John Snow and The Cholera Epidemic

DESCRIPTION:
Students will learn the essential steps in an epidemiology investigation by studying John Snow's classic investigation of the cholera epidemic in London in 1854.

RATIONALE:
In the Mysterious Illness Outbreak scenario, students take on the roles of epidemiologists to investigate an outbreak of illness in Hydroville.

PURPOSE/GOALS:
Students will be able to:
- Develop an understanding of the science of epidemiology and the methods of epidemiologists.
- Analyze epidemiological data.
- Develop hypotheses.
- Outline an epidemiological investigation and compare their ideas to the design of an historical investigation.
- Apply ratios and proportions to epidemiological data.

PREREQUISITE KNOWLEDGE:
- Ability to calculate ratio and proportions.
- A picture of what life was like in 19th century London, including environmental factors and lifestyles.
- General knowledge of water and sewage systems in 19th century London: how water was delivered to communities, how a hand pump works, and what people did with their sewage.

TIME ESTIMATE:
Prep: 30 minutes for photocopying
30 minutes for listening to Part I: The Early Years: a Powerpoint slide presentation by Dr. Ralph Frerichs of UCLA or reading the many articles found at www.ph.ucla.edu/epi/snow.html.
Activity time: Two to three 50-minute class periods
Day 1: Introduction and Part 1
Day 2: Parts 2 and 3
Day 3: The Broadstreet Pump Outbreak by Dr. Ralph Frerichs, a powerpoint slide presentation at www.ph.ucla.edu/epi/snow.html. The site requires high speed internet access, computer and projector.

MATERIALS:
- Hydroville Science Journal

- Computer and projector
- High speed internet access
- Calculator

MATERIAL TO PHOTOCOPY:
- Transparency: Introduction to London 1850's
- Student Instructions: John Snow's Classic Studies of Cholera Epidemics in London 1854 (1/student) –Make a class set: These sheets can be laminated or placed in transparency sleeves to be used in all of your classes.
- Student Worksheet: (1/student)

BACKGROUND INFORMATION:

WHAT IS EPIDEMIOLOGY?
(*Adapted from*: Epidemiology for Journalists. by Dr. Daniel Wartenberg)

Epidemiology is the study of patterns of disease in human populations: who has disease, how much disease they have, and why they have it. The primary goal of epidemiology is to identify causes of disease and injury and explore ways to control and prevent them.

Unlike physicians who study disease in individuals, epidemiologists study disease in groups of people, or populations. Where physicians address specifics, focusing on the uniqueness of each patient, epidemiologists focus on what is common and general about members of populations, inferring principles that apply to most, if not all, of the study subjects.

Most epidemiological studies are field studies. Unlike the laboratory studies of the physicist or the chemist in which the investigator determines the conditions under which observations shall be made, epidemiologists observe the world as it is and must draw inferences that accommodate the study subjects' particular habits (like smoking, drinking, and overeating).

To further complicate matters, epidemiologists are able to study the same population under the same conditions only once. It is extremely difficult—often impossible—to replicate the specific history and experiences of any study group.

In conducting an epidemiology study, epidemiologists need to know about as many characteristics of the study population as possible to make sure that every factor that affects disease is included. For example, if epidemiologists are studying the possible association between childhood leukemia and exposure to electric and magnetic fields, they need to take into account a wide range of factors other than electric and magnetic field exposures to which the child has been exposed. They might include whether the child was exposed to x-rays prenatally (a known risk factor for leukemia), whether the child was exposed to leukemogenic solvents or pesticides, or if the parents smoked cigarettes in the house. This means collecting a wide spectrum of information, which is

a difficult and time-consuming process. Epidemiologists have developed carefully designed protocols to tease out the important risk factors from the complex relationships.

WATERBORNE DISEASES AND SANITATION

Waterborne Diseases: The first epidemic of a waterborne disease probably was caused by an infected caveman relieving himself in waters upstream of his neighbors. Perhaps the entire clan was decimated, or maybe the panicky survivors packed up their gourds and fled from the "evil spirits" inhabiting their camp to some other place. As long as people lived in small groups, isolated from each other, such incidents were sporadic.

But as civilization progressed, people began clustering into cities. They shared communal water, handled unwashed food, stepped in excrement from casual discharge or spread as manure, used urine for dyes, bleaches, and even as an antiseptic. As cities became crowded, they also became the nesting places of waterborne, insect borne, and skin-to-skin infectious diseases that spurted out unchecked and seemingly at will.

