

# Infection and response revision notes

Pathogens such as viruses, bacteria, protists and fungi cause infectious diseases in animals and plants. This topic covers how diseases spread, how the body and plants defend themselves, and how vaccination, antibiotics and new medicines help us to prevent and treat disease.

For AQA GCSE Biology 8461 and Combined Science: Trilogy 8464. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

## 1 Communicable diseases Spec 4.3.1

### Communicable (infectious) diseases Spec 4.3.1.1

**Pathogens** are microorganisms that cause infectious disease. Pathogens may be viruses, bacteria, protists or fungi. They may infect plants or animals.

Pathogens depend on their host to provide the conditions and nutrients they need to grow and reproduce.

#### How pathogens spread

Pathogens can be spread by **direct contact**, by **water** or by **air**.

#### Routes of infection, with examples from this topic

| Route                           | Examples                                                                                           |
|---------------------------------|----------------------------------------------------------------------------------------------------|
| <b>Direct contact</b>           | HIV (sexual contact, exchange of body fluids such as blood); gonorrhoea (sexual contact)           |
| <b>Water</b>                    | Rose black spot in plants (spread in the environment by water)                                     |
| <b>Air</b>                      | Measles (inhaling droplets from sneezes and coughs); rose black spot (spread by wind)              |
| <b>Other routes in the spec</b> | Salmonella (in food, or on food prepared in unhygienic conditions); malaria (carried by mosquitos) |

#### How pathogens make us ill

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

#### Reducing or preventing the spread

To explain how spread can be reduced, link the method to the way the disease is passed on.

- Good hygiene, such as washing hands and preparing food hygienically, reduces spread by contact and in food.
- Covering the mouth and nose when coughing or sneezing, and keeping infected people away from others, reduces spread through the air.
- Vaccination prevents people from becoming infected.
- Controlling vectors, such as stopping mosquitos from breeding, and avoiding bites reduces the spread of malaria.

- Barrier contraception (a condom) and not sharing needles reduce the spread of sexually transmitted and blood-borne diseases.
- Treating infected people, for example with antibiotics for gonorrhoea, reduces the chance of them passing the pathogen on.
- In plants, destroying infected leaves and using fungicides reduce the spread of fungal disease.

*Exam tip: For a 'how can the spread be reduced' question, name the method and say why it works. 'Wash hands' alone is not enough; add 'to remove pathogens that could be passed on by contact'.*

|                 |                                                                           |
|-----------------|---------------------------------------------------------------------------|
| <b>Pathogen</b> | A microorganism that causes infectious disease.                           |
| <b>Toxin</b>    | A poison produced by bacteria that damages tissues and makes us feel ill. |

## Viral diseases Spec 4.3.1.2

### Measles

Measles is a viral disease. The symptoms are a fever and a red skin rash. It is spread by **inhalation of droplets** from sneezes and coughs.

Measles is a serious illness that can be fatal if complications arise. For this reason most young children are vaccinated against measles.

### HIV

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**, happens when the immune system becomes so badly damaged that it can no longer deal with other infections or cancers.

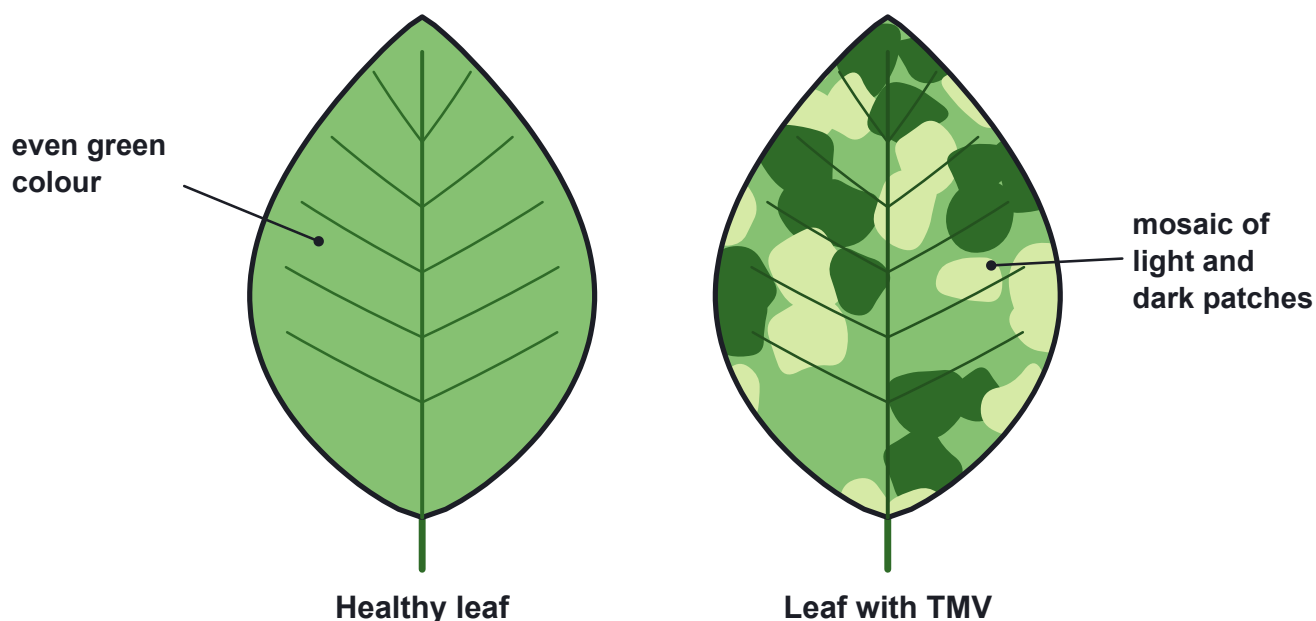
HIV is spread by sexual contact or by the exchange of body fluids such as blood, which happens when drug users share needles.

