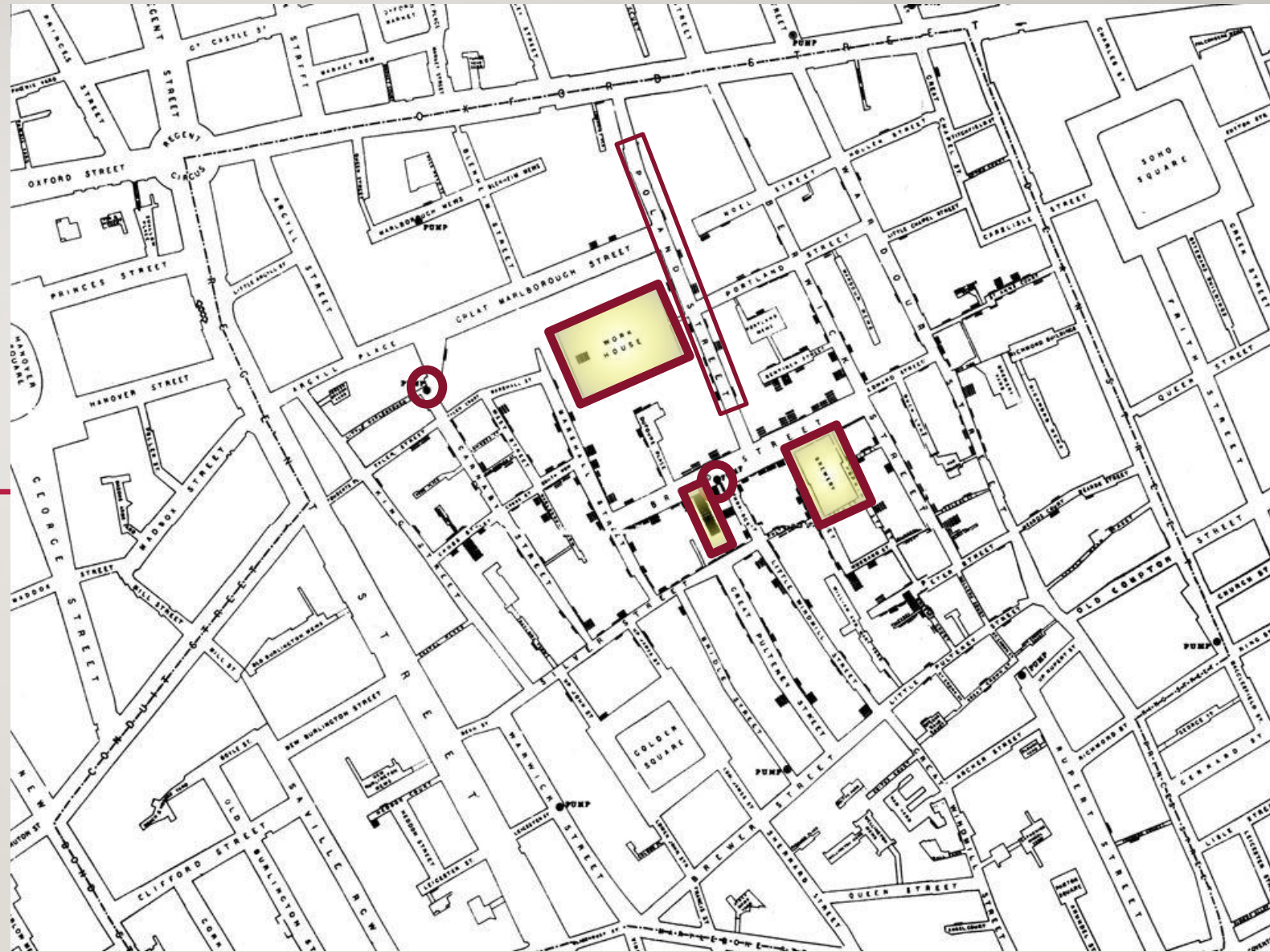


THURSDAY,
SEPTEMBER 7

- Snow appears at the Vestry Hall and asks to address the Board of Guardians of St. James Parish
- They admitted him as an act of desperation
- Explained his investigations
- Asked them to remove the pump handle
- Didn't find him convincing, but they had little to lose