The ancients had no inkling as to the true cause of their misery. People believed divine retribution caused plagues and epidemics, or else bad air, or conjunction of the planets and stars, any and all of these things.
Hippocrates, the "Father of Medicine" who lived around 350 B.C., recommended boiling water to filter out impurities - those particles that pollute its sweet taste, mar its clarity or poison the palate. He was onto something, but his advice pertained only to what the observer could taste, touch, smell or see with the naked eye. The "what you see is what you get" approach was about the extent of scientific water analysis until the late 1800s.

That *invisible* organisms also thrive and swim around in a watery environment was beyond imagination until a few centuries ago, and their connection with disease wasn't established till a scant 100 years ago. Although the microscope was invented in 1674, it took 200 years more for scientists to discover its use in isolating and identifying specific microbes of particular disease. Only then could public health campaigns and sanitary engineering join forces in eradicating ancient and recurring enteric diseases, at least in developed countries of the world.

Sanitation: From archeology we learn that various ancient civilizations began to develop rudimentary plumbing. Evidence has turned up of a positive flushing water closet used by the fabled King Minos of Crete back around 1700 B.C. The Sea Kings of Crete were renowned for their extravagant bathrooms, running hot and cold water systems, and fountains constructed with fabulous jewels and workings of gold and silver.

Ancient water supply and sewerage systems - along with various kinds of luxury plumbing for the nobility - also have been discovered in early centers of civilization such as Cartage, Athens and Jerusalem. But it was the Roman Empire of biblical times that reigns supreme, by historical standards, in cleanliness, sanitation and water supply.

The Romans built huge aqueducts conveying millions of gallons of water daily, magnificent public baths and remarkable sewer systems. Rome spread its plumbing technology throughout many of its far-flung territories as well.

A luxury toilet in the private houses of the well-to-do was a small, oblong hole in the floor, without a seat - similar to toilets that prevailed in the Far East and other sections of the world even today. A vertical drain connected the toilet to a cesspool below.

Though the Roman Empire would last until the 6th century A.D., its fall was preceded by centuries of gradual decay, conflict and unrest. During the final century of Roman domination, there was a succession of earthquakes, volcanic eruptions and disease epidemics. Soon afterwards, rampaging Vandals and other barbaric tribes completed the breakdown of Western civilization, as they systematically leveled and defiled the great Roman cities and their water systems.

Then came a thousand years of medieval squalor: a thousand years of sicknesses and plague of unbridled virulence, fanned by fleas and mosquitoes, excrement and filth, stagnant and contaminated water of every description. The typical peasant family of the aptly-named Dark Ages lived in a one-room, dirt-floor hovel, with a hole in the thatched roof to let out the smoke of the central fire. The floor was strewn with hay or rushes, easy havens for lice and vermin. Garbage accumulated within. If they were lucky, the family had a chamber pot, though more likely they relieved themselves in the corner of the hovel or in the mire and muck outside.

Water was too precious to use for anything except drinking and cooking, so people rarely bathed. Heck, they barely changed clothes from one season to another, wearing the same set every day, perhaps piling on more rags for warmth.

These are the conditions which spawned the infamous Black Plague in the 14th century, killing an estimated one third of the European population. Although not directly related to bad plumbing, the plague serves as the most striking example of misery caused by poor sanitation in general, and the ignorance of people in controlling the outbreak. So bad was the "Black Death," the Great Fire of London in 1666 can be viewed as a blessing in disguise. Though it killed thousands of people, the holocaust also consumed garbage, muck and black rats, effectively ending the plague.

The Cholera Story: Among waterborne disease, cholera has proven one of history's most virulent killers. The good news is that it was through cholera epidemics that epidemiologists finally discovered the link between sanitation and public health, which provided the impetus for modern water and sewage systems.

Now, in the 21st century, we know cholera is caused by ingesting water, food or any other material contaminated by the feces of a cholera victim. Casual contact with a contaminated chamber pot, soiled clothing or bedding, etc., might be all that's required

to contract cholera. The disease is stunning in its rapidity. The onset of extreme diarrhea, sharp muscular cramps, vomiting and fever, and then death - all can transpire within 12-48 hours. So much fluid is lost that the blood appears thick and about half of the patients will die, mainly of dehydration. It strikes so suddenly a man could be in good health at daybreak and he buried at nightfall.

In the 19th century, cholera became the world's first truly global disease in a series of epidemics that proved to be a watershed for the history of plumbing. Festering along the Ganges River in India for centuries, the disease broke out in Calcutta in 1817 with grand-scale results.

