

4.3 Infection and response

Pathogens are microorganisms such as viruses and bacteria that cause infectious diseases in animals and plants. They depend on their host to provide the conditions and nutrients that they need to grow and reproduce. They frequently produce toxins that damage tissues and make us feel ill.

This section will explore how we can avoid diseases by reducing contact with them, as well as how the body uses barriers against pathogens. Once inside the body our immune system is triggered which is usually strong enough to destroy the pathogen and prevent disease.

When at risk from unusual or dangerous diseases our body's natural system can be enhanced by the use of vaccination. Since the 1940s a range of antibiotics have been developed which have proved successful against a number of lethal diseases caused by bacteria. Unfortunately many groups of bacteria have now become resistant to these antibiotics. The race is now on to develop a new set of antibiotics.

4.3.1 Communicable diseases

4.3.1.1 Communicable (infectious) diseases

Students should be able to explain how diseases caused by viruses, bacteria, protists and fungi are spread in animals and plants.

Students should be able to explain how the spread of diseases can be reduced or prevented.

Pathogens are microorganisms that cause infectious disease. Pathogens may be viruses, bacteria, protists or fungi. They may infect plants or animals and can be spread by direct contact, by water or by air.

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.

4.3.1.2 Viral diseases

Measles is a viral disease showing symptoms of fever and a red skin rash. Measles is a serious illness that can be fatal if complications arise. For this reason most young children are vaccinated against measles. The measles virus is spread by inhalation of droplets from sneezes and coughs.

HIV 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. HIV is spread by sexual contact or exchange of body fluids such as blood which occurs when drug users share needles.

Tobacco mosaic virus (TMV) is a widespread plant pathogen affecting many species of plants including tomatoes. It gives a distinctive 'mosaic' pattern of discolouration on the leaves which affects the growth of the plant due to lack of photosynthesis.

4.3.1.3 Bacterial diseases

Salmonella food poisoning is spread by bacteria ingested in food, or on food prepared in unhygienic conditions. In the UK, poultry are vaccinated against Salmonella to control the spread. Fever, abdominal cramps, vomiting and diarrhoea are caused by the bacteria and the toxins they secrete.

Gonorrhoea is a sexually transmitted disease (STD) with symptoms of a thick yellow or green discharge from the vagina or penis and pain on urinating. It is caused by a bacterium and was easily treated with the antibiotic penicillin until many resistant strains appeared. Gonorrhoea is spread by sexual contact. The spread can be controlled by treatment with antibiotics or the use of a barrier method of contraception such as a condom.

4.3.1.4 Fungal diseases

Rose black spot is a fungal disease where 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. It is spread in the environment by water or wind. Rose black spot can be treated by using fungicides and/or removing and destroying the affected leaves.

4.3.1.5 Protist diseases

The pathogens that cause malaria are protists.

The malarial protist has a life cycle that includes the mosquito. 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.

4.3.1.6 Human defence systems

Students should be able to describe the non-specific defence systems of the human body against pathogens, including the:

- skin
- nose
- trachea and bronchi
- stomach.

Students should be able to explain the role of the immune system in the defence against disease.

If a pathogen enters the body the immune system tries to destroy the pathogen.

White blood cells help to defend against pathogens by:

- phagocytosis
- antibody production
- antitoxin production.

4.3.1.7 Vaccination

Students should be able to explain how vaccination will prevent illness in an individual, and how the spread of pathogens can be reduced by immunising a large proportion of the population.

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.

Students do not need to know details of vaccination schedules and side effects associated with specific vaccines.

4.3.1.8 Antibiotics and painkillers

Students should be able to explain the use of antibiotics and other medicines in treating disease.

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.

4.3.1.9 Discovery and development of drugs

Students should be able to describe the process of discovery and development of potential new medicines, including preclinical and clinical testing.

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, efficacy and dose.

Preclinical testing is done in a laboratory using cells, tissues and live animals.

Clinical trials use healthy volunteers and patients.

- Very low doses of the drug are given at the start of the clinical trial.
- If the drug is found to be safe, further clinical trials are carried out to find the optimum dose for the drug.
- In double blind trials, some patients are given a placebo.

4.3.2 Monoclonal antibodies (biology only) (HT only)

4.3.2.1 Producing monoclonal antibodies

Students should be able to describe how monoclonal antibodies are produced.

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.

4.3.2.2 Uses of monoclonal antibodies

Students should be able to describe some of the ways in which monoclonal antibodies can be used.

Some examples include:

- *for diagnosis such as in pregnancy tests*
- *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.*

Students are not expected to recall any specific tests or treatments but given appropriate information they should be able to explain how they work.

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

4.3.3 Plant disease (biology only)

4.3.3.1 Detection and identification of plant diseases

(HT only) 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.**

(HT only) Identification 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 infected by a range of viral, bacterial and fungal pathogens as well as by insects.

Knowledge of plant diseases is restricted to tobacco mosaic virus as a viral disease, black spot as a fungal disease and aphids as insects.

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

- *stunted growth caused by nitrate deficiency*
- *chlorosis caused by magnesium deficiency.*

Knowledge of ions is limited to nitrate ions needed for protein synthesis and therefore growth, and magnesium ions needed to make chlorophyll.

4.3.3.2 Plant defence responses

Students should be able to describe physical and chemical plant defence responses.

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.*