WALKING DISTANCE TO THE BROAD STREET PUMP





FRIDAY, SEPTEMBER 8, 1854



Death's Dispensary

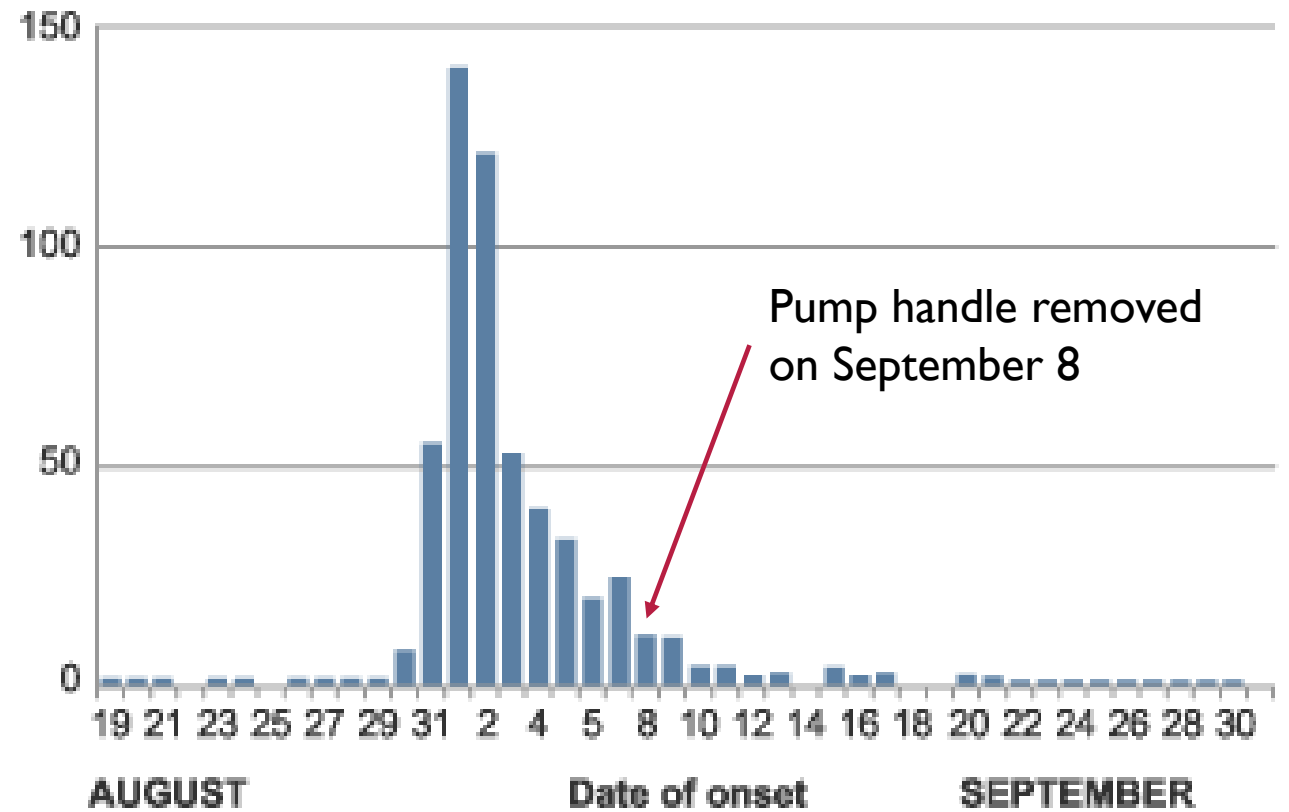
AFTER THE HANDLE WAS REMOVED

September 8 – 30, 1854

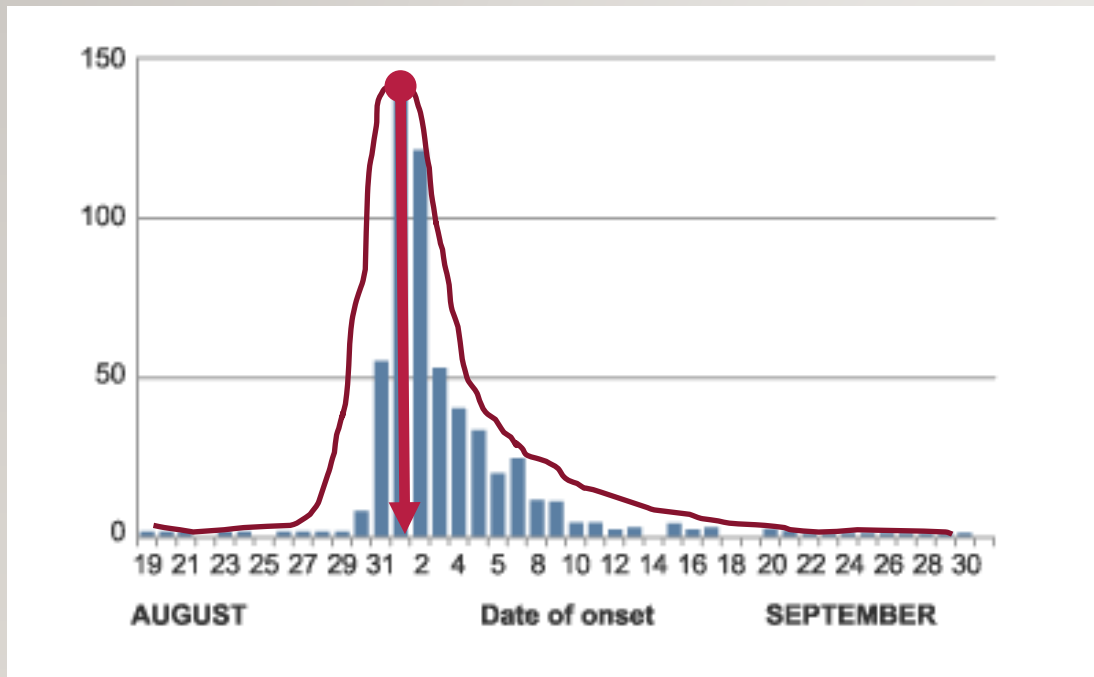


DAILY FATAL CASES OF CHOLERA NEAR GOLDEN SQUARE

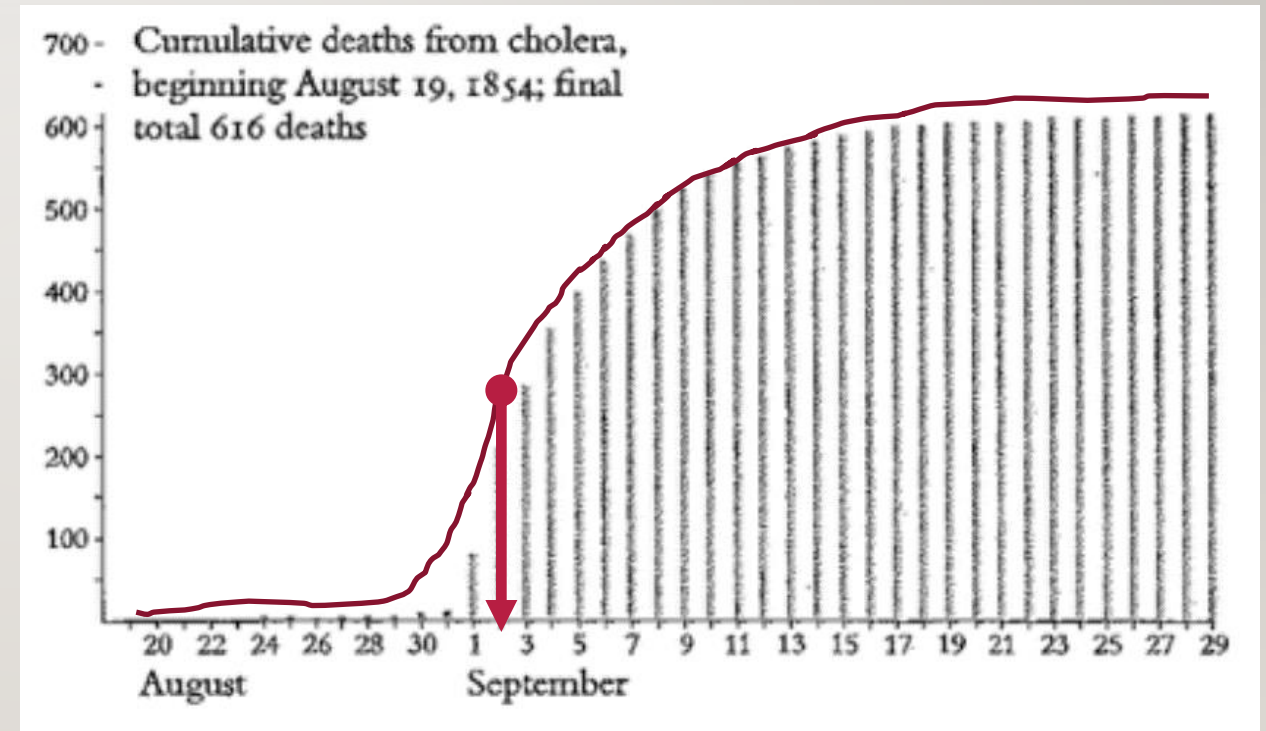