India's traditional, great Kumbh festival at Hardwar in the Upper Ganges triggered the outbreak. The festival lasts three months, drawing pilgrims from all over the country. Those from the Lower Bengal brought the disease with them as they shared the polluted water of the Ganges and the open, crowded camps on its banks.

When the festival was over, they carried cholera back to their homes in other parts of India. There is no reliable evidence of how many Indians perished during that epidemic, but the British army counted 10,000 fatalities among its imperial troops. Based on those numbers, it's almost certain that at least hundreds of thousands of Indians must have fallen victim across that vast land.

When the festival ended, cholera raged along the trade routes to Iran, Baku and Astrakhan and up the Volga into Russia, where merchants gathered for the great autumn fair in Nijni-Novgorod. When the merchants went back to their homes in inner Russia and Europe, the disease went along with them.

Cholera sailed from port to port, the germ making headway in contaminated kegs of water or in the excrement of infected victims, and transmitted by travelers. The world was getting smaller thanks to steam-powered trains and ships, but living conditions were slow to improve. By 1827 cholera had become the most feared disease of the century.

The worldwide cholera epidemic was aided by the Industrial Revolution and the accompanying growth of urban tenements and slums. There was little or no provision at all for cesspools or fresh water supplies. Tenements were several stories high, but cesspools were only on the ground floor with no clear access to sewers or indoor running water. It didn't make much difference, because until the 1840s a sewer was simply an elongated cesspool with an overflow at one end. "Night men" had to climb into the morass and shovel the filth and mire out by hand. In most cases, barrels filled with excrement were discharged outside, or contents of chamber pots flung from open windows to the streets below.

Water hydrants or street pumps provided the only source of water, but they opened infrequently and not always as scheduled. They ran only a few minutes a day in some

of the poor districts. A near riot ensued in Westminster one Sunday when a water pipe that supplied 16 packed houses was turned on for only five minutes that week.

Cholera first hit England through the town of Sunderland, on October 26, 1831. One William Sproat died that day from the disease, though nobody wanted to admit it. Merchants and officials found plenty of reasons to rationalize away a prospective 40 day maritime quarantine of the ports. England was reaping the profits of the Industrial Revolution and a quarantine of ships would be catastrophic for the textile industry.

By the end of the first cholera epidemic, the relationship between disease and dirty, ill-drained parts of town was rather well established. This should have spurred sanitary reform. But little action followed. An out-of-sight, out-of-mind syndrome developed when the first epidemic ended. The learned *Edinburgh Medical and Surgical Journal* at one point declared they would review no more books on the subject "because of the multitude of books which have recently issued from the press on the subject of cholera, and our determination to no longer try the patience of our readers."

Dr. John Snow: The eminent Dr. John Snow demonstrated how cases of cholera that broke out in a district of central London could all be traced to a single source of contaminated drinking water. Sixteen years later Snow would win a 30,000 franc prize by the Institute of France for his theory that cholera was waterborne and taken into the body by mouth. But Snow's original work received little attention from the medical profession. He was attacked at the weakest point - that he could not identify the nature of the "poison" in the water.

When the second cholera epidemic hit England in 1854, Snow described it as "the most terrible outbreak of cholera which ever occurred in this kingdom." At least it provided him with an opportunity to test his theory. By charting the incidence of the disease, he showed that over 500 cases occurred within 10 days over a radius of some 250 yards centered on London's Broad Street. He looked for some poison which he believed came from the excreta of cholera patients and swallowed by the new victims. A common factor was their use of water from the Broadstreet pump.

By the methodical process of elimination, he proved his point: A workhouse in that area had its own private well, and there were only 5 deaths among its 535 inmates. A brewery on Broad Street likewise never used the water from the Broad Street pump. Its workers drank beer and it had no cases among its 70 workers.

But Dr. Snow died in 1858 not knowing what caused cholera. It wasn't until 1876 that a German doctor, Robert Koch discovered the comma-shaped bacillus, *vibrio cholera*, that causes cholera. Through microscopic examination, he ascertained that "excrement may contain cholera bacteria a good while after the actual attack of the disease."

TERMINOLOGY:

Epidemic Epidemiologists Epidemiology

Theory Hypothesis Cholera

SUGGESTED LESSON PLAN:

PART 1: INTRODUCTION AND PART I

Getting Started

1. To introduce the students to a hand pump and the environmental conditions of London in the1850's, (which is significant to understanding the cholera outbreak), show Transparency 1. Have students respond to the Journal Prompt in their Hydroville Journals or in small groups. (Transparency 1: "When and where do you think this drawing is taking place? What do you think were the environmental and social conditions of the time?")

