Infection & Response

Communicable (infectious) disease

Pathogens are microorganisms that cause infectious disease. Pathogens may be **viruses, bacteria, protists or fungi**. They may infect plants or animals. Transmission is the spread of disease and can occur in the ways shown in the table below.

Type	Examples
Direct contact	This can be sexual contact during intercourse or non-sexual contact, like shaking hands.
Water	Dirty water can transmit many diseases, such as the cholera bacterium.
Air	When a person who is infected by the common cold sneezes, they can spray thousands of tiny droplets containing virus particles to infect others.
Food	Undercooked or reheated food can cause bacterial diseases like Escherichia coli which is a cause of food poisoning.
Vector	Any organism that can spread a disease is called a vector. Many farmers think tuberculosis in their cattle can be spread by badgers.

Bacteria and viruses may reproduce rapidly inside the body. Bacteria may produce poisons (**toxins**) that damage tissues and make us feel ill. Viruses live and reproduce inside cells, causing cell damage.

The Immune System

If a pathogen enters the body the immune system (**white blood cells**) tries to destroy the pathogen.

One type of white blood cell are called **phagocytes**. They surround any pathogens in the blood and engulf them. The phagocyte's membrane surrounds the pathogen and enzymes found inside the cell break down the pathogen in order to destroy it.

Lymphocytes are another type of white blood cell. They recognise proteins on the surface of pathogens called **antigens**. Lymphocytes detect that these are foreign (not naturally occurring within your body) and produce **antibodies**. This can take a few days, during which time you may feel ill. The antibodies cause pathogens to stick together and make it easier for phagocytes to engulf them.

Some pathogens produce **toxins** which make you feel ill. Lymphocytes can also produce **antitoxins** to neutralise these toxins. Both the antibodies and antitoxins are highly specific to the antigen on the pathogen.

Preventing the Spread of Disease

Transmission can be prevent in the following ways:

Method	Example	How it works
Sterilising water	Cholera	Chemicals or UV light kill pathogens in unclean water.
Unsuitable hygiene - food	Salmonella	Cooking foods thoroughly and preparing them in hygienic conditions kills pathogens.
Unsuitable hygiene - personal	Athlete's foot	Washing surfaces with disinfectants kills pathogens. Treating existing cases of infection kills pathogens.
Vaccination	Measles	Vaccinations introduce a small or weakened version of a pathogen into your body, and the immune system learns how to defend itself.
Contraception	HIV/AIDs	Using barrier contraception, like condoms, stops the transfer of bodily fluids and sexually transmitted diseases.

Human Defence Systems

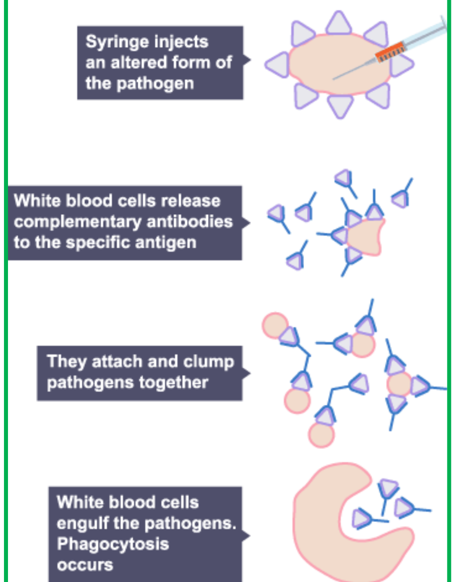
The first line of defence against infection stops the pathogens from entering your body. These are general defences, they are **not specifically** to fight against certain types of pathogen.