August 19 to September 30, 1854



DAILY AND CUMULATIVE DEATH RATES

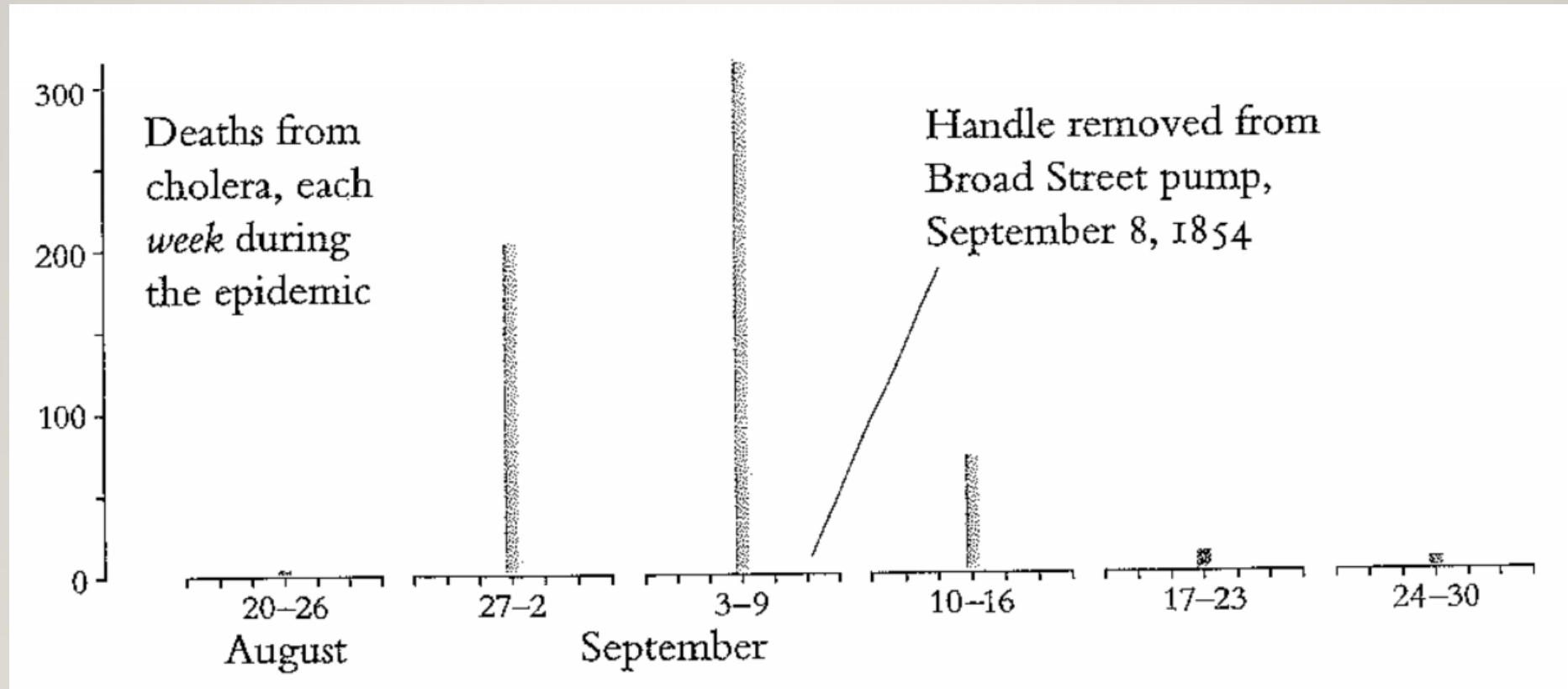


Daily death rate

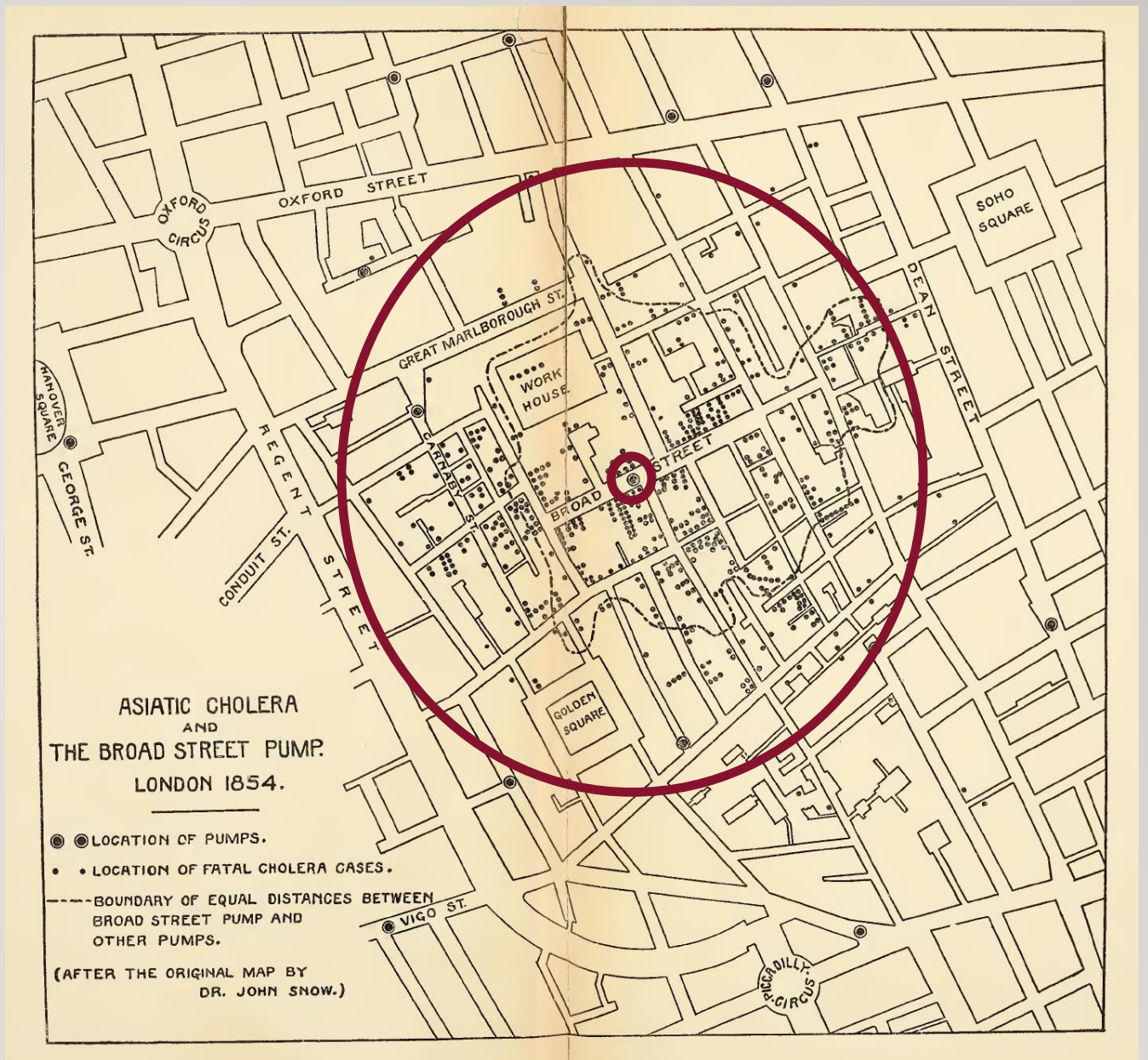


Cumulative deaths

GROUPING OF DATA CAN ALTER THE STORY



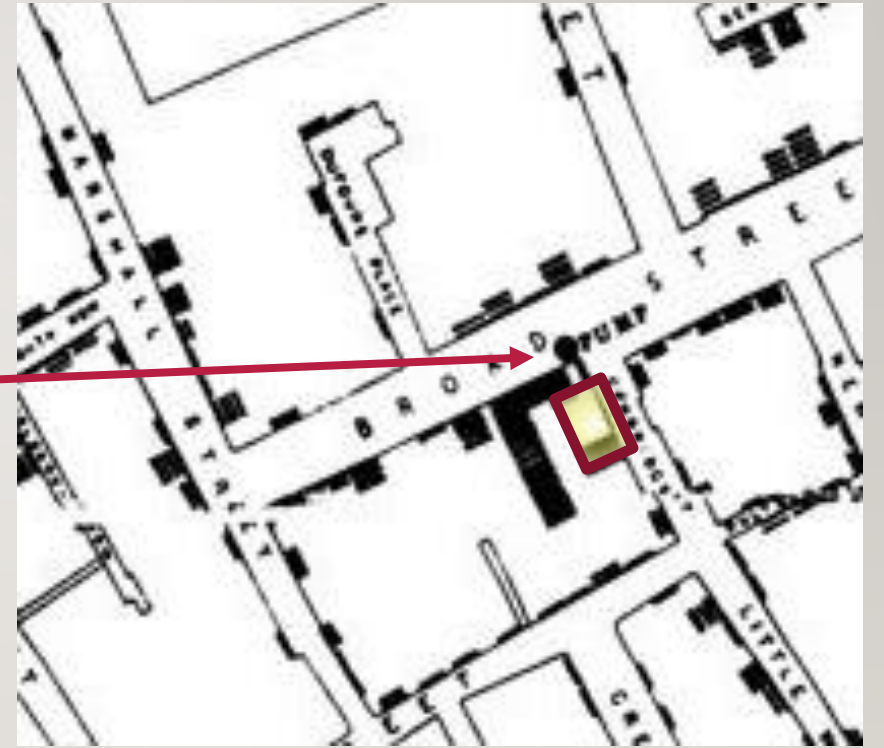