   Women are drawing water from a hand pump located on Broad Street in London during the 1800's. London experienced great change during the life of John Snow. The city grew dramatically between 1813 and 1858, and was at the center of a financial and social empire, which reached around the world. Yet during these same years, residents of London suffered greatly from death and disease, including epidemics of cholera. In addition they faced extensive environmental pollution, most notably of the majestic River Thames.

2. This activity is divided into two parts. Provide each student with a copy of the Student Instructions for Part 1 and Student Worksheet and then the Student Instructions for Part 2 and then Part 3. To save on photocopying costs, Student Instructions for Parts 1-3 can be laminated or placed into transparency sleeves and be reused by other classes.

Doing the Activity

1. Students can work individually or in pairs. They answer questions on a copy of the Student Worksheet.
2. **Class Discussion**: Use the information provided in the Teacher Introduction and at www.ph.ucla.edu/epi/snow.html to help students answer the following questions.
   - What would a person living in 1840 know about the causes of disease? What would a doctor know? How would diseases be treated in a pioneer cabin? In an Indian longhouse?
   - How would someone living in a tenement in London or New York City in 1840 get their water?
   - In 1840, what would the sanitation system be like in a pioneer cabin? A home in Chicago? An apartment in inner city London?
3. Have students work together on the instructions for Part 1.

4. When the students have completed answering the questions from Part 1, have a group discussion to review what was covered and what the students learned.
5. Hand out the Student Instructions for Part 2 and repeat the process.
6. Hand out the Student Instructions for Part 3 and repeat the process.

Wrap-up

- Part 2: Broad Street Pump Outbreak (www.ph.ucla.edu/epi/snow.html) is an excellent review of the work of John Snow by Dr. Ralph Frerichs of UCLA. It takes about 45 minutes to show and requires a computer, projector, and high speed internet connection. Or students could view this as a homework or library assignment.
- **Journal Prompt**: Each student should write a response to the following prompt in his or her Science Journal: "If you were investigating a cholera epidemic today, how would your study be different from John Snow's? (What would you do that he didn't do?)"

ASSESSMENT:
Collect student worksheets. Answers will vary. Assessment will be subjective, based on the thoughtfulness or reasoning evident, and on completion.

EXTENSIONS:

Science
- Microbes in the Water: Have students take a microscopic look at different types of water (i.e., drinking water, river water, distilled water or water from a pond or ditch).

RESOURCES:
A biography of John Snow, descriptions the Broad Street pump outbreak, and drawings are included at the following web site - http://www.ph.ucla.edu/epi/snow.html:

- UCLA Department of Epidemiology. School of Public Health. John Snow – An Historical Giant in Epidemiology. http://www.ph.ucla.edu/epi/snow/snowbio.html
- Broad Street Pump Outbreak: http://www.ph.ucla.edu/epi/snow/broadstreetpump.html
- An illustration of The Broad Street Pump http://www.ph.ucla.edu/epi/snow/broadstpumpwomen.htm
- BBC Online, 2001. John Snow 1813-1858. http://www.ph.ucla.edu/epi/snow/bbc_snow.htm
- Center for Disease Control. Biography of John Snow http://www.cdc.gov/ncidod/dbmd/snowinfo.htm
- University of Texas Library Online. Historical Map of London available at this web site: http://www.lib.utexas.edu/maps/historical/thames_river_1882.jpg

TRANSPARENCY 1:

Broad Street Pump

Source: The Broad Street Pump, *Safe & Sound*, Penguin, 1971 in English MP. *Victorian Values – The Life and Times of Dr. Edwin Lankester*, 1990.

Learning Log Prompt:

When and where do you think this drawing is taking place?

What do you think were the environmental and social conditions of the time?

TEACHER KEY

STUDENT ANSWER SHEET

PART 1

1. Using Snow's spot map (Figure 1), what observations can you make about the distribution of the cholera cases?
   Students should notice that most of the cases are near water pump A, and very little near water pumps B and C.

2. Which well would you pick as the most likely source of contaminated water?
   Well A.

3. Why wouldn't you identify pump C as the possible source?
   Because very few cases of cholera occurred near pump C.

4. What reasons could explain why there were no cases of cholera in the people living in the two- block area around the brewery east of pump A?
   Most teams will probably say that those people drank beer instead of water. (They are correct, but the brewery also had a deep well used by the people that worked there.)

5. What could Snow do to test his hypothesis that the epidemic was caused by water from Pump A? (Remember that he couldn't actually test the water for bacteria.)
   Answers should vary, but focus on collecting data about where people got their water.

6. What did John Snow do to prove that pump A was the source of the cholera?
   He interviewed people with cholera about where they got their water.