- **Skin:** The skin covers almost all parts of your body to prevent infection from pathogens. If it is cut or grazed it immediately begins to heal itself, often by forming a scab, which prevents infection as the skin acts as a physical barrier.
- The eyes produce tears, which contain **enzymes**, which destroy pathogens.
- **Nose:** The nose has internal hairs, which act as a physical barrier to infection. Cells in the nose produce **mucus**. This traps pathogens before they can enter the lungs
- **Trachea & bronchi:** The cells that line the trachea also have hairs called **cilia**, which are much smaller than those in the nose. The **ciliated cells** waft their hairs and move mucus and pathogens upwards towards the throat where it is swallowed into your **stomach**. Other cells called **goblet cells** create the mucus in order to trap pathogens.
- **Stomach:** Stomach acid does not break down food. It is **hydrochloric acid** and kills any pathogens that have been caught in mucus in the airways or consumed in food or water.

Disease	Microbe	Organisms affected	Transmission	Symptoms	Treatment/prevention
Measles	Virus	Humans	Inhalation of droplets from sneezes and coughs.	Fever and a red skin rash. Measles is a serious illness that can be fatal if complications arise.	Vaccination
Tobacco mosaic virus	Virus	Many species of plants including tomatoes	Contact	It gives a distinctive 'mosaic' pattern of discolouration on the leaves which affects the growth of the plant due to lack of photosynthesis.	There's no cure therefore farmers must try to reduce the infection to their crops or attempt to reduce the spread of the virus.
HIV	Virus	Humans	Sexual contact or exchange of body fluids such as blood which occurs when drug users share needles.	Initially causes a flu-like illness. Unless successfully controlled with antiretroviral drugs the virus attacks the body's immune cells. Late stage HIV infection, or AIDS, occurs when the body's immune system becomes so badly damaged it can no longer deal with other infections or cancers.	Use condoms during sex, don't share needles. Treated with antiretroviral drugs
Salmonella	Bacteria	Humans	Bacteria ingested in food, or on food prepared in unhygienic conditions	Fever, abdominal cramps, vomiting and diarrhoea are caused by the bacteria and the toxins they secrete.	In the UK, poultry are vaccinated against Salmonella to control the spread.
Gonorrhoea	Bacteria	Humans	Sexually transmitted disease (STD)	A thick yellow or green discharge from the vagina or penis and pain on urinating. If untreated it can result in infertility.	It was easily treated with the antibiotic penicillin until many resistant strains appeared. Prevented by using condoms.
Malaria	Protist	Humans	The malarial protist has a life cycle that includes the mosquito. It is spread when a mosquito bites a human.	Malaria causes recurrent episodes of fever and can be fatal.	The spread of malaria is controlled by preventing the vectors, mosquitos, from breeding and by using mosquito nets to avoid being bitten.
Rose black spot	Fungus	Roses	Spread in the environment by water or wind.	Purple or black spots develop on leaves, which often turn yellow and drop early. It affects the growth of the plant as photosynthesis is reduced.	Rose black spot can be treated by using fungicides and/or removing and destroying the affected leaves.

Vaccines

Vaccination involves introducing small quantities of dead or inactive forms of a pathogen into the body to stimulate the white blood cells to produce antibodies. If the same pathogen re-enters the body the white blood cells respond quickly to produce the correct antibodies, preventing infection.



During the **primary infection** the antibodies slowly increase, peak at around ten days and then gradually decrease. A **second** exposure to the same pathogen causes the white blood cells to respond quickly in order to produce lots of the relevant antibodies, which prevents infection.

Herd immunity

The majority of the population must be vaccinated against serious diseases to provide **herd immunity**. If the number of people vaccinated against a specific disease drops in a population, it leaves the rest of the population at risk of mass infection, as they are more likely to come across people who are infected and contagious. This increases the number of infections, as well as the number of people who could die from a specific infectious disease.

Antibiotics and painkillers

Antibiotics, such as penicillin, are medicines that help to cure bacterial disease by killing infective bacteria inside the body. It is important that specific bacteria should be treated by specific antibiotics. The use of antibiotics has greatly reduced deaths from infectious bacterial diseases. However, the emergence of strains resistant to antibiotics is of great concern. Antibiotics cannot kill viral pathogens. Painkillers and other medicines are used to treat the symptoms of disease but do not kill pathogens. It is difficult to develop drugs that kill viruses without also damaging the body's tissues.