”THE BROAD STREET PUMP WAS A KIND OF URBAN ANTENNA, SENDING OUT A SIGNAL THROUGHOUT THE SURROUNDING NEIGHBORHOOD, A SIGNAL WITH A DETECTIBLE PATTERN THAT ALLOWED HUMANS TO ‘SEE’ *V. CHOLERAE* WITHOUT THE AID OF MICROSCOPES.”



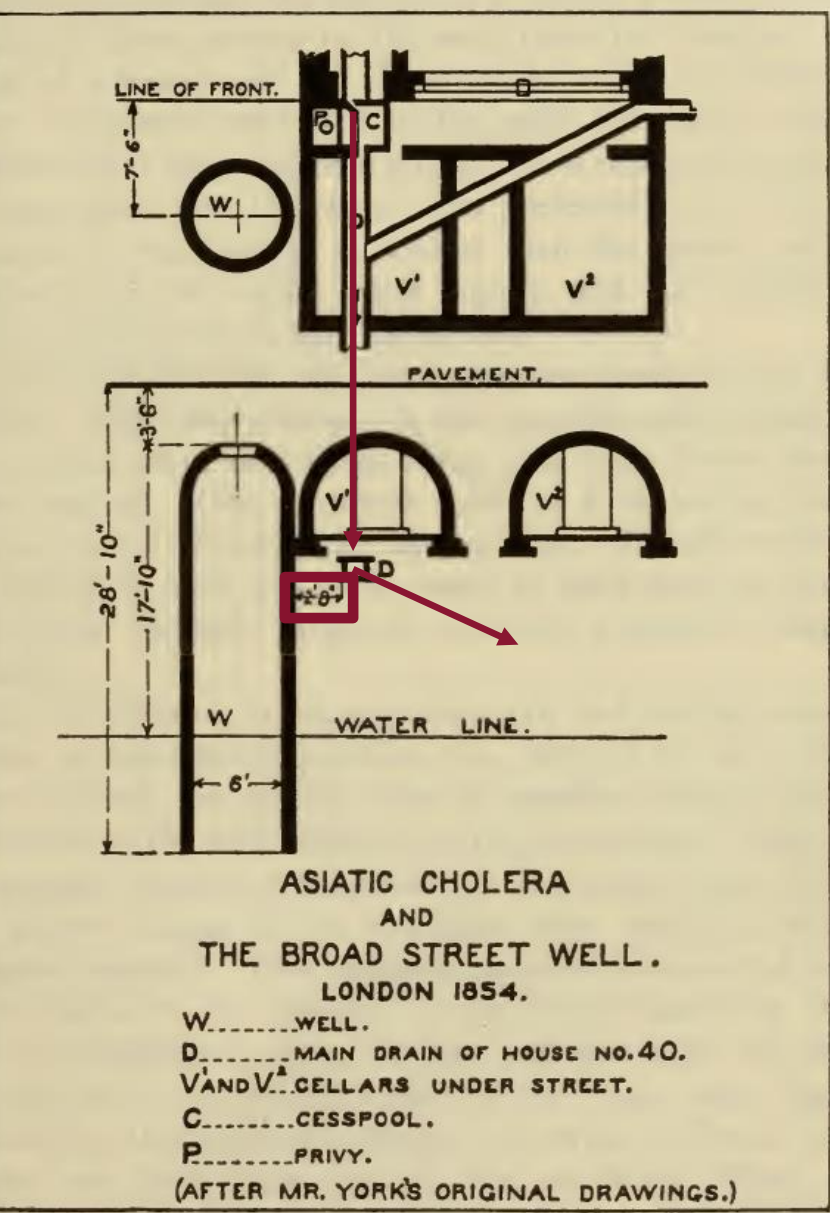
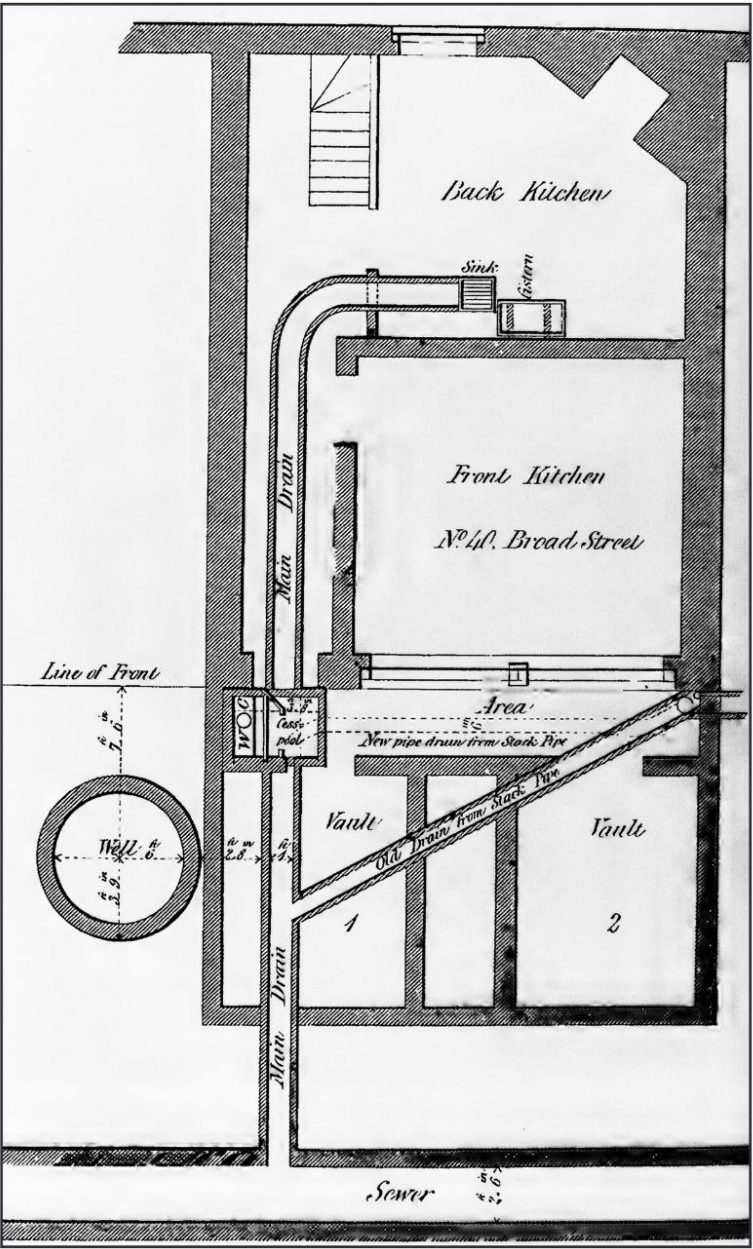
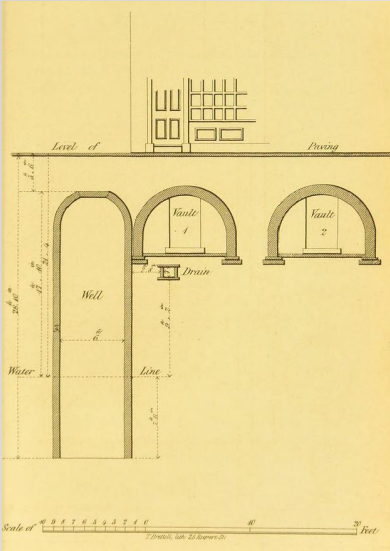