*Common mistake: HIV is the virus. AIDS is the late stage of the infection. Do not say that HIV is 'the same as' AIDS, and do not say that antiretroviral drugs cure it. They control the virus.*

### Tobacco mosaic virus (TMV)

TMV is a widespread plant pathogen. It affects many species of plants, including tomatoes.

It gives a distinctive **mosaic** pattern of discolouration on the leaves. This affects the growth of the plant because there is less photosynthesis.



TMV gives leaves a **mosaic** of light and dark patches, so there is **less photosynthesis**.

## Bacterial diseases Spec 4.3.1.3

### Salmonella food poisoning

*Salmonella* food poisoning is spread by bacteria ingested in food, or on food prepared in **unhygienic conditions**.

The 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

Gonorrhoea is a sexually transmitted disease (STD) caused by a bacterium. The symptoms are a thick yellow or green discharge from the vagina or penis, and pain on urinating.

It was easily treated with the antibiotic penicillin until many **resistant strains** appeared. It is spread by sexual contact.

The spread can be controlled by treatment with antibiotics or by using a **barrier method of contraception** such as a condom.

| Two bacterial diseases compared |                                                                     |                                                     |
|---------------------------------|---------------------------------------------------------------------|-----------------------------------------------------|
|                                 | Salmonella food poisoning                                           | Gonorrhoea                                          |
| <b>Spread by</b>                | Eating contaminated food, or food prepared in unhygienic conditions | Sexual contact                                      |
| <b>Symptoms</b>                 | Fever, abdominal cramps, vomiting, diarrhoea                        | Thick yellow or green discharge; pain on urinating  |
| <b>Control</b>                  | Vaccinating poultry in the UK                                       | Antibiotics; barrier contraception such as a condom |

**Exam tip:** Use the full name 'barrier method of contraception' or 'condom'. 'Protection' is too vague for a mark.

## Fungal diseases Spec 4.3.1.4

Rose black spot is a fungal disease of plants. Purple or black spots develop on the leaves, which often turn yellow and drop early.