7. Compare your answer to question 6 with your answer for question 5. How did your plan differ from what Snow actually did?
   Based on previous student answers.

PART 2

8. Refer to Table 2. Does this data support Snow's hypothesis that polluted water causes cholera? Why or Why not?
   Table 2 does support Snow's theory and points to Company 1 as the source because so many people getting water from that company got cholera, and no cholera deaths occurred in the population served only by Company 2.

9. Is it conclusive proof that Snow's hypothesis is correct? Why or why not? It is not conclusive proof. *The large number of deaths in areas served by both water companies is not explained.*

10. What other factors might be causing the difference in cholera rates in the different London districts?
    Students must brainstorm possible causes here. They could include: Foods, animals, where

people worked, age, sex, places they visited (e.g. churches, theatres), number of individuals in a household, air pollution in their neighborhood, wealth or poverty, etc.

11. Design (briefly outline) an investigation that would confirm Snow's hypothesis that polluted water, and not some other factor, was causing the cholera epidemic.
    This should be brief, but include the collection of data by surveying households of cholera victims, identifying their water supplier, and collecting other information which might be a cause (such as age, food, and other items mentioned in question 1). Teams could also suggest how the data might be organized and interpreted.

PART 3

12. Using ratios and proportions, calculate the "Deaths per 10,000 Houses" and complete Table 3.
    Company 1: 0.0315deaths/ house or 315 deaths per 10,000 houses
    Company 2: 0.0037deaths/house or 37 deaths per 10,000 houses
    Rest of London: 0.0059 deaths/house or 59 deaths per 10,000 houses

13. Which data is more meaningful when comparing deaths in the three districts?
    The deaths per 10,000 houses are more meaningful because you are not dealing with fractional deaths, and you are using a standard of comparison (per 10,000 houses over the three districts).

14. From what you know today, would filtering the water completely solve the cholera problem? Why?
    No, because most filters would not remove the cholera bacteria.

15. What was Snow's hypothesis for the 1853 – 1854 cholera epidemic?
    The cholera epidemic is caused by contaminated water supplied by the Southwark and Vauxhall water companies.

16. How did he test his hypothesis?
    He went from house to house, and for every dwelling in which a cholera death had occurred, he asked questions to determine the source of the water, and also inquired about and observed other conditions, which could have been possible causes.

17. List at least three possible alternative explanations he considered when testing his hypothesis. (He mentioned many conditions of the people surveyed in the italicized quote from his book)
    Possible alternative causes Snow mentioned include mixing the water supply; rich and poor; large houses and small; condition of the persons; occupations of the persons; sexes; age; rank and station.

18. List at least two possible explanations for the deaths from cholera in the homes supplied by the Lambeth Company.

Team answers will vary. Residents could have gotten some water at a neighbor's, at their employment, or at an eating establishment. Cholera could be on food bought at a market or fish caught in a river, etc.

19. Write a testable hypothesis for one of your explanations above. Briefly describe how your hypothesis could be tested.
    The team hypotheses should be based on the understanding they have developed about sources of cholera, and they should describe how it could be tested.

20. From your knowledge of the London lifestyle, what actions would you take to protect the public's health? Was there a need to change the way things were? What are your thoughts on disease and unsanitary conditions?
    Answer will vary.

STUDENT PAGES
FOR

JOHN SNOW AND THE CHOLERA EPIDEMIC

FOLLOW THIS PAGE

STUDENT INSTRUCTIONS:

JOHN SNOW'S CLASSIC STUDIES OF CHOLERA EPIDEMICS IN LONDON

PART 1

A. 1848–1849 Epidemic

In the early 19th century, medical statistics for England and Wales were carefully kept by the Office of the Registrar General of England and Wales. The physician, William Farr, published annual reports from this data and recognized that this information could be used to learn about human illness. In the mid-19th century, cholera epidemics were hitting London in waves. Cholera is a disease that is characterized by watery diarrhea, vomiting, cramps, dehydration, and death. Farr and the physician John Snow set about using data collected about these epidemics to find out what was causing the cholera in the hopes of preventing future epidemics. In the early 1800s, it was not known that microbes caused disease.

John Snow's first study of cholera was conducted in 1848 when an epidemic of cholera occurred in the area of Golden Square in London. At this time, most of the people in London obtained their water from a community hand pump that drew water from a well from an underground source. These communal pumps were usually located in a square or on a street corner. People would bring buckets or containers and pump the water into the bucket and carry it home for use by their families.