SEARCHING FOR THE INDEX CASE

No. 40, BROAD STREET.					Whether or no drank the Pump Water previous to illness.
Floor.	Age.		Date of Attack.	Date of Death.	
Back Parlour	6 mths	L. ...	28 Aug. 6 A.M.	2 Sep.	No.
1st Back ...	25 years	Mr. G.	31 Aug. 1 P.M.	2 Sep. 1 P.M.	Yes.
3rd Back ...	25 do.	Mr. R.	1 Sep. 9 A.M.	18 Sep. in hos- pital	Yes.
Ditto ...	36 do.	Mrs. G.	4 Sep. 6 A.M.	5 Sep. 10 A.M.	Yes.
Back Parlour	49 do.	Mr. L.	8 Sep.	19 Sep.	No.



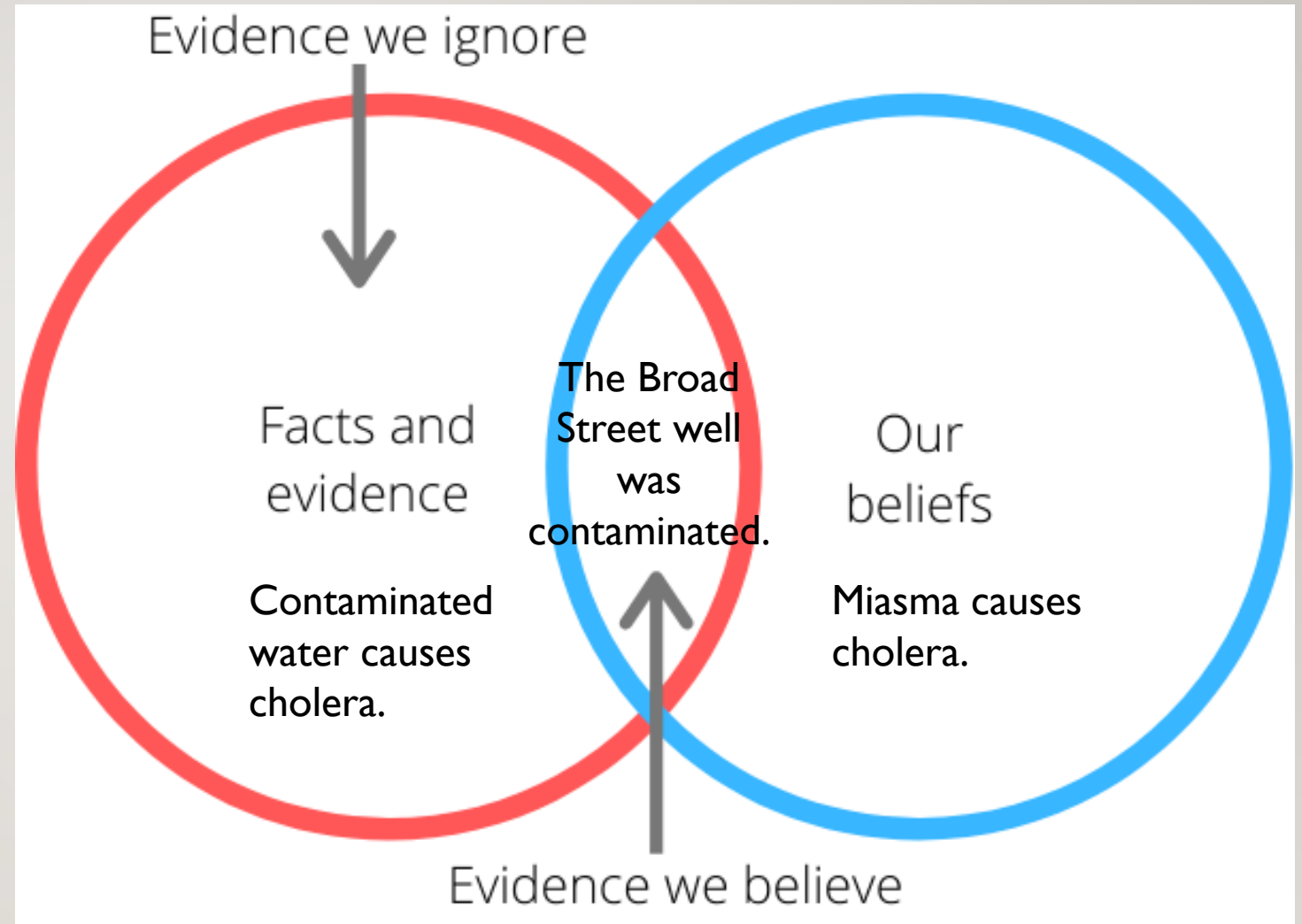
PLUMBING AT 40 BROAD STREET



SEPTEMBER 9, 1954

- Thomas Lewis fell ill at 40 Broad
- Sarah Lewis soaked his dirty linens in pails of water and threw the slops into the cesspit
- Thomas died on September 19

THE BOARD OF HEALTH REPORT AND CONFIRMATION BIAS



AN UNLIKELY PARTNERSHIP



“You and I may not live to see the day, and my name may be forgotten when it comes, but the time will arrive when great outbreaks of cholera will be things of the past; and it is the knowledge of the way in which the disease is propagated which will cause them to disappear.”

- John Snow to Henry Whitehead

EPILOGUE



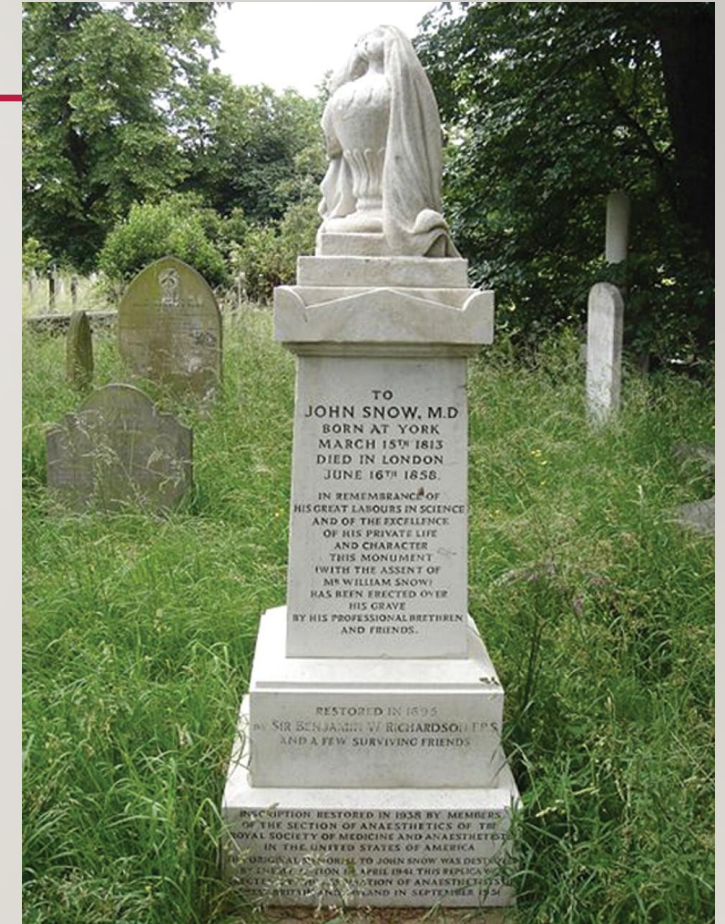
JOHN SNOW'S OBITUARY IN *THE LANCET*

JUNE 26, 1858

Births, Marriages, and Deaths.