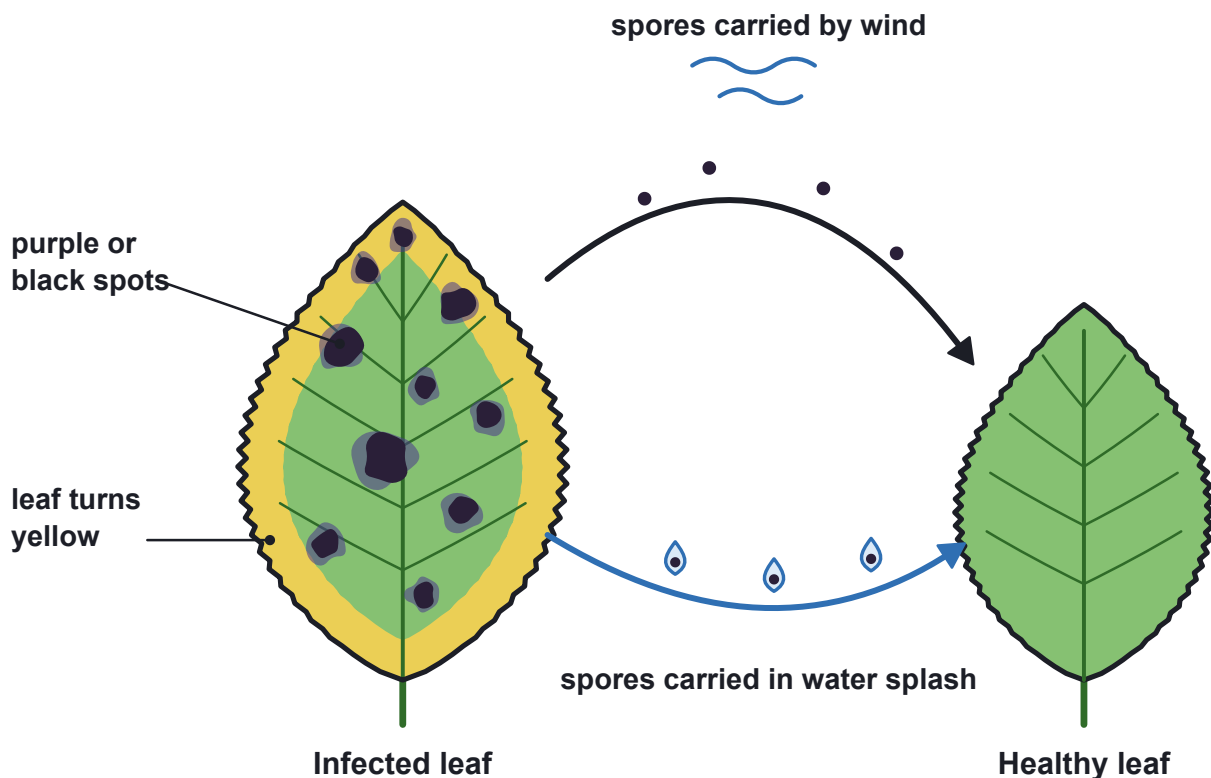
It affects the growth of the plant because photosynthesis is reduced. Less photosynthesis means less glucose is made for growth.

It is spread in the environment by water or wind.

### Treatment

- Using fungicides.
- Removing and destroying the affected leaves.

*Exam tip: The leaves are removed and destroyed, not just removed. Destroying them stops the fungus spreading to other plants.*



Rose black spot: spores of the fungus are spread to healthy leaves by wind and water splash.

## Protist diseases Spec 4.3.1.5

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.

### How malaria spreads

The mosquito is a vector: an organism that carries a pathogen from one host to another. A mosquito picks up the protist when it feeds on the blood of an infected person. It passes the protist on when it bites another person.

