DISEASE & RESISTANCE

The body's first line of defence against harmful pathogens is the skin and stomach acid, the second is white blood cells. Vaccination involves exposing the body's immune system to a weakened or harmless version of the pathogen in order to stimulate white blood cells to produce antibodies.

Pathogens

Pathogens are micro-organisms that cause infectious disease. Bacteria and viruses are the main pathogens.

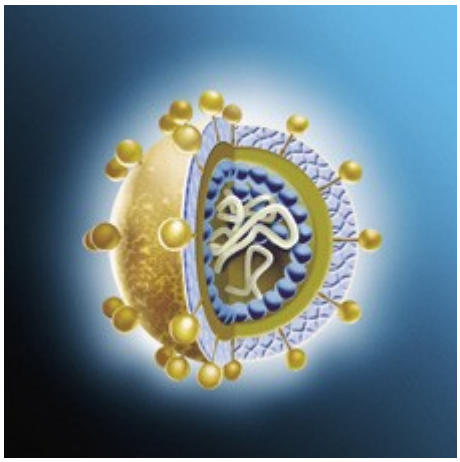
Bacteria

Salmonella bacterium cell

Bacteria come in many shapes and sizes, but even the largest are only ten micrometres long (ten-millionths of a metre).

Bacteria are living cells and can multiply rapidly in favourable conditions. Once inside the body, they release poisons or toxins that can make us feel ill.

Viruses



Hepatitis C virus. DNA are enclosed in a protein coat.

Viruses are many times smaller than bacteria. They are among the smallest organisms known, consisting of a fragment of genetic material inside a protective protein coat.

Viruses can only reproduce inside host cells, damaging them when they do so. Once inside, they take over the cell and make hundreds of thousands of copies of themselves. Eventually, the virus copies fill the whole host cell and it bursts open. The viruses then pass out through the bloodstream, the airways, or by other routes.

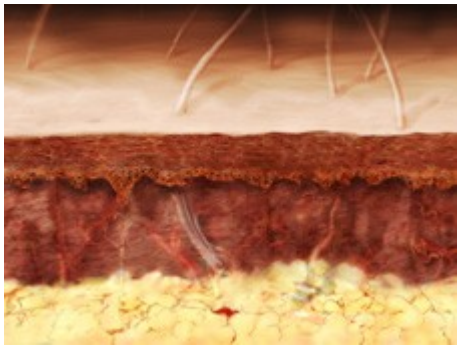
The first line of defence

Most pathogens have to get inside someone's body in order to spread infection. Once they are in, the body provides ideal living conditions: plenty of food, water and warmth. Standing in their way are our immune systems, which are the body's coordinated response to invading pathogens.

The first line of defence, though, is the body's natural barriers. These include:

- skin
- chemicals in tears
- chemicals in sweat
- stomach acid

The skin



Cross-section of skin

The skin covers the whole body and protects it from physical damage, microbe infection and dehydration. It is difficult for microbes to penetrate the skin's dry, dead outer cells. In addition the sebaceous glands produce oils which also help to kill microbes.

Stomach acid

The stomach contains hydrochloric acid. It destroys micro-organisms which you swallow with your food and drink. This helps to protect against food poisoning caused by salmonella and other harmful bacteria.

The second line of defence

When micro-organisms enter the body, they release toxins. The toxins damage cells and this causes the symptoms of the disease.

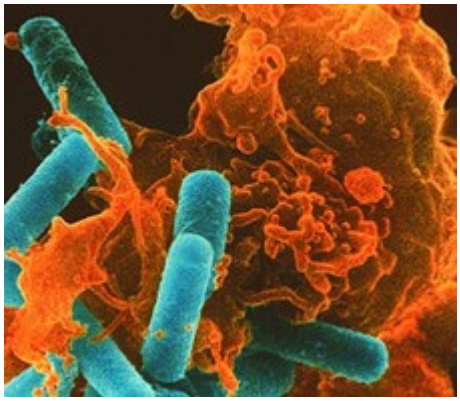
White blood cells

The body's first line of defence is called passive immunity, which means preventing the pathogen from entering in the first place. If a pathogen manages to get into the body, the second line of defence takes over. This is called **active immunity**. The white blood cells have key functions in this.

Functions of the white blood cells

White blood cells can:

- ingest pathogens and destroy them
- produce antibodies to destroy pathogens
- produce antitoxins that neutralise the toxins released by pathogens



A white blood cell ingesting disease-causing bacteria

In a written examination, it is easy to get carried away and write about things like invaders and battles. You should stick to the point. Note that:

- The pathogens are not the disease, they cause the disease.
- White blood cells do not eat the pathogens, they ingest them.
- Antibodies and antitoxins are not living things, they are specialised proteins.

Types of white blood cell

There are several types of white blood cell, each with a different function. But there are two main groups. These are phagocytes or macrophages, and lymphocytes.

Phagocytes

Phagocytes can pass easily through blood vessel walls into the surrounding tissue, and move towards pathogens or toxins. They then either:

- ingest and absorb the pathogens or toxins
- release an enzyme to destroy them

Having absorbed a pathogen, phagocytes may also send out chemical messages that help nearby lymphocytes to identify the type of antibody needed to neutralise them.

Lymphocytes

Pathogens contain certain chemicals that are foreign to the body. These are called antigens. Each lymphocyte carries a specific type of antibody - a protein with a chemical ‘fit’ to a certain antigen. When a lymphocyte with the appropriate antibody meets the antigen, the lymphocyte reproduces quickly to make many copies of the antibody that neutralises the pathogen.

.