DEATHS.

DR. JOHN SNOW.—This well-known physician died at noon on the 16th instant, at his house in Sackville-street, from an attack of apoplexy. His researches on chloroform and other anæsthetics were appreciated by the profession.



TWO GUYS AND A MAP



JOHN SNOW'S MAPS



SNOW'S ORIGINAL MAP



SNOW'S SECOND MAP

“[Snow had] imagined an overview of the Golden Square neighborhood, with a boundary line running an erratic circle around the pump. Every person inside that border lived closer to the poisoned well; everyone outside would have had reason to draw water from a different source.”

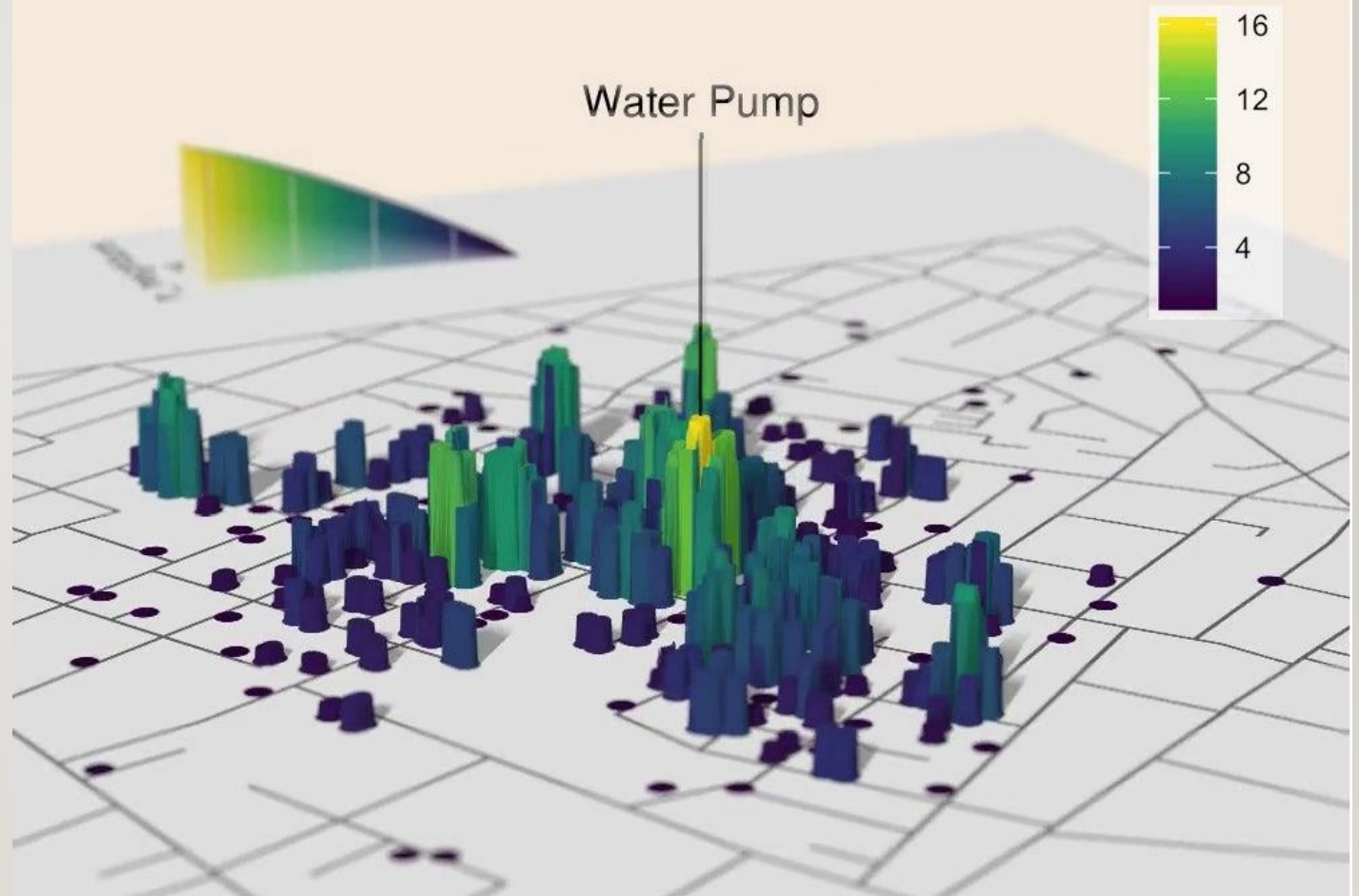
-Steven Johnson, Ghost Map, p. 141



Cholera Clusters (# of nearest neighbors)

SNOW'S MAP WITH MODERN TECHNOLOGY

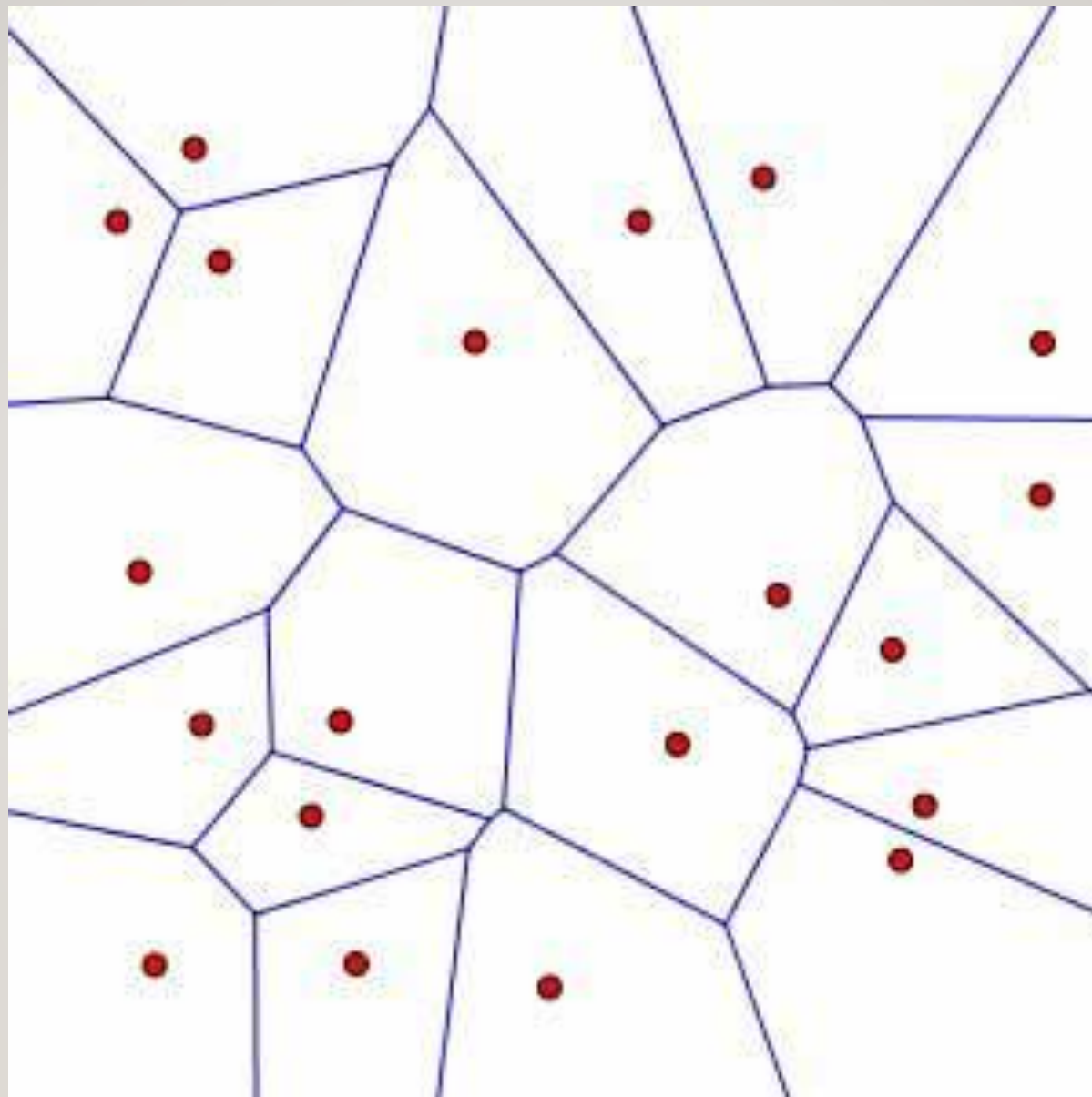
John Snow's London cholera map, # of nearest neighbors