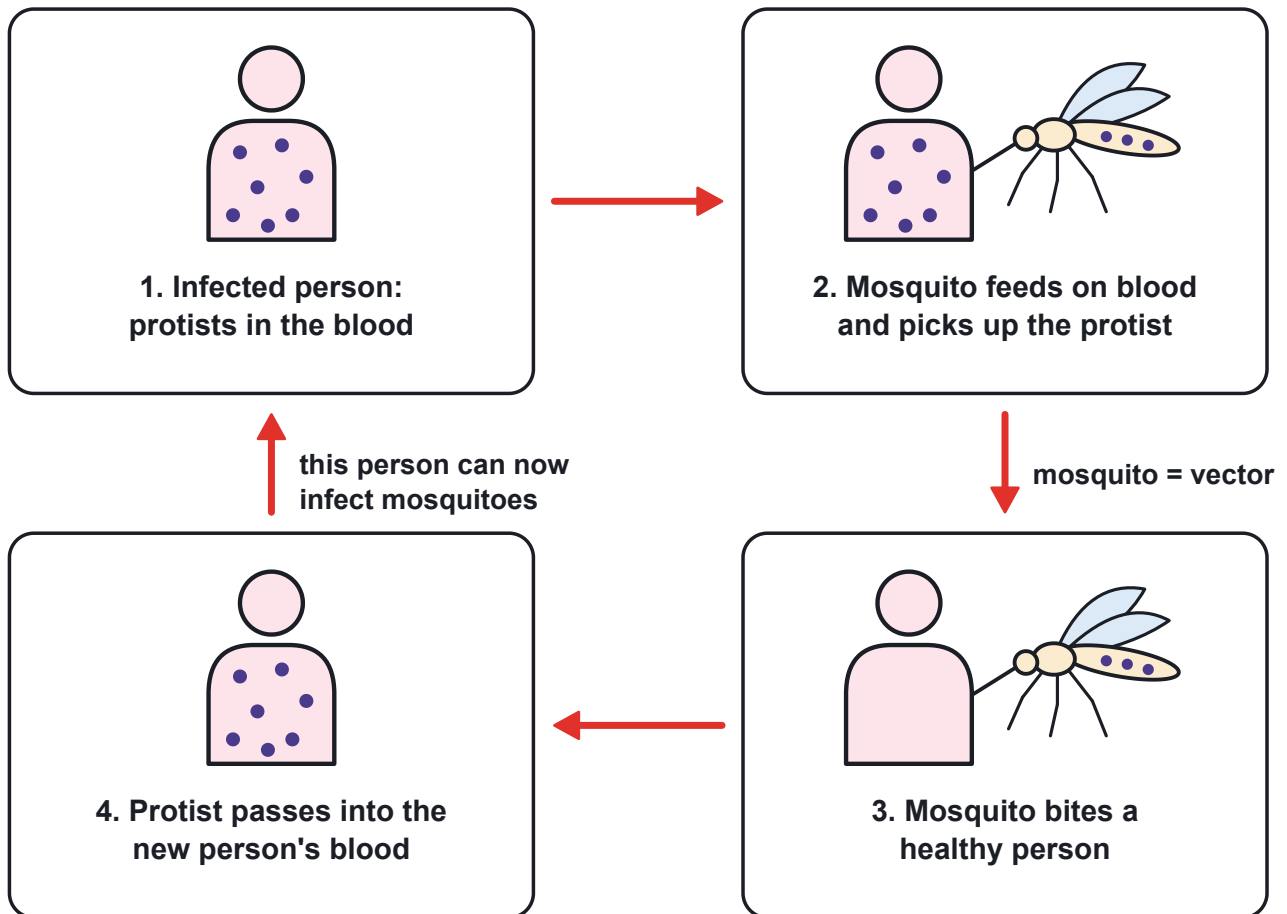
### Controlling malaria

- Prevent the vectors, the mosquitoes, from breeding.
- Use mosquito nets to avoid being bitten.

## Vector

An organism that carries a pathogen from one host to another. For malaria the vector is the mosquito.

*Common mistake: The mosquito is not the pathogen. The pathogen is the protist, and the mosquito carries it between people.*



Malaria: the mosquito is the **vector** that carries the protist from one person to another.

## Human defence systems Spec 4.3.1.6

### Non-specific defences

These defences are the same whatever the pathogen. They stop pathogens getting into the body, or kill them before they can cause infection.

#### Non-specific defences of the human body

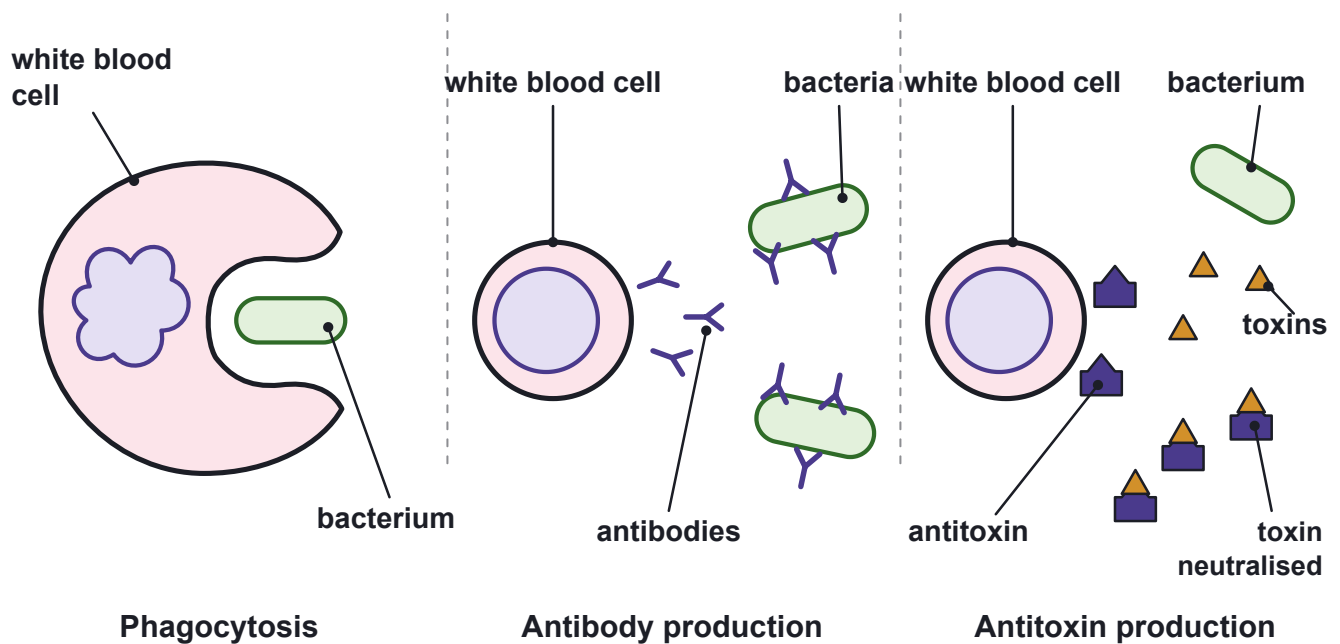
| Defence                    | How it protects                                                                                                           |
|----------------------------|---------------------------------------------------------------------------------------------------------------------------|
| <b>Skin</b>                | Acts as a physical barrier to pathogens and secretes substances that kill them.                                           |
| <b>Nose</b>                | Hairs and mucus trap particles, including pathogens, in the air you breathe in.                                           |
| <b>Trachea and bronchi</b> | Lined with mucus that traps pathogens and cilia (tiny hairs) that move the mucus up to the throat, where it is swallowed. |
| <b>Stomach</b>             | Produces hydrochloric acid, which kills pathogens that are swallowed with food, drink or mucus.                           |