To study the cholera epidemic, Snow acquired information about the location of each case and used this data to create a spot map. Refer to Figure 1, Distribution of Cholera Cases in the Golden Square Area of London, August –September 1848 on the following page. This map is from Snow's book, On the Mode of Communication of Cholera, published in 1855. The circled X's are the locations of the pumps that supplied water to this area of London. Snow labeled three of these pumps, A, B, and C.

Using Snow's spot map (Figure 1), answer questions 1-4 on the Student Worksheet:

1. What observations can you make about the distribution of the cholera cases?

2. Which well would you pick as the most likely source of contaminated water?

3. Why wouldn't you identify pump C as a possible source?

4. What reasons could explain why there were no cases of cholera in the people living in the two-block area around the brewery east of pump A?

STUDENT INSTRUCTIONS: PART 1B

Because of the clustering of cases around Public Water Pump A, Snow concentrated on this pump as the source of the cause of the cholera. The absence of clusters around pumps B and C indicated that they were less likely to be the source. Snow found that the water from pump B was so grossly contaminated that residents avoided it and got their water from pump A. Pump C was in a location that made it difficult for the majority of cases to use it.

Answer question 5 on the Student Worksheet:

5. What could Snow do to test his hypothesis that the epidemic was caused by water from Pump A? (Remember that he couldn't actually test the water for bacteria.)

PART 1 C

Snow went to the homes with cases of cholera and interviewed people about their source of drinking water. The consumption of water obtained from pump A proved to be the one factor common among these cases. The brewery workers got their water from a deep well on the premises and were also allotted a daily quota of beer so they did not drink water from any of the pumps. Snow's detailed study of the outbreak convinced the vestrymen of the St. James parish of London to remove the pump handle from pump A, which stopped the cholera epidemic.

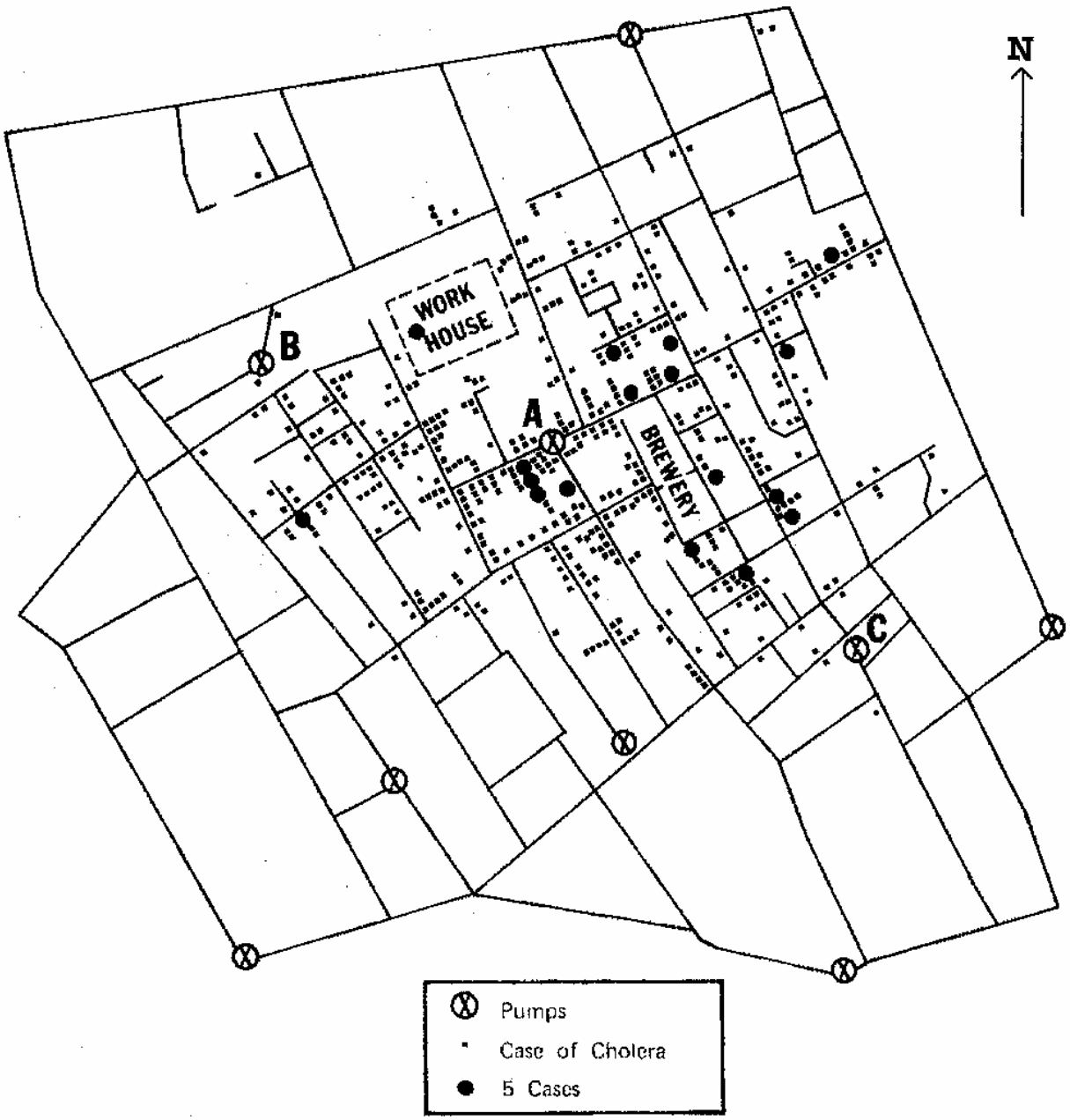
Answer questions 6-7 on the Student Worksheet:

