7.3 How important was Joseph Lister?

Joseph Lister is credited with helping to bring Pasteur's Germ Theory to acceptance in Britain. He also made use of the Germ Theory in his discovery of antiseptic surgery. What was Lister's contribution to medical science?

Objectives

- **Describe** Joseph Lister's antiseptic ideas and techniques.
- **Assess** why there was opposition to Lister's antiseptic approach in Britain.

Key Biography

Joseph Lister (1827–1912)
Born in Essex, Lister studied surgery and became a fellow of the Royal College of Surgeons in 1852. In 1860, he moved to Glasgow to become a Professor of Surgery. He introduced new principles of cleanliness in surgery.

In Glasgow, 1860, Joseph Lister realised that operations went well as long as the wound was kept free from infection. A Professor of Chemistry, Thomas Anderson, then suggested to Lister that he might be interested in a report by the French scientist Louis Pasteur. Lister thought that Pasteur's Germ Theory might explain the problems of infection he encountered. He asked Anderson if there was a chemical that could kill bacteria; Anderson recommended the use of carbolic acid.

Lister and the antiseptic approach

Lister believed that infections only happened when the skin was broken, and microbes could get in and start an infection. In place of the skin, Lister decided to put a chemical barrier. His first experiment with an antiseptic method was in August 1865. A young boy, Jamie Greenlees, had been run over by cart, which had fractured his leg. The bones were sticking through the skin of Jamie's leg. The traditional surgical procedure would be to amputate above the fracture. Instead, Lister set the bones and used dressings that had been soaked in carbolic acid. The dressings stayed in place for four days, after which time Jamie complained of irritation. Lister feared the worst and expected to find an infection when he took off the dressings. He was impressed to see instead that the fracture and the skin were healing well; the irritation was because of the strength of the carbolic acid. The dressings were replaced and the wound stayed infection-free. After six weeks, Jamie walked out of hospital.

Lister began to test this antiseptic approach out on other surgeries: his method was to spray carbolic acid to coat the surgeon's hands, the wound and the instruments used in an operation. He also soaked the bandages, ligatures and dressings to be applied to the wound in diluted carbolic acid.

▼ **SOURCE A** *An operation in Edinburgh, 1871, where Lister's methods are being used*

▼ **B** *The number of patients dying after Lister used his antiseptic method fell dramatically, as his own records show*

Years	Total amputations	Lived	Died	Mortality (%)
1864–66 (without antiseptics)	35	19	16	46
1867–70 (with antiseptics)	40	34	6	15

Reactions to Lister's work in Britain

Lister published his results in March 1867, giving details of 11 patients with compound fractures, none of whom died of infection. He also publicised Pasteur's Germ Theory through his explanation of the antiseptic technique. In August 1867, Lister lectured doctors about his techniques for using carbolic acid dressings in compound fractures. What was controversial was that he said that infection in wounds was caused by microbes in the air. Surgeons had long debated whether to leave wounds open to the air or to cover them with bandages. Lister argued that the oxygen in the air was irrelevant: it was the microbes in the air that were important. He said that the cause of sepsis came from outside the body and not from spontaneous generation, and recommended his form of antiseptic surgery, which people nicknamed 'Listerism'.

But Lister's ideas were criticised. In 1860s Britain, when people were still not very familiar with Germ Theory, Lister's biologically-based theory of infection was not seen to be the correct view. The wider public health debate was still focused on various chemical theories about causes of infection. Many British surgeons were coming up with new theories: for example, in 1868, Professor John Bennett argued that as cells died, they spontaneously generated infection.

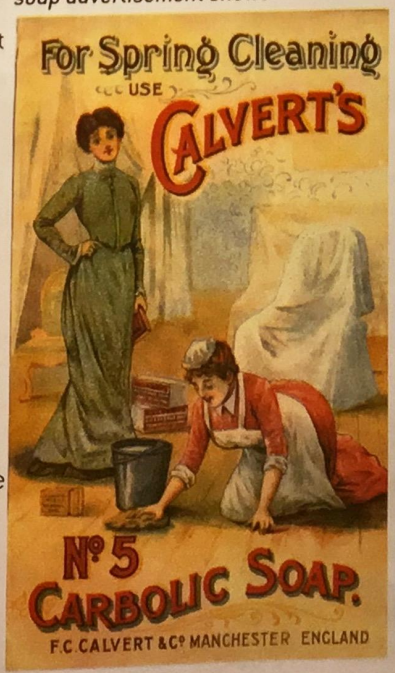
The most influential writer on surgical infection was Charlton Bastian, who strongly championed spontaneous generation. He wrote and lectured widely against Listerism in the late 1860s to the early 1870s. And although Lister clearly linked his techniques with Pasteur's proven new ideas, he retreated from these wider discussions about infection theories, and focussed his research on surgery itself.