## The immune system

If a pathogen enters the body, the **immune system** tries to destroy it. White blood cells help to defend against pathogens in three ways.

- **Phagocytosis**: a white blood cell engulfs the pathogen and digests it.
- **Antibody production**: white blood cells make antibodies that target a particular pathogen and help to destroy it.
- **Antitoxin production**: white blood cells make antitoxins that neutralise the toxins released by pathogens.

*Exam tip: Antibodies act on the pathogen. Antitoxins act on the toxins. Keep these two apart in your answers.*



Three ways white blood cells defend us: **phagocytosis**, **antibodies** (act on the pathogen) and **antitoxins** (act on the toxins).

## Vaccination Spec 4.3.1.7

Vaccination involves introducing small quantities of **dead or inactive forms** of a pathogen into the body. This stimulates the white blood cells to produce **antibodies**.

### How it protects an individual

1. A vaccine containing dead or inactive pathogen is given.
2. The white blood cells are stimulated to produce antibodies.
3. If the same pathogen re-enters the body later, the white blood cells respond **quickly** to produce the **correct antibodies**.
4. The pathogen is destroyed, preventing infection and illness.

### How it protects a population

If a **large proportion of the population** is immunised, the pathogen cannot spread easily because most people it reaches are protected. People who have not been vaccinated are less likely to come into contact with an infected person. This is sometimes called herd immunity.

### Evaluating the global use of vaccination

You may be given data, such as the number of cases of a disease against the percentage of people vaccinated, and asked to evaluate. Describe the trend, then link it to the idea above: more people

vaccinated means fewer cases.

- Benefit: prevents illness in individuals and reduces the spread of disease through the population.
- Benefit: protects even people who have not been vaccinated, if enough people are immunised.
- Limitation: it is only effective if a large proportion of the population is immunised.
- Limitation: if the proportion of people vaccinated falls, the disease can spread again and cases rise.

**Maths skill:** To find the percentage of a population vaccinated, divide the number vaccinated by the total population and multiply by 100.

#### Percentage vaccinated

In a town of 8000 people, 6800 have been vaccinated. Calculate the percentage of the population that is vaccinated.

1.  $\text{number vaccinated} \div \text{total population} = 6800 \div 8000 = 0.85$

2.  $0.85 \times 100 = 85$

**Answer:** 85%

**Common mistake:** A vaccine contains dead or inactive pathogen, not active pathogen. It does not contain antibodies, because the white blood cells make them.

You do not need to know vaccination schedules or the side effects of specific vaccines.

## Antibiotics and painkillers Spec 4.3.1.8

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 are 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.

### What antibiotics cannot do

- Antibiotics cannot kill viral pathogens.
- It is difficult to develop drugs that kill viruses without also damaging the body's tissues, because viruses live and reproduce inside cells.

### Painkillers

Painkillers and other medicines are used to treat the symptoms of disease but do not kill pathogens.

| Antibiotics and painkillers compared |                               |                                              |
|--------------------------------------|-------------------------------|----------------------------------------------|
|                                      | Antibiotics                   | Painkillers                                  |
| What they do                         | Kill bacteria inside the body | Treat symptoms such as pain                  |
| Do they kill pathogens?              | Yes, bacteria only            | No                                           |
| Work on viruses?                     | No                            | They do not kill them, but can ease symptoms |

**Exam tip:** If asked why an antibiotic is not given for a viral illness, say that antibiotics cannot kill viruses. Do not say that viruses are 'too small'.