Discovery and development of drugs

Traditionally drugs were extracted from plants and microorganisms.

- The heart drug **digitalis** originates from **foxgloves.**
- The painkiller **aspirin** originates from **willow**.
- **Penicillin** was discovered by **Alexander Fleming** from the Penicillium mould.

Most new drugs are synthesised by chemists in the pharmaceutical industry. However, the starting point may still be a chemical extracted from a plant.

New medical drugs have to be tested and trialled before being used to check that they are safe and effective. New drugs are extensively tested for:

- **Toxicity:** This is important as some drugs are **toxic**, and have other side effects that might be harmful to people
- **Efficacy:** This checks how well the drug cures the disease, or improves symptoms.
- **Dose:** This varies, and has to be closely controlled, as too high a concentration might be toxic.

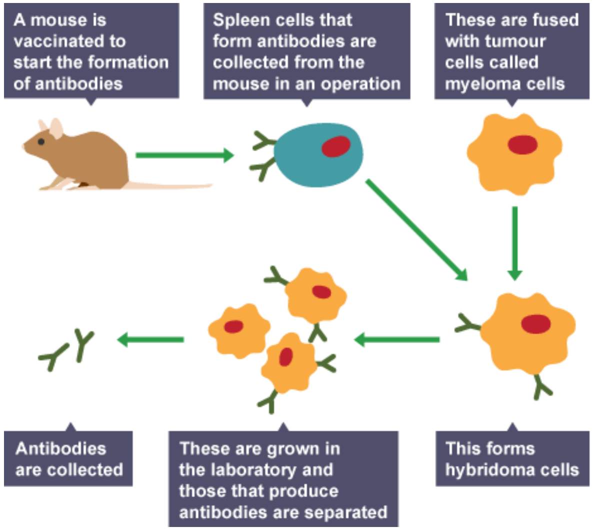
Three stages of testing drugs

1. The drugs are tested using **computer models** and **human cells grown in the laboratory**. This allows the efficacy and possible side effects to be tested. Many substances fail this first test of a **preclinical drug trial** because they damage cells or do not seem to work.
2. Drugs that pass the first stage are **tested on animals in the second part of a preclinical drug trial**. In the UK, new medicines have to undergo these tests. But it is illegal to test cosmetics and tobacco products on animals. A typical test involves giving a known amount of the substance to the animals, then monitoring them carefully for any side-effects.
3. Drugs that have passed animal tests are used in **human clinical trials**. They are tested on healthy volunteers to check that they are safe. The substances are then tested on people with the illness to ensure that they are safe and that they work. Low doses of the drug are used initially, and if this is safe the dosage increases until the optimum dosage is identified.

The **placebo** effect occurs when someone feels they are better when they have been given a dummy form of the drug, not the drug itself.
To reduce the placebo effect in drug testing **double blind trials** are carried out. This is where neither the doctor nor the patient knows who has been given the drug or placebo. Only the researchers know so they can compare the results of the new drug against the placebo effect.

Monoclonal antibodies *(Separate Biology Only)*

Monoclonal antibodies are produced from a single clone of cells. The antibodies are specific to one binding site on one protein antigen and so are able to target a specific chemical or specific cells in the body. They are produced by stimulating mouse lymphocytes to make a particular antibody. The lymphocytes are combined with a particular kind of tumour cell to make a cell called a hybridoma cell. The hybridoma cell can both divide and make the antibody. Single hybridoma cells are cloned to produce many identical cells that all produce the same antibody. A large amount of the antibody can be collected and purified.