Reasons for opposition to antiseptic surgery

- Doctors at the time did not accept Pasteur's Germ Theory and there were many opinions in Britain about the role of microbes in surgery and the causes of infected wounds.
- In the late 1860s, antiseptic chemicals had been widely used, and what Lister was proposing was not revolutionary.
- Lister claimed that his methods of dealing with wound infections were superior to others, but some surgeons thought that their existing methods worked perfectly well.
- His methods were often difficult or unpleasant to use. Carbolic acid made people's hands dry up and crack, and breathing it irritated their lungs. It took a long time for the nurses to prepare his carbolic methods. Lister tried to improve his techniques and made changes. Some surgeons pointed to this as a weakness and suggested that Lister did not know what he was doing.

Although Lister gave advice to prevent hospital infections, he still did not fully understand microbes. In the early 1870s, he believed that microbes were very simple things and incorrectly thought that there might be only one type that caused disease. He also did not scrub his hands before surgery, but merely rinsed them in carbolic acid, and he continued to operate in his street clothes.

▼ **SOURCE C** *Due to Listerism, carbolic acid became associated with a germ-free environment, as this 1910 soap advertisement shows*



Work

1. Describe Lister's antiseptic techniques in surgery.
2. Explain how Lister applied Pasteur's Germ Theory to his own discoveries.
3. Why was there opposition to Lister's antiseptic ideas?

Practice Question

Explain the significance of Lister's work for the development of medicine. **8 marks**

Study Tip

Consider the impact of Lister's work at the time in saving lives and changing the way surgeons and doctors thought about their work. Mention the use of antiseptics in medicine today.

7.4 The debate continues in Britain: accepting Pasteur's Germ Theory

By the 1890s, surgeons in Britain had moved away from antiseptic methods of surgery to **aseptic** ones. So, surgical practices became safer, but doctors were still unsure how people got infections. Various infection theories were still hotly debated, despite Lister's attempts to share Pasteur's Germ Theory with the British audience. Why did it take so long for Pasteur's work to be accepted in Britain? What were the steps towards the acceptance of Germ Theory in Britain?

Objectives

- **Explore** why Pasteur's theory took so long to be accepted in Britain.
- **Examine** the contribution of British scientists and doctors to the acceptance of Pasteur's Germ Theory.

Aseptic surgery

By the 1890s, surgeons in Europe and North America went beyond Lister's antiseptic methods and developed aseptic surgery. Operating theatres were no longer to be soaked in carbolic acid in order to kill microbes; rather, microbes were to be excluded from the start. Surgeons had to be well-scrubbed, wearing gowns and new, thin flexible gloves, and using well-sterilised instruments. The first British surgeon to use rubber gloves was Berkeley Moynihan in the 1890s. Facemasks, rubber gloves, surgical gowns, and replacing huge public operating theatres with smaller rooms dramatically reduced infections. Aseptic surgery depended on accepting Pasteur's theory. When did this begin to happen in Britain?

The evidence for Germ Theory

Louis Pasteur understood from his experiments that specific germs might turn liquid foods – such as milk – sour, or give diseases to animals. However, his ideas were not immediately accepted in Britain. Also, most doctors at the time still did not believe that microscopic germs could harm something as large and advanced as a human. Instead, the idea that specific germs might cause diseases was first noted in Britain not by doctors, but by vets.

The cattle plague of 1866

During the cattle plague of 1866, it was assumed that the disease had started spontaneously. Farmers were reluctant to kill cattle, so the disease quickly spread nationwide. It was soon realised that the outbreak could only be controlled by the quarantining and slaughtering of cattle. As a result of this, there were food shortages and prices rose.

The government appointed the leading scientific user of the microscope, Professor Lionel Beale, to investigate the crisis. In June 1866, Beale's findings not only recognised the specific microbe responsible, 'a living particle of extremely minute size', but also demonstrated how the microscope could help with

▼ **SOURCE A** *A public notice in 1867 in Eccles, Berwickshire showing the use of quarantine to control the cattle plague*

CATTLE PLAGUE.

NOTICE.