6. What did John Snow do to prove that pump A was the source of the cholera?

7. Compare this answer with your answer for question 5. How did your plan differ from what Snow actually did?

Figure 1

Distribution of Cholera Cases in the Golden Square Area of London, August – September, 1848



Adapted from:
Snow, J., On the Mode of Communication of Cholera. (Second Edition). 1855. Churchill, London.

STUDENT INSTRUCTIONS: PART 2

EPIDEMIC 2

In the 1850's London residents began to obtain their water in their homes rather than from communal pumps. They signed up with one of the many water supply companies competing to supply home water. The water intakes for the water supply companies were in a much polluted part of the Thames River. Sometime between 1849 and 1854, one of the companies, the Lambeth Company, moved its water source to an area of the Thames where the water was relatively free from the sewage of London.

In 1854, Snow noted that a terrible outbreak of cholera occurred in a few square blocks of an area of London. "Within two hundred and fifty yards of the spot where Cambridge Street joins Broad Street, there were upwards of five hundred fatal attacks of cholera in ten days." Snow wondered what the cause of this outbreak could be. Using data from the Office of the Registrar General of England and Wales, Snow tabulated the number of deaths from cholera in 1853-1854 according to the two water companies supplying the various sub-districts of London.

Table 2. Death Rates from Cholera, 1853-54
By Water Company supplying sub-districts of London

District	Water Company Supplying the Sub-District	Population in 1851	Cholera Deaths 1853-1854	Deaths per 100,000 Living
1	Southwark & Vauxhall	167,654	192	114
2	Lambeth	14,632	0	0
3	Both Companies – Southwark & Vauxhall and Lambeth	301,149	182	60

Answer questions 8 – 11 on the Student Worksheet:

8. Refer to Table 2. Does this data support Snow's hypothesis that polluted water causes cholera? Why or Why not?

9. Is it conclusive proof that Snow's hypothesis is correct? Why or why not?

10. What other factors might be causing the difference in cholera rates in the different London districts?

11. Design (briefly outline) an investigation that would confirm Snow's hypothesis that polluted water, and not some other factor, was causing the cholera epidemic?

STUDENT INSTRUCTIONS: PART 3A

Snow also recognized that many factors in these London districts other than the water supplier were different and could be the reason for the difference in cholera rates. Snow's unique contribution to epidemiology was to recognize a way to test his hypothesis that the water supply caused the cholera epidemic. Snow outlined his investigation in the book *On the Mode of Communication of Cholera*, published in 1855:

> *In sub-districts enumerated in the above table as being supplied by both Companies, the mixing of the supply is of the most intimate kind. The pipes of each Company go down all the streets, and into nearly all the courts and alleys. A few houses are supplied by one Company and a few by the other, according to the decision of the owner or occupier at the time when the Water Companies were in active competition. In many cases a single house has a supply different from that on either side. Each company supplies both rich and poor, both large houses and small; there is not any difference either in the condition or occupation of the persons receiving the water of different Companies.*
>
> *The experiment, too, was on the grandest scale. No fewer than three hundred thousand people of both sexes, of every age and occupation, and of every rank and station, from gentle folk down to the very poor, were divided into two groups without their choice, and, in most cases, without their knowledge...*
>
> *To turn this grand experiment to account, all that was required was to learn the supply of water to each individual house where a fatal attack of cholera might occur.*