## Discovery and development of drugs Spec 4.3.1.9

### Where drugs come from

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.

### Testing and trialling

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

|                 |                                                                   |
|-----------------|-------------------------------------------------------------------|
| <b>Toxicity</b> | How harmful the drug is to cells and the body.                    |
| <b>Efficacy</b> | How well the drug works to treat the condition.                   |
| <b>Dose</b>     | The amount of drug to give so that it works without causing harm. |

1. Preclinical testing is done in a laboratory using cells, tissues and live animals.
2. Clinical trials use healthy volunteers and patients.
3. Very low doses of the drug are given at the start of the clinical trial.
4. If the drug is found to be safe, further clinical trials are carried out to find the optimum dose.
5. In double blind trials, some patients are given a placebo.

A placebo looks like the drug but contains no active drug. In a double blind trial, neither the patients nor the doctors know who has the real drug and who has the placebo until the end. This stops expectations affecting the results.

### Peer review

The results of testing and trials are published only after scrutiny by peer review. Other scientists check the methods and conclusions before they are published.

*Exam tip: Preclinical comes first and uses cells, tissues and animals. Clinical trials come second and use people. Do not swap them.*

### Quick check

1. Name the four types of pathogen.
2. Name the three ways white blood cells defend against pathogens.
3. Why can antibiotics not be used to treat a viral disease?
4. What does a vaccine contain?
5. Where is preclinical testing carried out, and on what?

## 2 Monoclonal antibodies Spec 4.3.2 Triple only Higher tier

### Producing monoclonal antibodies Spec 4.3.2.1

Monoclonal antibodies are produced from a **single clone of cells**. The antibodies are specific to **one binding site on one protein antigen**, so they are able to target a specific chemical or specific cells in the body.

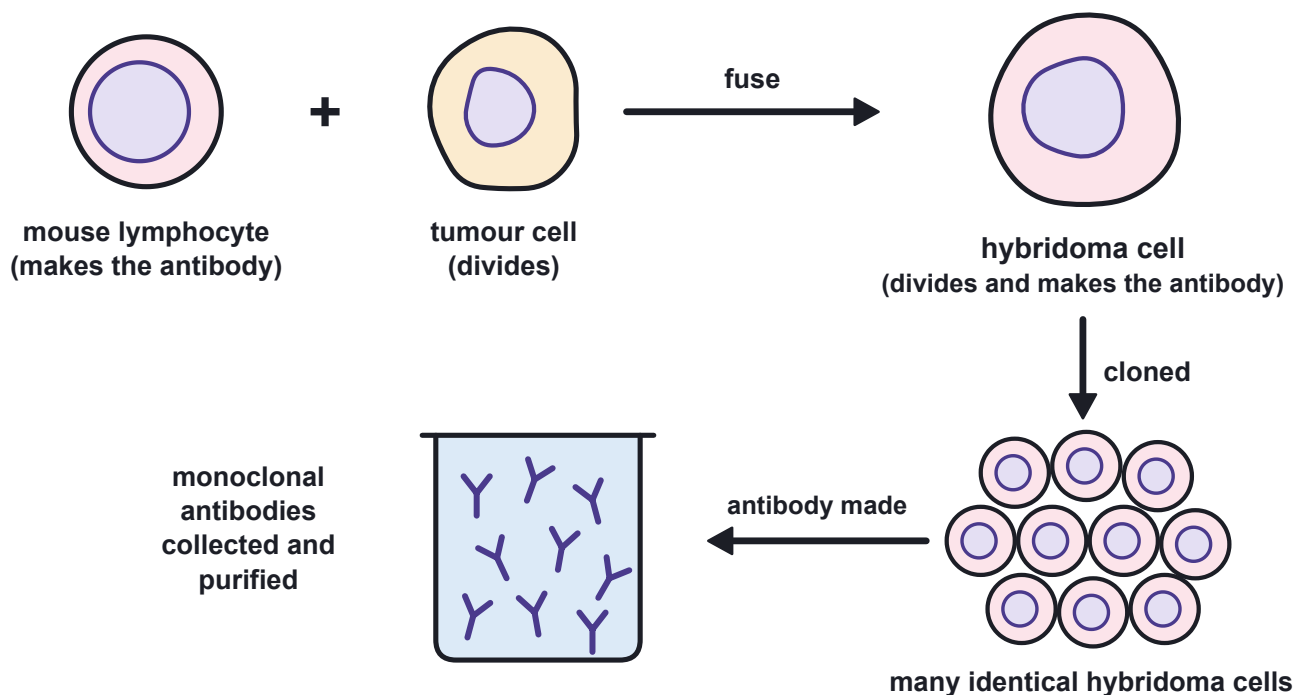
An antigen is a molecule that an antibody can bind to. Lymphocytes are a type of white blood cell that make antibodies.

