The Case Studies

1. Smallpox, the First Vaccine
A country doctor named Edward Jenner developed the first smallpox vaccine nearly 150 years before the virus could be seen with an electron microscope. His technique of injecting a less harmful virus into the body to stimulate the immune system was truly remarkable. The action of white blood cells was not understood until nearly 100 years after the administration of the first smallpox vaccine.

Despite a lack of information on how the disease spread, Edward Jenner developed a successful vaccine in 1796. By noticing that rural townsfolk seemed less susceptible to the deadly smallpox, Jenner began to formulate a hypothesis. He believed that the immunity of the country people must be related to their environment. He noted that dairy maids had a particularly low incidence of smallpox, but a high incidence of a much less harmful disease called cowpox. Cowpox produced many of the same symptoms as smallpox.

a) Dairy maids often had cowpox sores on their hands.
Suggest a possible source of the virus.

b) Assuming that the virus is contagious, would you expect to find that cowpox would infect people other than dairy maids? Give your reasons.

Jenner reasoned that cowpox must have provided some immunity to the more virulent smallpox virus. To test his theory, he injected the pus from a festering wound on the arm of a dairy maid, Sarah Nelms, into a young boy named James Phipps. Not surprisingly, James developed cowpox.

However, he recovered from the mild infection quickly. Two months later, Jenner inoculated James once again, but this time with the more virulent smallpox. When James failed to develop smallpox, Jenner declared that a successful vaccine had been developed.

c) What dangers did Jenner's untried procedure hold for young James Phipps?

d) Jenner's experiment was successful; however, many modern-day scientists would argue against using humans for such a test. Why do you think using humans as a first test subject is no longer accepted?

The cowpox virus has a shape that is very similar to that of smallpox. White blood cells identify cowpox antigens and signal other white blood cells to produce antibodies against them. Fortunately, the antibodies for cowpox also
Mechanism of Immunity

Cowpox antigen (virus) invade cells of the body. The antigen disrupts the normal activities of the cell.

Many times, the cowpox virus kills the cell and virus particles escape. The dead cells often appear as sores. The viruses that escape can invade other cells, causing further cell damage.

White blood cells identify cowpox antigens and signal other white blood cells to produce antibodies against them. The antibodies tie up the antigens. This makes the antigen less soluble and easier to engulf by the white blood cells.

Prove successful against smallpox. (See the diagram on the following page.) If Jenner had injected smallpox first, James might have died. Smallpox reproduces much faster than cowpox. Fortunately for James, the antibodies against cowpox lay in wait for the more dangerous smallpox.

e) What makes the cowpox virus less virulent than smallpox?

f) Explain why cowpox antibodies stop the spread of smallpox in the human body.

In this century, a coordinated international vaccination program against smallpox has resulted in the elimination of the disease. The World Health Organization has officially declared smallpox defeated. The last recorded case of smallpox was in October 1977.
b) Why do the symptoms of rabies not show up immediately after the virus enters the first cell?

The technique used for smallpox cannot be applied to all microbes. Most virulent microorganisms do not have a harmless twin like cowpox. Injecting a full-strength virus means developing the disease. Louis Pasteur was able to grow the virus in tissue cultures. Using trial-and-error testing, he found ways of weakening the virus.

i) Why did Pasteur want to weaken the rabies virus before injecting it into a person?

Because the rabies virus remains dormant in the body for 14 days, a weakened virus would stimulate the production of antibodies that would lie in wait for the virulent rabies. Once the dormant virus emerged, the antibodies would destroy it before it could gain a foothold in the body.

ii) Draw a diagram showing how the virus is defeated when it emerges from the body cell after its incubation period.

In 1885, Pasteur administered the vaccine to Joseph Meixner, a nine-year-old boy who had been bitten by a dog carrying rabies. Joseph lived to become the gatekeeper at the Pasteur Institute. His devotion was so great that he committed suicide rather than open Pasteur's crypt for the invading Nazi army in 1940.

ii) The Rabies Vaccine

Rabies, although never the mass killer like smallpox, was greatly feared for its devastating effects. The tiny virus migrated from the blood into the nervous system, where it destroyed cells, causing convulsions and great suffering.

j) The rabies virus enters the cell and multiplies inside the cell. Fourteen days later, many virus particles emerge from the cell. Explain why the reproduction of the virus inside the host cell makes it especially dangerous.

The rabies virus multiplies inside the cell and emerges 14 days later.
Pasteur discovered that the rabies virus was less virulent if it was grown in the brain tissue of rabbits. He used chemicals to weaken the virus further.

III The Polio Vaccine

The polio virus was responsible for many deaths before the development of the Salk vaccine in 1955, but far more were left crippled for life by this devastating disease.

Jonas Salk became an overnight celebrity with the development of a vaccine,研究院 killing the virus in a bath of formaldehyde. Salk was able to inject it into test animals without causing the disease. The viral coats stimulated the production of antibodies. The invasion of any virulent polio viruses would now have to deal with the antibodies, if they were to gain a foothold. The vaccine is 60% successful against type 1 polio, and 90% successful against types 2 and 3.

k) Propose an explanation for why an antibody would work well against one type of polio but not against another.

Case-Study Application Questions

1. The following procedures are used in disease prevention.

   a) Isolate the organism suspected of causing the disease.
   b) Grow the organism in the laboratory.
   c) Inoculate healthy animals with the cultured organism.
   d) Observe the animal to determine if it contracts the disease.
   e) If the animal contracts the disease, isolate the organism once again and attempt to weaken it or slow its reproduction.

2. Why do you think most vaccines are injected rather than taken orally?

3. The first chemical therapy for disease control was developed by Paul Ehrlich. He used an arsenic compound called salvarsan to kill syphils microorganisms. Salvarsan acts on the microbe as a chemical poison without destroying human blood cells. It is often described as a selective toxin. Explain how chemical therapy differs from vaccines.

Chapter Seven: Taxonomy and Viruses