NOTICE IS HEREBY GIVEN, That persons who are not employed on the Farm of LANGRIG, in the Parish of Eccles and County of Berwick, are prohibited from entering any Building or Enclosed Place on said Farm, without my permission in writing.

JOHN DOVE.

LANGRIG,
19th November, 1867.

NOTICE IS FURTHER GIVEN, That any person contravening this Order is liable, under the Act of Parliament 29 Vic. cap. 15, to a Penalty of £5, or imprisonment for each offence, and the Police are authorised to apprehend offenders, or report them for prosecution.

GEORGE H. LIST,
Chief Constable.

COUNTY POLICE OFFICE,
Dunse, 19th November, 1867.

J. M. WILKIE, PRINTER, DUNSE.

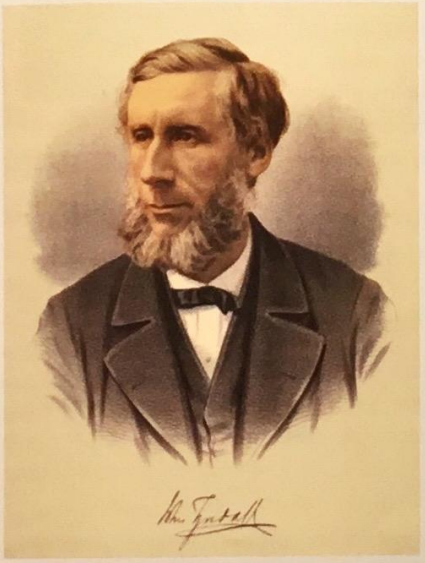
complex medical research. The cattle plague was clearly identified as an example of a contagious disease.

Bastian versus Tyndall

Despite Beale's findings, the dominant view in Britain about infection was still that it occurred spontaneously, and that it was a chemical action that produced poisons. The views of Charlton Bastian, Professor of Anatomy at University College London, dominated debate and he had written many articles in the late 1860s that supported spontaneous generation.

However, in January 1870, Bastian came up against the arguments of the physicist John Tyndall. Tyndall very publicly defended Pasteur's Germ Theory, and argued against Bastian. Tyndall lectured on both dust and

▼ **SOURCE B** *John Tyndall, painted c1890*



Extension

GCSE

You will find that John Tyndall (1820–93) is an important figure in public health debates in Britain in the nineteenth century. Research his contributions to nineteenth-century science.

Key Word

aseptic

disease, bringing together Pasteur and Lister's work with experiments on light that showed the tiny microbes in ordinary air.

Typhoid fever

Many British doctors' views about Germ Theory finally changed due to public health debates about the disease typhoid fever. Typhoid fever was an infectious bacterial fever, and symptoms included red spots and severe intestinal irritation. It was common throughout Britain, but public awareness was raised in 1861 when it was said to be the cause of Prince Albert's death. Anti-contagionists had always said that typhoid fever was the disease that clearly proved they were right about cleaning up urban areas. Therefore it was important news when, in 1874, the scientist Emanuel Klein announced that he had identified the typhoid microbe. Immediately, Tyndall criticised spontaneous generation and said that Germ Theory explained typhoid fever. Unfortunately, Klein was mistaken: he had not found the typhoid microbe.

However, within two years, the work of Robert Koch and others after him proved to doctors that Germ Theory could explain human diseases such as typhoid fever.

Fact

Natural remedies

While debates raged about whether illnesses were caused by biological or chemical processes, many doctors continued to use natural drugs, such as herbs, to heal people and prevent sickness. For example, it had been known since the seventeenth century that Peruvian bark could prevent malaria.

Work

1 How does aseptic surgery differ from antiseptic surgery?

2 a How did the 1866 cattle plague contribute to people's acceptance of Pasteur's Germ Theory in Britain?
  b What about typhoid fever? How did that contribute to the acceptance of the theory?

3 It took a long time for Germ Theory to be accepted in Britain. Create a timeline or a chart to explain the contribution of all the individuals who helped in its acceptance, and the opposition they faced at the time. Make sure you include: Lionel Beale, John Tyndall, Joseph Lister.

8.1 How did scientists discover that germs caused human diseases?

Louis Pasteur made a momentous breakthrough in 1861 with the publication of his Germ Theory. He had proven that germs were all around, and some of them could cause disease – but he was a chemist, not a doctor. He wasn't able to link his Germ Theory to humans. Many doctors did not realise that germs could harm humans too. It took a German doctor, Robert Koch, to apply Pasteur's theories to human diseases. How did Koch's work impact on medical progress in Britain?