### Making monoclonal antibodies

1. Mouse lymphocytes are stimulated to make a particular antibody.
2. The lymphocytes are combined with a particular kind of **tumour cell** to make a **hybridoma cell**.
3. The hybridoma cell can both divide and make the antibody.
4. Single hybridoma cells are **cloned** to produce many identical cells that all produce the same antibody.
5. A large amount of the antibody can be collected and purified.

*Exam tip: Say what each cell contributes. The lymphocyte makes the antibody. The tumour cell lets the hybridoma divide. The hybridoma does both.*

|                            |                                                                                                         |
|----------------------------|---------------------------------------------------------------------------------------------------------|
| <b>Hybridoma cell</b>      | A cell made by combining a lymphocyte with a tumour cell. It can both divide and make the antibody.     |
| <b>Monoclonal antibody</b> | An antibody produced from a single clone of cells, specific to one binding site on one protein antigen. |



Making monoclonal antibodies: lymphocyte + tumour cell = **hybridoma cell**, which is **cloned**.

## Uses of monoclonal antibodies Spec 4.3.2.2

Because each monoclonal antibody binds to one specific antigen, it can be used to find or target one chemical or cell type. Some examples are:

- Diagnosis, such as in **pregnancy tests**. The antibody binds to a hormone in the urine, which causes a visible change.
- 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.

### Treating cancer

For cancer, the monoclonal antibody can be bound to a **radioactive substance**, a **toxic drug** or a chemical which stops cells growing and dividing. The antibody delivers the substance to the cancer cells **without harming other cells** in the body.

You are not expected to recall specific tests or treatments. Given appropriate information, you should be able to explain how they work: the antibody binds only to its specific antigen, so it carries the substance or label to exactly the right place.

### Advantages and disadvantages

| Evaluating monoclonal antibodies                                                                                         |                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Advantage                                                                                                                | Disadvantage                                                                     |
| <b>Very specific: they target one chemical or one type of cell</b>                                                       | They create more side effects than expected                                      |
| <b>In cancer treatment, they can deliver a drug or radioactive substance to cancer cells without harming other cells</b> | They are not yet as widely used as everyone hoped when they were first developed |

The power of monoclonal antibodies raises ethical issues too. They are produced using mice, which some people object to.

*Exam tip: In an 'explain how it works' question, always say that the antibody is specific and binds to its antigen. That one idea earns the key mark.*

### Quick check

1. What does 'monoclonal' mean?
2. Which two kinds of cell are combined to make a hybridoma cell?
3. Why can a monoclonal antibody target specific cells?
4. Give two uses of monoclonal antibodies.

### 3 Plant disease

Spec 4.3.3

Triple only

#### Detection and identification of plant diseases Spec 4.3.3.1

Higher tier

##### Detecting plant disease

Higher tier

Plant diseases can be detected by:

Higher tier

- stunted growth
- spots on leaves
- areas of decay (rot)
- growths
- malformed stems or leaves
- discolouration
- the presence of pests.

Higher tier

##### Identifying plant disease

Higher tier

Identification can be made by:

Higher tier

- reference to a gardening manual or website
- taking infected plants to a laboratory to identify the pathogen
- using **testing kits that contain monoclonal antibodies**.

Higher tier

*Exam tip: A testing kit works because the monoclonal antibody binds only to an antigen from the specific pathogen. Say this to explain why the result is reliable.*

#### Plant pathogens and pests

Plants can be infected by a range of viral, bacterial and fungal pathogens as well as by insects. Your knowledge of plant diseases is restricted to:

- **tobacco mosaic virus** as a viral disease
- **black spot** as a fungal disease
- **aphids** as insects. Aphids are insect pests that feed on plants.

#### Ion deficiency conditions

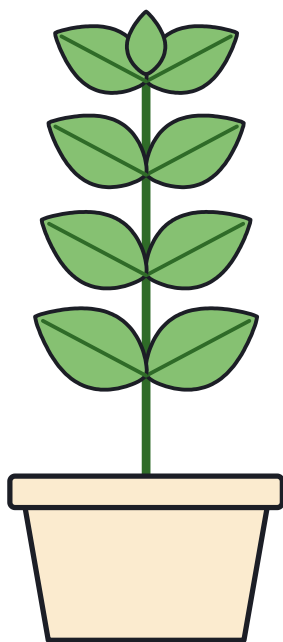
Plants can be damaged by a range of ion deficiency conditions.