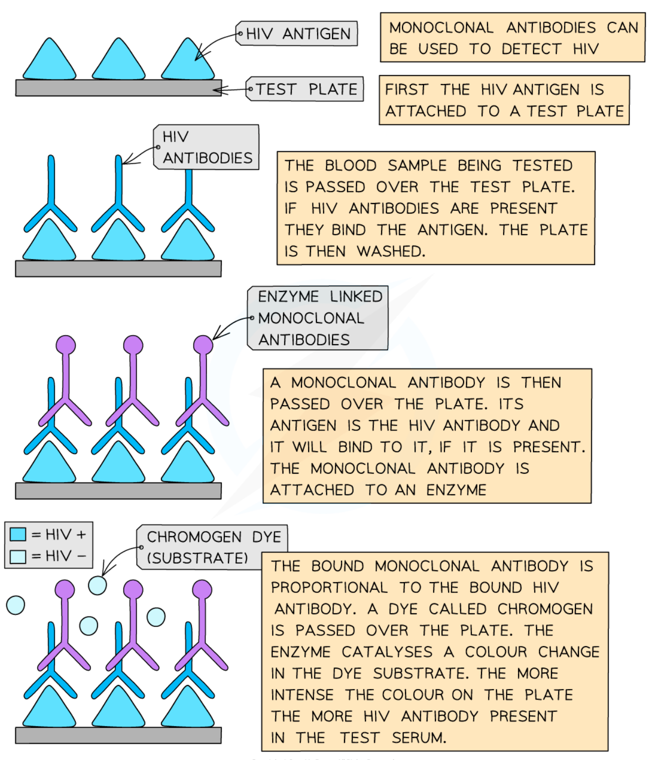


Uses of Monoclonal Antibodies *(Separate Biology Only)*

Some examples of the uses of monoclonal antibodies include:

- for diagnosis such as in **pregnancy tests:** These have been designed to bind with a **hormone** called HCG which is found only in the urine of pregnant women. Monoclonal antibodies are attached to the end of a pregnancy test stick onto which a woman urinates. If she is pregnant, HCG will be present in her urine and will bind to the monoclonal antibodies on the test stick. This will cause a change in colour or pattern which will indicate pregnancy. These specific monoclonal antibodies in the **pregnancy test** will only bind with HCG.
- in laboratories to measure the levels of hormones and other chemicals in blood, or to detect pathogens
- in research to locate or identify specific molecules in a cell or tissue by binding to them with a fluorescent dye
- to treat some diseases: for cancer the monoclonal antibody can be bound to a radioactive substance, a toxic drug or a chemical which stops cells growing and dividing. It delivers the substance to the cancer cells without harming other cells in the body.

Monoclonal antibodies create more side effects than expected. They are not yet as widely used as everyone hoped when they were first developed



Plant defence responses

(Separate Biology Only)

Plants have a range of physical and chemical defence mechanisms to protect them from disease.

Physical defence responses to resist invasion of microorganisms.

- Cellulose cell walls.
- Tough waxy cuticle on leaves.
- Layers of dead cells around stems (bark on trees) which fall off.

Chemical plant defence responses.

- Antibacterial chemicals.
- Poisons to deter herbivores.

Mechanical adaptations.

- Thorns and hairs deter animals.
- Leaves which droop or curl when touched.
- Mimicry to trick animals.

Plant disease

(Separate Biology Only)

Plants can be infected by a range of viral, bacterial and fungal pathogens as well as by insects.

Plant diseases can be detected by:

- Stunted growth
- Spots on leaves
- Areas of decay (rot)
- Growths
- Malformed stems or leaves
- Discolouration
- The presence of pests.

Identification of the disease can be made by:

- Reference to a gardening manual or website
- Taking infected plants to a laboratory to identify the pathogen
- Using testing kits that contain monoclonal antibodies.

Plants can be damaged by a range of ion deficiency conditions:

- Stunted growth caused by **nitrate** deficiency. This is because nitrate ions are needed for protein synthesis and therefore growth.

- **Chlorosis** (yellow leaves) caused by **magnesium** deficiency. Magnesium ions are needed to make chlorophyll (the green pigment in chloroplast which absorbs light energy). The absence of this leads to yellowed leaves.