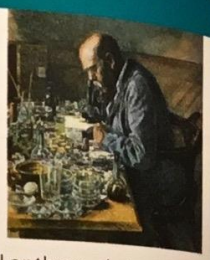
Objectives

- **Describe** Robert Koch's methods and discoveries on microbes.
- **Evaluate** the contribution of Koch to medical progress.
- **Explain** Koch's impact in Britain.

Key Biography

Robert Koch (1843–1910)

Dr Robert Koch was born in Germany. He studied to be a doctor, and was a brilliant student under Professor Frederick Henle (the first person to challenge spontaneous generation and suggest that microbes caused infection). Koch worked as a surgeon in the Franco-Prussian War; from 1872 to 1880 he was German Medical Officer. He was a pioneering microbiologist, and he was appointed to the Imperial German Health Bureau in Berlin. Koch is known as the founder of modern bacteriology (study of bacteria), and made key discoveries in public health, including identifying the specific bacteria that caused anthrax, cholera, and tuberculosis. He was awarded the Nobel Prize in 1905.



Koch and Pasteur's Germ Theory

Koch first became famous in 1876 for his work on anthrax microbes. Anthrax is a disease that causes sores on the lungs, and can kill both humans and animals. Koch found a way of staining and growing the particular germ he thought was responsible for anthrax. He then proved that it was this bacterium that caused the disease by injecting mice and making them ill. For the first time, he was able to apply Pasteur's theory to prove that germs caused diseases in humans.

Later on, using similar methods, Koch was able to identify the germs that caused the deadly diseases of cholera and tuberculosis. Although Koch was very much inspired by Pasteur, they saw each other as rivals: through their new scientific discoveries, they competed in honour of their respective countries.

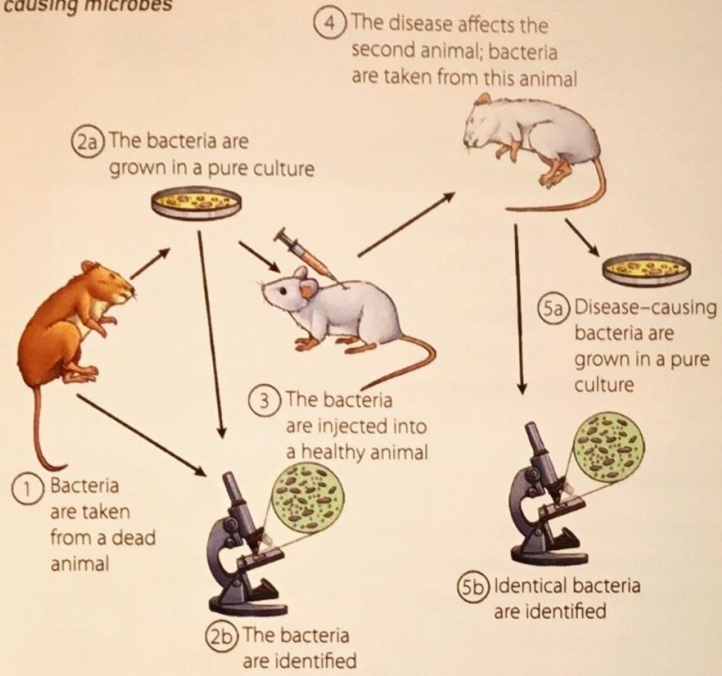
Robert Koch's methods

Koch not only made improvements, but also changed the study of bacteria. Previously it was believed that most germs were the same. His methods and findings allowed other scientists to locate specific germs that might cause specific human diseases. Some of his main principles of studying bacteriology follow.

- To prove a specific bacterium was responsible for a specific disease, Koch said the bacterium had to be present in successive experimental animals that were infected with it. The bacterium could be retrieved from each dead animal and cultured (grown) again.
- Koch developed the technique of growing microbes on a plate made of solidified agar (a seaweed extract), which encourages microbes to grow.
- He found ways of using dyes to stain specific microbes under the microscope so that they would stand out among all the other germs.
- He also developed ways of photographing microbes so that other scientists could study them in detail, and find them in samples.

Koch turned bacteriology into a science. He perfected the methods that allowed scientists to hunt specific disease-causing microbes.

▼ **A** *Robert Koch's laboratory method of identifying specific disease-causing microbes*



Koch didn't work alone – he had a team working with him, and also trained many young scientists to use his methods. Scientists produced a string of discoveries in the decades to follow, identifying the specific germs responsible for typhoid, pneumonia, meningitis, plague and tetanus.