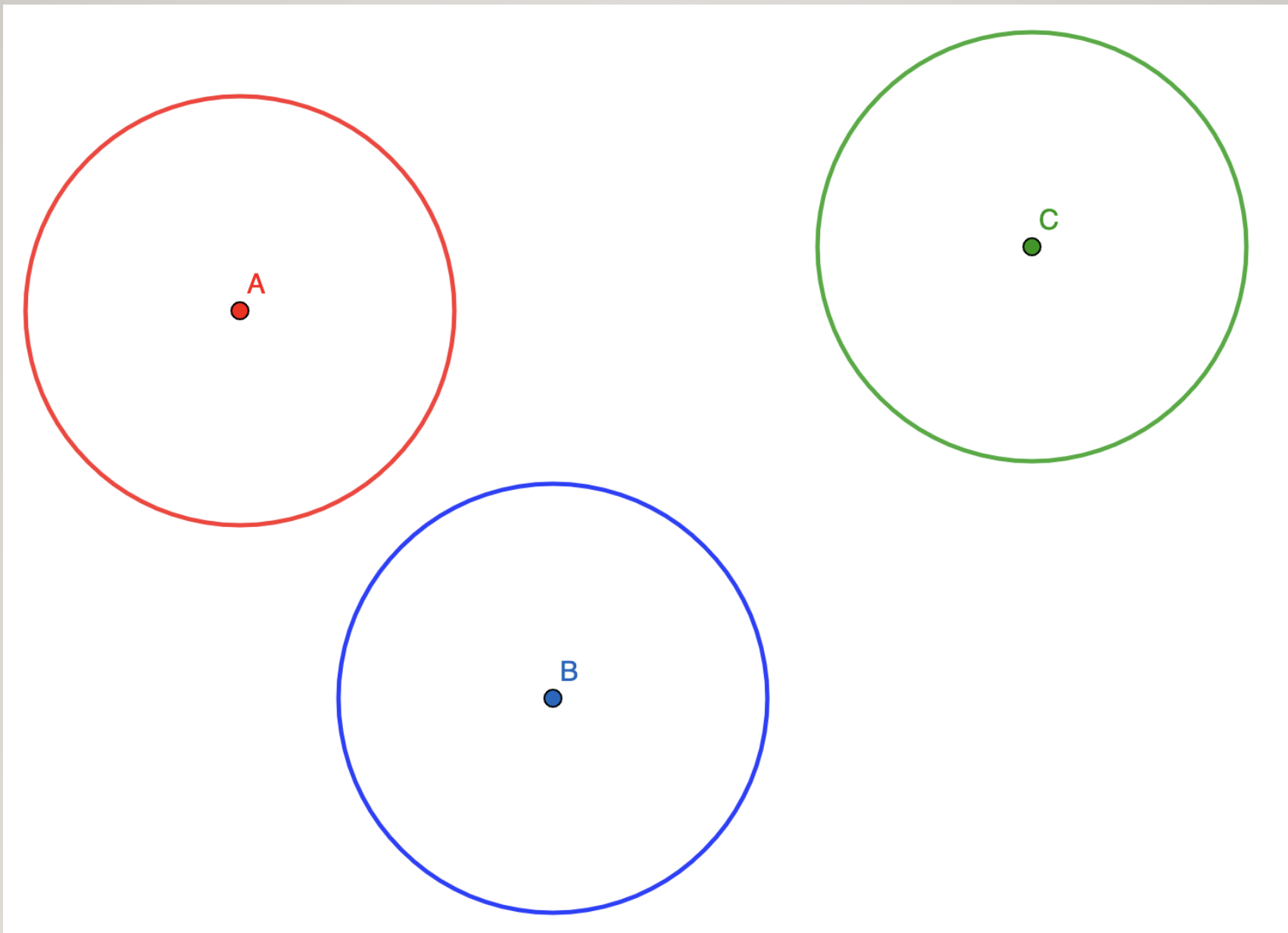


VORONOI DIAGRAMS

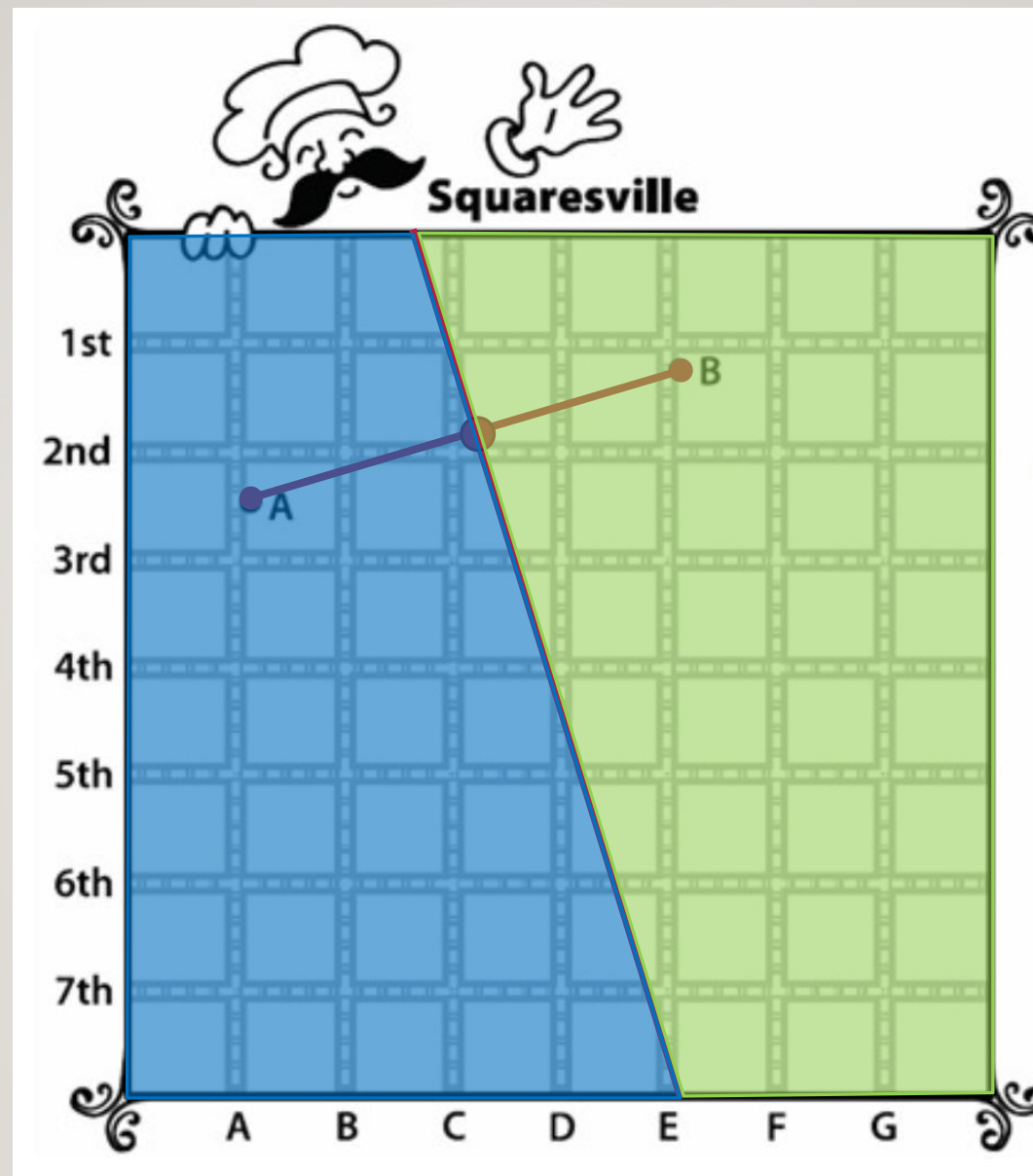




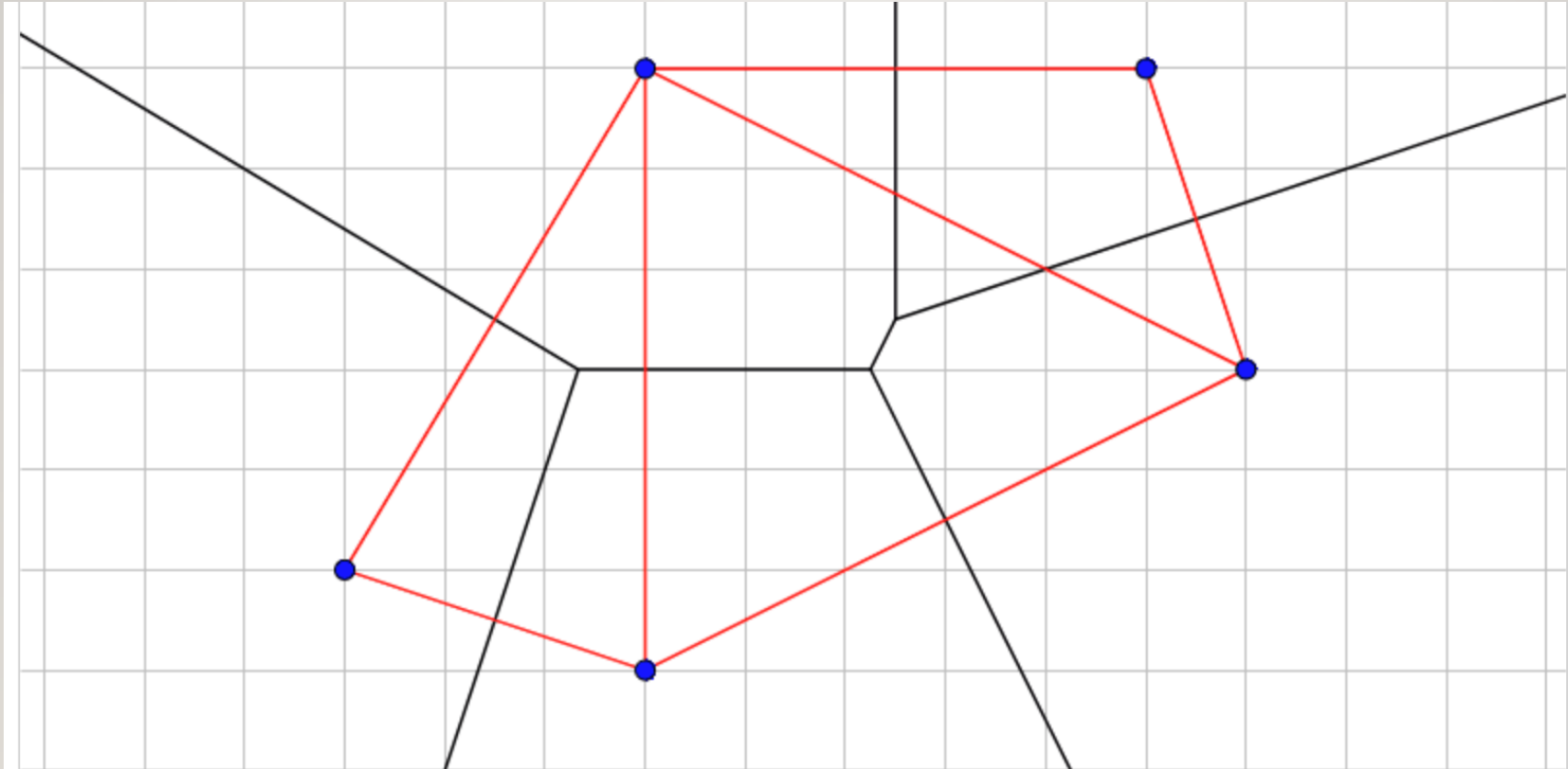








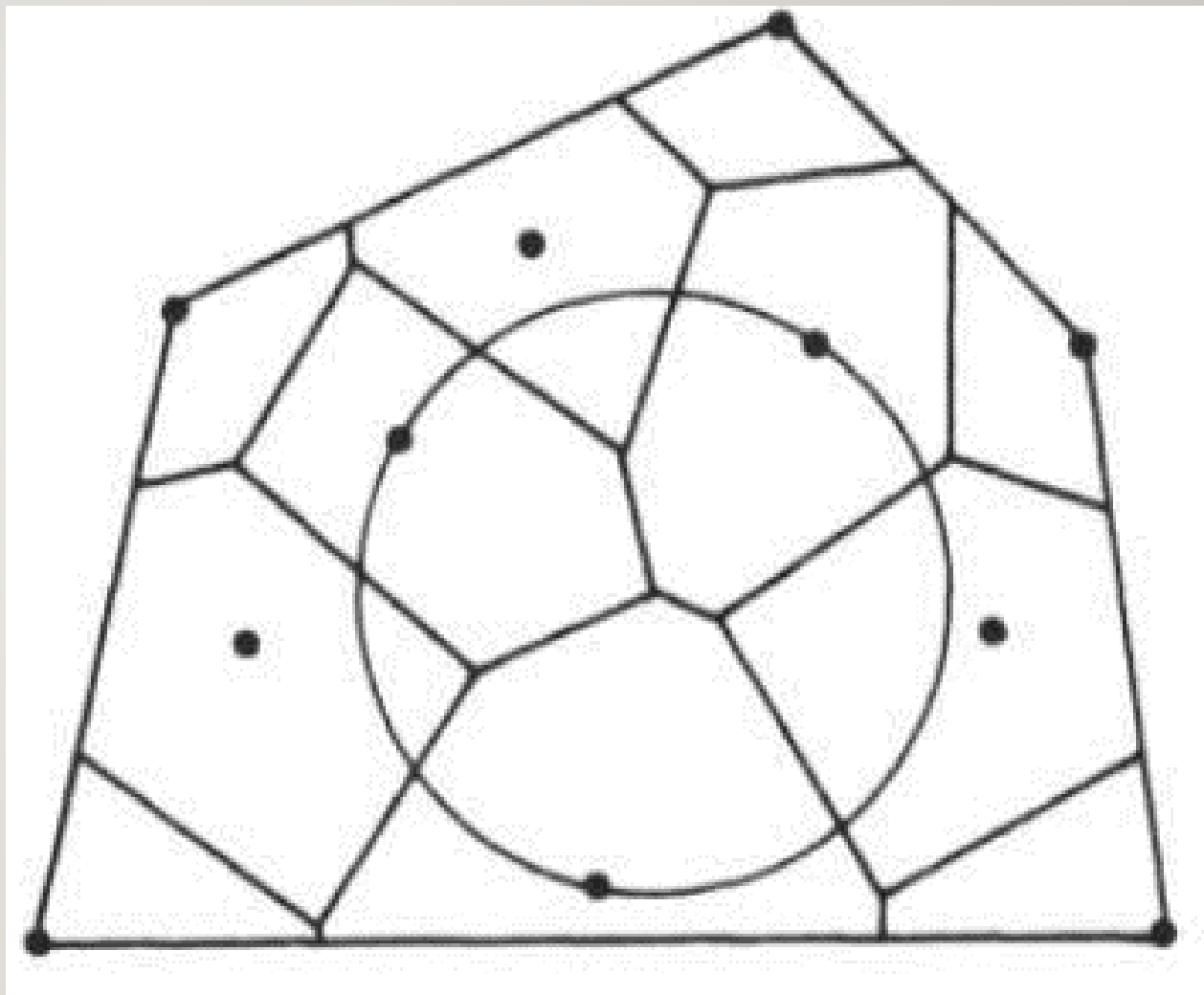
VORONOI DIAGRAMS WITH MORE THAN TWO POINTS



