

## Germ theory of Disease - John Snow

### Introduction

This activity is for use in class with alternating reading and discussion of a question. It teaches an interesting and important story in the history of the Germ Theory of Disease. It also introduces some key ideas about how a scientific theory develops. These will be expanded and reinforced later in the course.

### Teaching approach

One starting point would be to talk about a modern epidemic, AIDS for example, before giving out the sheets and introducing the history of cholera. The teacher could talk about the information or the students can read it for themselves.

### The questions are meant as teaching points, not as tests of comprehension

One way to use them is at the end of each section, to get students to briefly discuss their answer in pairs; then to have a teacher-led discussion with the whole class, section by section so that they begin to understand how ideas about science are relevant to the story.

Students find it quite difficult to think themselves back to a time when the germ theory was not known.

If time is short or the class finds the ideas difficult the last section, “a more rigorous test” could be omitted. It does however provide a useful introduction to several Ideas about Science.

The homework is not as demanding as the worksheet itself and gives an opportunity for the non-science students to shine.

### Answers to the questions

1. Smells were readily observed and the correlation between smelly districts and illness must have been obvious to most people.
2. If the disease had been caused by smells in the air then most people would have been exposed at the same time and might be expected to get ill at the same time. Contagion requires that the disease has time to multiply in one person before it is spread to others, explaining the delay.
3. Based on his observations Snow had an idea that the disease was spread by water. It is an idea that can be tested. This is a hypothesis - it could not be called a theory at this stage because it has not been confirmed by observation or experiment.

#### References

**Textbook**  
Chapter 1

**Specification**  
*9.1 Infectious diseases*

*12.1 d-i*

*12.2 a-c*

*13.9*

#### Method

**Use small group discussion because**

- Students enjoy it
- It allows active involvement by everyone
- One loud or quicker thinking student cannot dominate the class
- The shy and less articulate are more able to contribute
- Students learn from each other
- Everyone gets more practice at expressing their ideas
- A two way discussion is almost always more creative than individual thoughts
- Social skills are practiced in a “safe” environment
- It helps individuals clarify arguments for a topic where there are no “right answers”

4. The miasma theory was widely believed and it takes strong persuasion for people to give up established ideas. There was no evidence of the infectious agent in water. They are of course too small to be seen by the naked eye.
5. The number of cases increased the closer the house was to the pump. He of course already suspected that water was involved so he was alert to this particular connection.
6. No it does not, for two reasons:
  - There is a correlation but this could be caused by some other factor which we do not know about which was different in these particular streets - such as the age of people or the level of overcrowding.
  - A correlation never provides definite proof. A causative mechanism must be found. This only happened in 1883 when Koch discovered the bacterium which causes cholera.
7. Social class could be a variable which affected the death rate from disease. The fact that his sample included all classes randomly in both groups excludes this as an explanation.
8. Because the two groups are not the same size, the total number of deaths would be different even if water supply had no effect. This gives a ratio, used in the same way as a percentage where percentages would give very small fractional numbers. A ratio or percentage allows comparisons to be made between two samples of different size.
9. If miasma were the cause of cholera we would expect the correlation to be between the street lived in and deaths, because everyone in the same street would have to breathe the same air with the same smells. There is a very strong correlation between water supply and deaths, which is exactly what Snow's hypothesis would predict. When a prediction is confirmed by observation it provides strong support for the hypothesis which led to the prediction.
10. In an attempt to reduce smells, the human waste (including any cholera bacteria) was pumped into the Thames and then into other peoples houses by the Southwark water company. The wrong theory can do real harm.
11. Isolation of sewage from drinking water. Treatment of drinking water to kill any bacteria that do accidentally get in it.

## *Germ Theory of disease - John Snow's Work on Cholera*

### **History**

In around 1817 an apparently new disease appeared in India. The symptoms were violent vomiting and diarrhoea, leading to dehydration, shock, spasms and often death within a few days. It spread across Europe and in 1831 people began dying in England. The disease came in waves called epidemics each lasting a few years. Each epidemic began with one or two isolated cases but the disease soon spread and people died in thousands. This epidemic ended in 1838 but in 1848 another even worse epidemic began in Europe. In some places nearly half of all those who become ill died. People, politicians and doctors were in panic, in some places doctors were attacked; it was thought that they were poisoning the people. In Paris the sick themselves were attacked.

### **Miasma theory**

It was necessary to do something but what? They had to have a theory about the cause to be able to take preventive action. The correlation between overcrowding with poor living conditions and disease was well known. The miasma theory, the idea that bad smells actually caused the disease, seemed to explain the correlation and efforts were made to reduce the smells. At that time there were few sewers, and rubbish of all kinds accumulated in the street. Campaigns to improve sanitation and rubbish collection began in many large cities. In London they built sewage pipes to take waste to the Thames, reducing the smells.