Reactions to Koch's and Pasteur's work in Britain

Role of Tyndall

As the debate about typhoid rumbled on in mid-1870s Britain (remember that Emanuel Klein thought he had identified the typhoid bacterium in 1874, but was mistaken), Germ Theory was finally starting to win acceptance. Firstly, a number of British germ studies were published between 1873 and 1875: these used microscope evidence and answered many questions about germs. For example, in 1874, William Dallinger and John Drysdale published a paper describing the life cycle of microbes. Secondly, John Tyndall continued to promote Pasteur's Germ Theory widely, and in 1876, he lectured to British doctors on Koch's discoveries about anthrax.

Work

1. Explain some of Koch's principles in your own words.
2. Discuss in groups or in pairs: in your opinion, which was the more important achievement of Robert Koch – his discoveries, or his methods? Why?
3. Add the contributions of William Roberts, William Cheyne and Robert Koch to your timeline from Work question 2, page 49.
4. Who was most responsible for the acceptance of the Germ Theory in Britain? Explain your answer.

Key word

vaccine

Roberts and Cheyne

In the end, it was the crucial contributions of two British doctors that won over opinion about Germ Theory in Britain. A Manchester doctor, William Roberts, who had supported Tyndall's criticisms of spontaneous generation, developed a doctor's version of the Germ Theory of disease: he linked all the laboratory research work with the practical evidence of surgeons and public health doctors. In particular, he used the work of Koch to draw attention to germs and their role in human infections.

Then, in 1879, Joseph Lister's deputy surgeon, William Cheyne translated Koch's work into English. He also wrote a paper based on Koch's findings. Cheyne explained that some microbes present in healthy tissue and wounds were harmless and did not always produce disease.

By the 1880s, British doctors accepted Germ Theory and its role in explaining infection. Surgery and public health benefited from Germ Theory, but doctors dealing with disease deep inside the body could not use intense heat or powerful antiseptics. Nobody had yet come up with a way to kill or alter microbes in the body without damaging healthy tissue. Despite this, there was great optimism that, as more specific microbes were isolated and identified, appropriate **vaccines** would follow.

Practice Question

Compare the work of Pasteur and Koch. In what ways were they different?

8 marks

Study Tip

Consider how much change each scientist brought about in medical thinking. You could refer to how many lives were affected by their work.

8.2 The search for vaccines and cures in Europe and Britain

As more specific disease-causing germs were identified, many doctors and scientists were eager to produce vaccines for the diseases. The two great giants of bacteriology – Louis Pasteur and Robert Koch – fought to make the next breakthrough.

Objectives

- **Summarise** Pasteur's and Koch's work in the 1880s.
- **Explain** the factors involved in the search for vaccines between 1800 and 1900.

Pasteur and Koch were not the only ones making scientific discoveries in the second half of the nineteenth century, but they were the most famous. There were several main factors that contributed to scientific breakthroughs in the 1880s and 1890s, as seen through the rivalry of Pasteur and Koch.

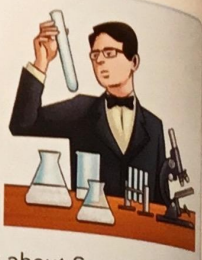
1 War

1871: The rivalry between Pasteur (a Frenchman) and Koch (a German) increased after France had lost a war against Germany. At this time, nations were interested in medical research because armies could lose more men to illness than to bullets. Defeating diseases could have a big impact on the battlefield.

2 Government and finance

Both Pasteur and Koch were equipped with a laboratory and a team of scientists, paid for by their governments. They both were recognised internationally with many honorary awards and prizes, including the Nobel Prize in 1905 for Koch, and the Copley Medal in 1874 for Pasteur.

3 Individual character



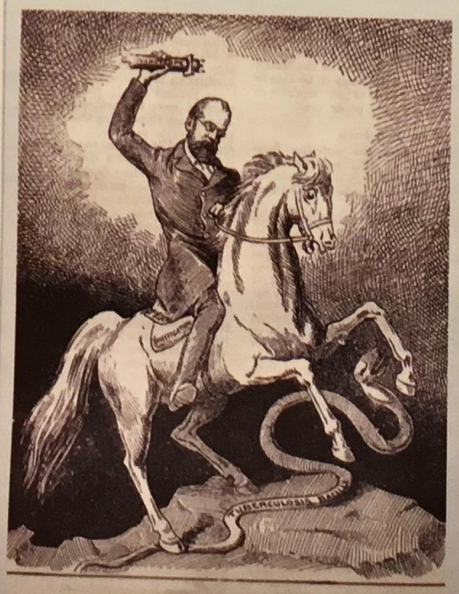
Pasteur: 1860s: He was a determined and hardworking scientist, despite suffering a stroke and losing his daughter to typhoid.