Antibodies neutralise pathogens in a number of ways:

- they bind to them and damage or destroy them
- they coat pathogens, clumping them together so that they are ingested easily by phagocytes
- they bind to the pathogens and release chemical signals to attract more phagocytes

Once the body has made an antibody that recognises a particular micro-organism, it is able to make it again very quickly. This means that if the micro-organism infects the body again, more antibodies are made rapidly. This protects the body against that micro-organism, which means that you are immune to it.

Vaccination

People can be immunised against a pathogen through vaccination. Different vaccines are needed for different pathogens.

Vaccination involves putting a small amount of an inactive form of a pathogen into the body. Vaccines can contain:

- live pathogens treated to make them harmless
- harmless fragments of the pathogen
- toxins produced by pathogens
- dead pathogens

These all act as antigens. When injected into the body, they stimulate white blood cells to produce antibodies to fight the pathogen.

The vaccine contains only a weakened or harmless version of a pathogen, which means that the vaccinated person is in no danger of developing the disease. Some people, however, may suffer a mild reaction. If the person later becomes infected with the pathogen, the required lymphocytes are able to reproduce rapidly and destroy it.

Vaccines and boosters

Vaccinations in early childhood can offer protection against many serious diseases. Sometimes more than one vaccine is given at a time, like the MMR triple vaccine against mumps, measles and rubella.

Sometimes vaccine boosters are required because the immune response ‘memory’ weakens over time. Anti-tetanus injections may need to be repeated every ten years, for example.

Ideas about science - making decisions

There is often a conflict between a person’s right to decide what is best for themselves and their family, and what is best for society as a whole. For example, some people used to think the MMR vaccine against measles, mumps and rubella could cause autism in children. They decided not to risk letting their child have the vaccine and

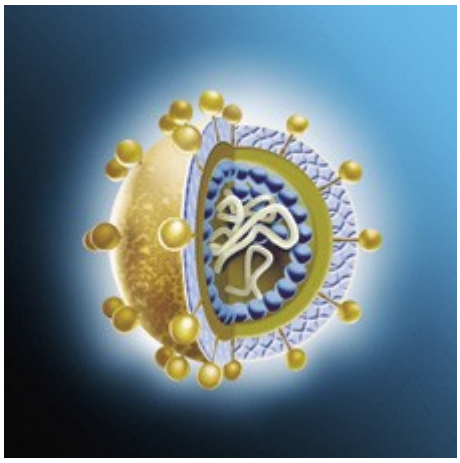
just hope they would not catch measles, mumps or rubella. But this meant that, as less and less children were vaccinated, the three diseases began to spread more easily and the number of cases began to increase. Therefore, a decision originally taken by a single individual had big implications for society as a whole.

Vaccinations can never be completely safe because side-effect levels vary. So, when making a decision, these are some of the factors that should be considered:

- When fewer people are vaccinated, the number of cases of the disease increases.
- The chance of falling seriously ill or dying from the disease may be far greater than the chance of experiencing a serious side-effect.
- Using a vaccine may be much cheaper than treating a very ill person.

Some issues with vaccination

Viruses



Hepatitis C virus. DNA are enclosed in a protein coat.

Some common diseases like influenza (flu) and the common cold are caused by viruses. These mutate quickly, and this changes their surface proteins. This makes it almost impossible to develop a permanent vaccine against them. A new flu vaccine has to be developed every year, after the strain has been analysed.

There is no vaccine for the common cold because the virus that causes it mutates far too quickly. By the time a vaccine could be developed, the virus would have changed its surface proteins. It would no longer be recognised by the antibodies.

The government has policies on vaccination. It advises on when people should be vaccinated against different diseases. The policies and advice are updated as and when new scientific information becomes available.

Ideas about science - weighing up arguments

With respect to vaccination policies, you need to be able to:

- Say clearly what the issue is. For example, is the risk of suffering side-effects from the vaccination greater or less than the risk of catching the disease?
- Summarise different views that might be held. For example, some people used to think there was a risk of children developing autism when they had the MMR vaccine. Other people thought the MMR vaccine was safe and there was no risk of developing autism.
- Identify and develop arguments based on the idea that the right decision is the one that leads to the best outcome for the majority of people. For example, even though there may be a slight risk from being vaccinated, society as a whole will benefit because it will help to reduce the risk of the disease being passed on to other people.
- Identify and develop arguments based on the idea that certain actions are never justified, because they are unnatural or wrong. For example, most people think the government should not pass a law making vaccination compulsory, because it would take away our human right to freedom of choice.

HIV -

HIV is the virus that causes AIDS. It is particularly difficult to develop a vaccine against HIV. This is because the virus not only mutates very quickly but it damages the infected person's immune system.

During an epidemic, an infectious disease spreads very quickly. Epidemics can be prevented if a high proportion of the population has been vaccinated. This reduces the number of people who are able to catch the disease and pass it on to others. The more infectious the disease, the higher the proportion of the population that must be vaccinated to prevent the epidemic.

Ideas about science - feasibility

With respect to vaccination policies, you need to be able to distinguish what can be done, ie what is technically feasible, from what should be done. For example, smallpox is the only disease that has been eradicated from the planet by vaccination. This was possible because smallpox is spread by direct contact, and not through the air.

This made it possible to vaccinate enough people in the world to completely stop the disease from spreading.

Some other diseases are more infectious. But if we could vaccinate a sufficient number of the world's population we could, in theory, eliminate the disease. However, at the moment this is not technically feasible because we do not have enough vaccine, some areas of the world are at war and inaccessible, and some people would refuse to be vaccinated.