### **1. Explain why the miasma theory seemed to be supported by the evidence available at the time.**

#### **Snow's contagion hypothesis**

During this time John Snow was working as a doctor. In Newcastle he saw the terrible effects of cholera on mining families in the 1831 epidemic. When he moved to London he continued to take an interest in cholera. He cared for patients, and observed the symptoms and progress of the disease but he also collected statistics on the distribution of cases, a science now known as epidemiology, and noticed how it spread from one case to many over a few days. This work led him to the hypothesis that cholera was caused by contagion rather than miasma. He stated his hypothesis as follows "*disease is communicated by something that acts directly on the alimentary canal. The excretions of the sick at once suggest themselves as containing some material which, being accidentally swallowed, might multiply itself*".

### **2. Explain how the pattern of spread of the disease can be explained by contagion better than by miasma.**

#### **Snow's transmission by water hypothesis**

During the 1848 epidemic he kept very careful records of all cholera cases. He noticed that those districts of London which used water from the River Thames had more cholera cases than those which got water from a river running in from rural Hertfordshire. In 1849, the year in which 50 000 people in England died of cholera, he published his hypothesis that the disease was caused by an infectious agent which was transmitted by water as well as by direct contact.

### **3. What do we mean by the word 'hypothesis'? Use Snow's ideas as an example to explain your answer.**

**4. Suggest two reasons why Snow’s new ideas on the causes of cholera were not believed at this stage.**

**A test of the hypothesis - the Broad St. Pump**

In August 1854 a cholera outbreak started close to John Snow’s home in central London.

*"The most terrible outbreak of cholera which ever occurred in this kingdom is probably that which took place in Broad Street, and the adjoining streets, a few weeks ago. 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. The mortality in this limited area probably equals any that was ever caused in this country, even by the plague; and it was much more sudden as the greater number of cases terminated within a few hours. The mortality would undoubtedly have been much greater had it not been for the flight of the population".*

*(John Snow 1854)*



When he visited each case he asked where the patient had obtained water. He found that almost all the sick had got their water from the same pump in Broad St. Others living in the same area but using a different pump did not become ill. Those living further away who chose to take water in Broad St did become ill. He persuaded the authorities to remove the pump handle after which there were no new cases. It is likely that these cases all arose from one case in a house which allowed sewage to seep into the ground and contaminate the well. The map with each case carefully marked is a good example of John Snow’s careful work in epidemiology.

**5. Explain how the map helped Snow reach the idea that the pump was the source of the infection.**

**6. Does the map definitely prove that cholera is transmitted by water?**

**A more rigorous test of the hypothesis**

During the summer of 1854 John Snow undertook painstaking house to house surveys, investigating the source of water used by cholera victims. In one region in South London some households had water piped from the Lambeth water company whilst **others in the same streets** were supplied by the Southwark company. The Lambeth company took its water from a clean stretch of the Thames before it entered London. The Southwark company used polluted Thames water in London. Snow described his work as follows:

*No fewer than 300 000 people of both sexes, of every age and occupation and every rank and station, from gentle folks down to the very poor, were divided into two groups without their choice, and in most cases without their knowledge; 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 having water quite free from such impurity. To turn this grand experiment into account all that was required was to learn the supply of water to each individual house, where a fatal attack of cholera may occur.*

*(John Snow 1855)*

<b>Water company</b>	<b>number of households</b>	<b>cholera deaths</b>	<b>deaths per 10 000 households</b>
Southwark (water from Thames in London)	40 046	1263	315
Lambeth (clean water from above London)	26 107	98	37

- 7. Why did Snow think the social class and age of the people he studied was worth mentioning?**
- 8. Explain why the column “deaths per 10 000 households” is the most useful data supporting Snow’s hypothesis?**
- 9. Snow’s results, shown in the table, are not easily explained by the miasma theory. Why not? Can they be explained by Snow’s hypothesis, that cholera is caused by an infectious agent carried in water?**
- 10. Why did earlier attempts to reduce cholera, based on the miasma theory, in fact increase the number of cases in customers of the Southwark water company?**
- 11. Explain how cholera infection could have been reduced more effectively.**

### **Summary**

Snow’s theory can be summarised as follows; cholera is spread by a specific agent which replicates in the digestive system. The agent is spread when faeces from the sick person comes into contact with another person’s digestive system, directly, through contaminated clothing or bedding or, most commonly, transmitted by water. His careful work added great support to the hypothesis. By 1875 London had an effective water and sewage treatment and suffered no further outbreaks of cholera.

### **The bacterium is discovered**

Snow’s work showed a correlation between infected water and cholera cases. A correlation can never totally confirm the cause of an illness. It is always necessary to show a causative mechanism. The ‘germ theory of disease’, as it came to be called, predicted that a germ would be found which was transmitted in water and multiplied itself in the sick. In 1883, working in Cairo during a cholera epidemic, Koch identified the cholera bacterium, *Vibrio cholerae*, in victims, in water and in food. This confirmed that the bacterium is the cause of cholera.

### **Modern treatment**

Death from cholera is usually caused by dehydration rather than the infection itself. Nowadays cholera is treated by Oral Rehydration Therapy, ORT and most people survive. The patient regularly takes water, containing sugar and essential salts to replace losses.

- 12. Snow himself campaigned actively to get the authorities to apply his new theory to the prevention of cholera. Write a short account, suitable for a newspaper of the time, with a headline, which would have helped the campaign. Use not more than 350 words.**