1871–75: He returned to work and continued to investigate agricultural problems, studied the fermentation of beer, and defended his ideas about Germ Theory.

1876–81: Koch's success in identifying the anthrax germ in 1876 spurred Pasteur and his team on to quickly develop vaccines for two animal diseases: cholera and anthrax.

Koch: 1882: Koch was also a strong-minded and rigorous scientist and doctor. After his first discovery, he went on to study tuberculosis (TB). The rivalry was further inflamed when Koch made a great breakthrough in 1882 by identifying the TB germ.

1883: Koch's team of scientists also beat a French team to identify the cholera germ.



KOCH AS THE NEW ST. GEORGE.

Fact

TB was the largest cause of adult deaths in Western Europe. Throughout the 1870s, it killed over 50,000 people a year in Britain.

◀ **SOURCE A** *A cartoon from the 1880s; it shows Koch conquering the bacteria responsible for tuberculosis*

4

Luck

1879: Pasteur was investigating chicken cholera, a disease that was crippling the French poultry industry. By accident, Charles Chamberland, one of Pasteur's assistants, used an old and weakened sample of the disease microbes. When the chickens were injected, they survived. More importantly, these chickens also survived when they were then injected with fresh strong germs. Pasteur showed that the weakened microbes built up the chicken's own defences against the stronger ones. This was how vaccines, or the prevention of diseases, worked!

5

Communication

Pasteur developed a vaccine against the deadly animal disease anthrax. He demonstrated his vaccine in front of an audience of politicians, farmers and journalists in France in May 1881. News of this success was quickly sent around Europe by electric telegraph. News of Koch's discoveries was spread by scientific articles and at conferences.

Impact of Pasteur's and Koch's work in Britain

Between them, Pasteur and Koch encouraged a whole new generation of scientists to study deadly diseases and to find ways of preventing them.

Many of these discoveries soon spread to Britain. For example, Joseph Lister introduced the French serum for diphtheria to Britain, and it was widely used after 1895. Within 10 years, the mortality rate in England dropped to less than half.

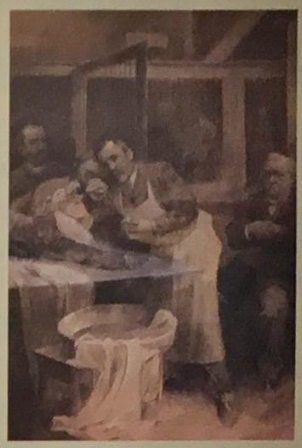
Work

1. Why did governments pay for scientific research?
2. **Source A** shows admiration for Koch's achievement. How do you know?
3. Explain the contributions of the following people to the development of effective treatment for diseases: Pierre Roux, Emil Behring, Paul Ehrlich.
4. How did Pasteur's discoveries help people understand how vaccinations worked?

6

Teamwork

1880–84: Working with Charles Chamberland and Pierre Roux, Pasteur developed a vaccine for rabies, based on the dried spinal cords of infected rabbits. But he was reluctant to test it on a person.



▲ **INTERPRETATION B**
Pasteur and his team collecting the saliva from a rabid dog

1885: Pasteur proved that vaccines worked on human, as well as animal, diseases when he gave a boy who had been bitten by a rabid dog the rabies vaccine.

1888–90: The rivalry continued over research on diphtheria, a highly contagious disease that affects the nose and throat. In France, Pierre Roux, one of Pasteur's scientists, showed that the diphtheria germ produced a poison or toxin. In 1890 in Germany, Emil Behring, one of Koch's students, showed that weakened diphtheria germs could be used to produce an antitoxin.

Fact

As well as the search for biologically-based vaccines to prevent illnesses, scientists also tried to find chemicals that would attack the specific germs that caused illnesses, and cure them. In 1909, Paul Ehrlich (a German doctor who had been part of Koch's team), developed the first chemical cure for a disease: he found that the chemical Salvarsan 606 cured syphilis. He described it as a 'magic bullet', because it targeted the harmful germ specifically, and destroyed it without harming the rest of the body.

Practice Question

Was luck the main factor in the development of vaccines between 1880 and 1900? **16 marks** **SPaG: 4 marks**

Study Tip

Write about luck and choose two other factors you think were important.