### Ion deficiency conditions

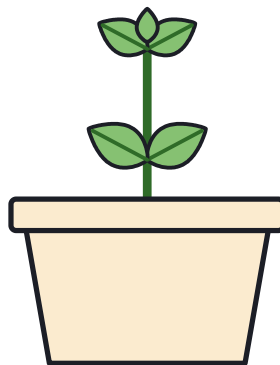
| Ion missing      | Why the plant needs it                             | Effect on the plant       |
|------------------|----------------------------------------------------|---------------------------|
| <b>Nitrate</b>   | Needed for protein synthesis, and therefore growth | Stunted growth            |
| <b>Magnesium</b> | Needed to make chlorophyll                         | Chlorosis (yellow leaves) |

Knowing about ion deficiencies allows horticulturists to provide the optimum conditions for plants. Your knowledge of ions is limited to nitrate and magnesium.

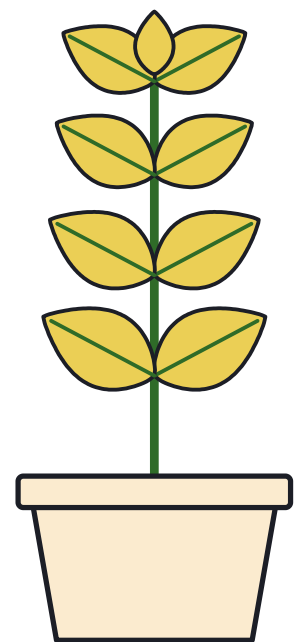
*Common mistake: Chlorosis is a lack of chlorophyll, which makes leaves yellow. In the exam, link chlorosis to magnesium and stunted growth to nitrate.*



**Healthy**



**Lacks nitrate:  
stunted growth**



**Lacks magnesium:  
yellow leaves (chlorosis)**

Lack of **nitrate** causes **stunted growth**; lack of **magnesium** causes **chlorosis** (yellow leaves).

### Plant defence responses Spec 4.3.3.2

Plants have defences that resist the invasion of microorganisms and deter animals that might eat them. You need to be able to describe physical and chemical responses, and mechanical adaptations.

#### Plant defence responses

| Type                                            | Examples                                                                                                                              |
|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <b>Physical defences against microorganisms</b> | <b>Cellulose cell walls</b> ; a <b>tough waxy cuticle</b> on leaves; layers of dead cells around stems (bark on trees) which fall off |
| <b>Chemical defences</b>                        | <b>Antibacterial chemicals</b> ; poisons to deter herbivores                                                                          |
| <b>Mechanical adaptations</b>                   | <b>Thorns and hairs</b> deter animals; leaves which droop or curl when touched; <b>mimicry</b> to trick animals                       |

Layers of dead cells around the stem, such as bark, act as a barrier. They fall off, which helps to remove any pathogens that have settled on them.

Mimicry means looking like something else so that animals are tricked, for example into avoiding the plant.

*Exam tip: Group your answer under physical, chemical and mechanical, and give a specific example for each. A plain 'plants have thorns' needs the idea 'to deter animals'.*

#### **Quick check**

1. Which ion deficiency causes stunted growth, and why?
2. Which ion deficiency causes chlorosis?
3. Name three physical plant defences.
4. Give two mechanical adaptations of plants.

## Quick check answers

### Communicable diseases

1. Viruses, bacteria, protists and fungi.
2. Phagocytosis, antibody production and antitoxin production.
3. Antibiotics cannot kill viral pathogens.
4. Small quantities of dead or inactive forms of a pathogen.
5. In a laboratory, using cells, tissues and live animals.

### Monoclonal antibodies

1. Produced from a single clone of cells.
2. A mouse lymphocyte and a tumour cell.
3. It is specific to one binding site on one protein antigen.
4. Any two of: diagnosis such as pregnancy tests, measuring hormones or detecting pathogens in the lab, locating molecules in research, treating diseases such as cancer.

### Plant disease

1. Nitrate. Nitrate ions are needed for protein synthesis and therefore growth.
2. Magnesium, because magnesium ions are needed to make chlorophyll.
3. Cellulose cell walls, a tough waxy cuticle on leaves, and layers of dead cells around stems.
4. Any two of: thorns and hairs, leaves that droop or curl when touched, mimicry.