SOME HANDS-ON PRACTICE

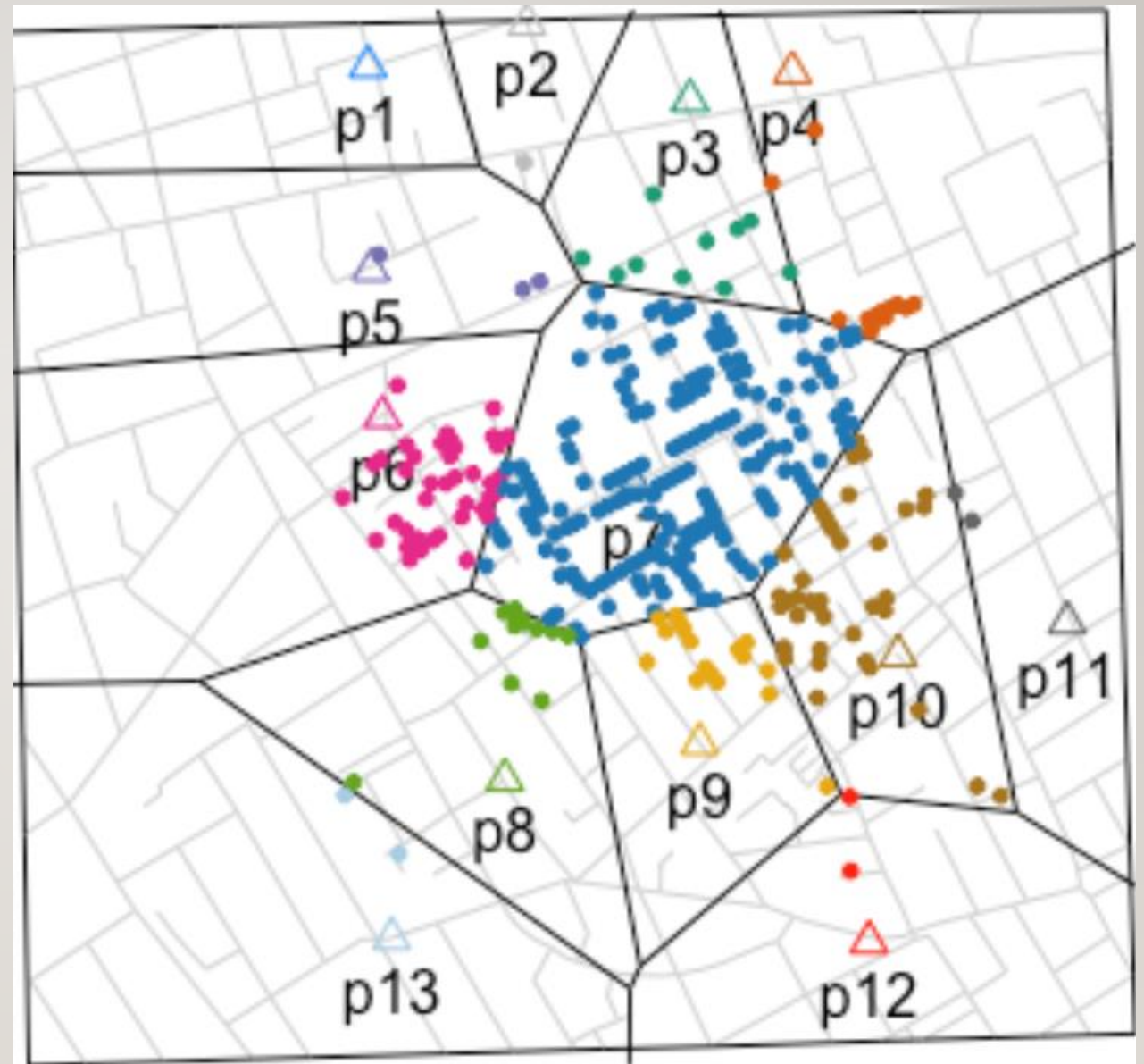


ADDING A NODE TO A VORONOI DIAGRAM



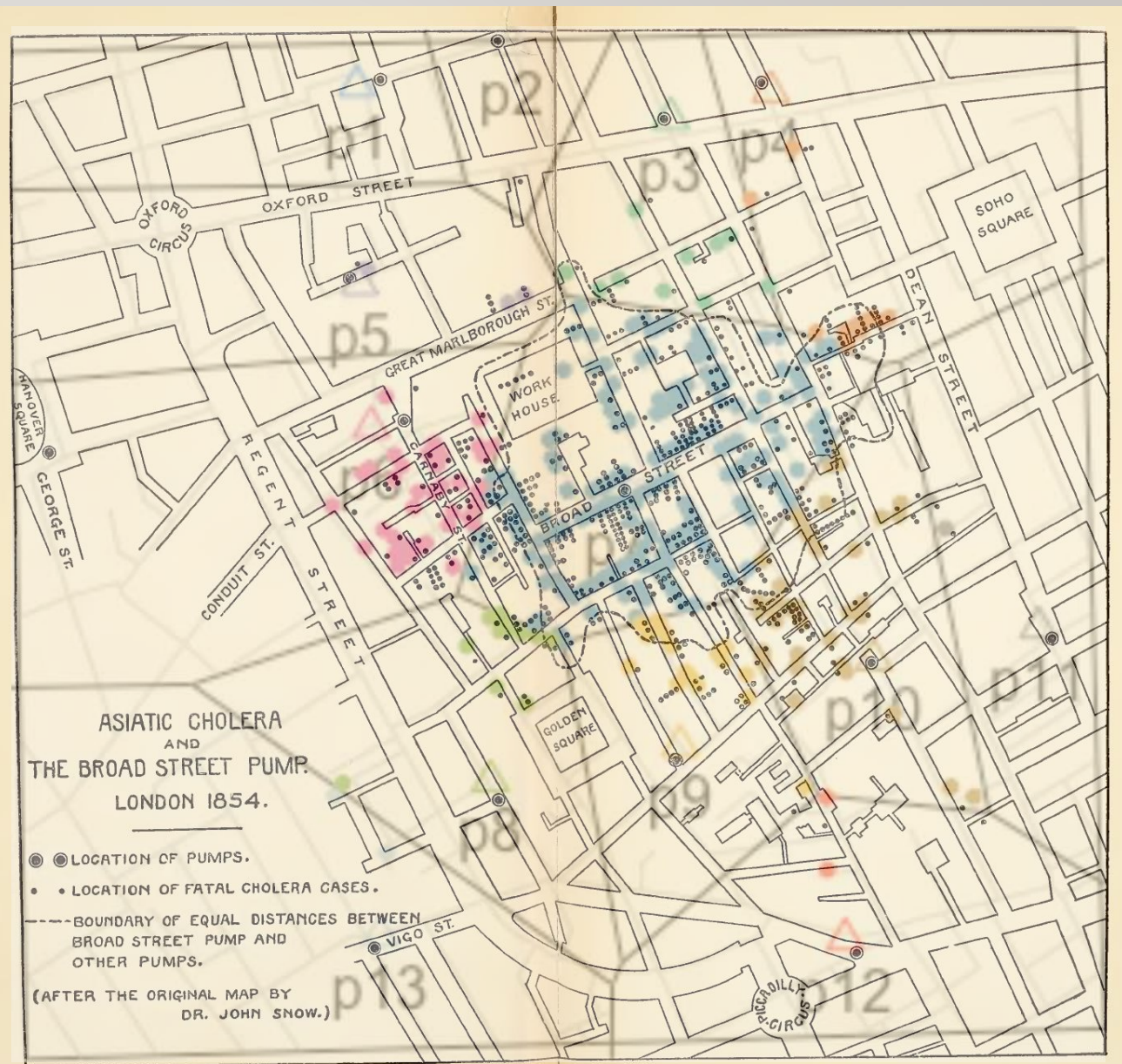
VORONOI DIAGRAM FOR THE 13 WATER PUMPS IN SOHO, LONDON 1854

Based on straight line distance to the
nearest pump



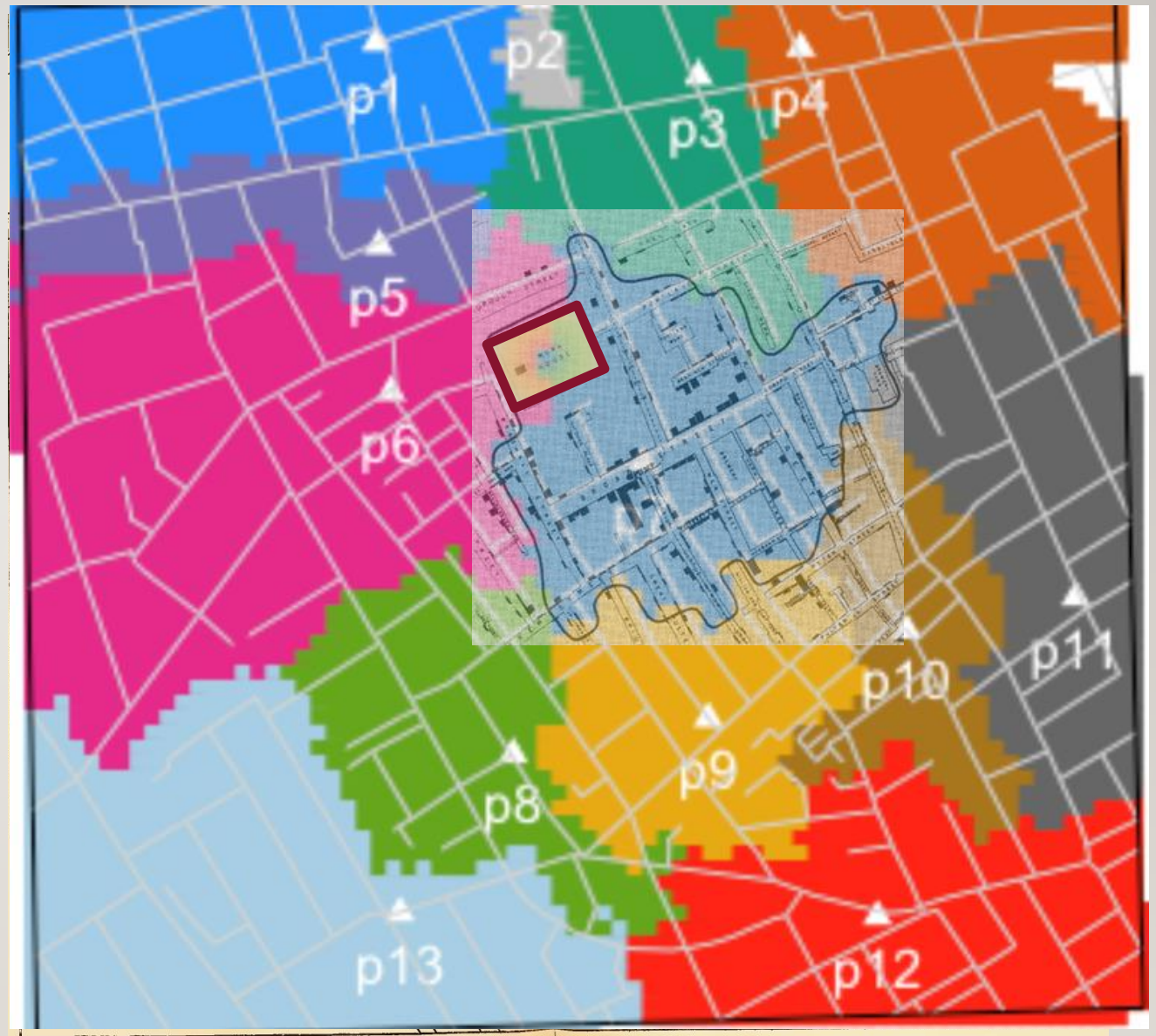
VORONOI DIAGRAM FOR THE 13 WATER PUMPS IN SOHO, LONDON 1854

Based on straight line distance to the
nearest pump



VORONOI DIAGRAM FOR THE 13 WATER PUMPS IN SOHO, LONDON 1854

Based on walking time to the nearest
pump



REFLECTION AND YOUR FEEDBACK



THANK YOU!