Therefore, Snow walked the London district supplied by both water companies, District 1 (Southwark and Vauxhall) and District 2 (Lambeth). He went from house to house and for every dwelling in which a cholera death had occurred, he asked questions to determine the source of the water. Snow summarized his data in the following table:

Table 3. Death Rates from Cholera in London, 1853-1854
(According to the water company supplying the actual house)

District	Water Company Supplying the District	Number of Houses	Deaths from Cholera	Death per House	Death per 10,000 Houses
1	Southwark & Vauxhall	40,046	1263		
2	Lambeth	26,107	98		

3	Rest of London	256,423	1422		

Answer questions 12-13 on the Student Worksheet:

12. Using ratios and proportions, calculate the "Deaths per House" and "Death per 10,000 Houses" and complete Table 3.

13. Which data is more meaningful when comparing deaths in the three districts? Why?

STUDENT INSTRUCTIONS: PART 3B

Snow's data conclusively showed that "one group being supplied with water containing the sewage of London, and amongst it, whatever might have come from the cholera patients. The other group has water quite free from such impurity." Snow's publication of his findings led to laws mandating that by 1857 all of the water supply companies in London must filter their water.

Answer question 14 on the Student Worksheet:

14. From what you know today, would filtering the water completely solve the cholera problem? Why?

Snow's investigation utilized the approach used by epidemiologists today. He used his clinical knowledge and his observations concerning the distribution of cholera rates to formulate a hypothesis. Snow then tested his hypothesis while recognizing the need to allow for testing of alternative explanations for his observations.

Answer questions 15-20 on the Student Worksheet:

15. What was Snow's hypothesis for the 1853–1854 cholera epidemic?

16. How did he test his hypothesis?

17. List at least three possible alternative explanations he considered when testing his hypothesis. (He mentioned many conditions of the people surveyed in the italicized quote from his book)

18. List at least two possible explanations for the deaths from cholera in the homes supplied by the Lambeth Company.

19. Write a testable hypothesis for one of your explanations above. Briefly describe how your hypothesis could be tested.

20. From your knowledge of the London lifestyle, what actions would you take to protect the public's health? Was there a need to change the way things were? What are your thoughts on disease and unsanitary conditions?

STUDENT WORKSHEET – PAGE 1: Name _____

Instructions: Read through each part in the Student Instructions and answer the accompanying questions for each part. There are three parts in all.

Part 1

1. Using Snow's spot map (Figure 1), what observations can you make about the distribution of the cholera cases?

2. Which well would you pick as the most likely source of contaminated water?

3. Why wouldn't you identify pump C as the possible source?

4. What reasons could explain why there were no cases of cholera in the people living in the two- block area around the brewery east of pump A?

5. What could Snow do to test his hypothesis that the epidemic was caused by water from Pump A? (Remember that he couldn't actually test the water for bacteria.)

6. What did John Snow do to prove that pump A was the source of the cholera?

7. Compare your answer for question 6 with your answer for question 5. How did your plan differ from what Snow actually did?

Part 2

8. Refer to Table 2. Does this data support Snow's theory that polluted water causes cholera? Why or why not?

9. Is it conclusive proof that Snow's theory is correct? Why or why not?

10. What other factors might be causing the difference in cholera rates in the different London districts?

11. Design (briefly outline) an investigation that would confirm Snow's hypothesis that polluted water, and not some other factor, was causing the cholera epidemic.

PART 3

12. Using ratios and proportions calculate the "Deaths per 10,000 Houses" and complete Table 3.

Table 3. Death Rates from Cholera in London, 1853-1854
(According to the water company supplying the actual house)

District	Water Company Supplying the District	Number of Houses	Deaths from Cholera	Death per House	Death per 10,000 Houses
1	Southwark & Vauxhall	40,046	1263		
2	Lambeth	26,107	98		
3	Rest of London	256,423	1422		

13. Which data is more meaningful when comparing deaths in the three districts? Why

14. From what you know today, would filtering the water completely solve the cholera problem? Why?

15. What was Snow's hypothesis for the 1853 – 1854 cholera epidemic?

16. How did he test his hypothesis?

17. List at least three possible alternative explanations he considered when testing his hypothesis? (He mentioned many conditions of the people surveyed in the italicized quote from his book.)

    1.

    2.

    3.

18. List at least two possible explanations for the deaths from cholera in the homes supplied by the Lambeth Company.

    1.

    2.

19. Write a testable hypothesis for one of your explanations above. Briefly describe how your hypothesis could be tested.

20. From your knowledge of the London lifestyle, what actions would you take to protect the public's health? Was there a need to change the way things were? What are your thoughts on disease and unsanitary conditions?