# OCR (B) Biology GCSE

## Topic B2: Keeping Healthy

### Notes

(Paragraphs in **bold** are higher tier only)

# What are the causes of disease?

**Pathogens** are agents which cause **infectious disease**. They are usually live **microorganisms**, such as **bacteria and viruses**, and can infect all living things. Diseases can reduce both **mental and physical health** by infecting and damaging tissues and organs within the body. This can be by destroying cells, producing **toxins** and inhibiting cells from carrying out their usual function, which harms the infected organism. This usually causes **symptoms** to appear, although not all diseases have visible symptoms and many symptoms do not appear immediately due to an **incubation period** after the organism is **infected** where the pathogen **replicates** itself inside the body.

Diseases can be **communicable** and **non-communicable**. Non-communicable diseases are usually associated with **genetic, environmental and lifestyle factors**, and **cannot be spread directly** between different organisms. This includes diseases such as diabetes, most cancers, and autoimmune diseases. Communicable diseases are caused by **infection from a virus, bacteria, fungi or protist**. These pathogens can passed between organisms, meaning that the disease **can be spread throughout a population**. The most common ways of transmission are **direct contact** with an infected organism, **airborne** microorganisms, **indirect contact** (e.g. through infected surfaces), and through **contaminated food and water**.

Examples of communicable diseases can be found below:

| | Name of disease | Name of pathogen | Transmission | Effects |
|---|---|---|---|---|
| **Human diseases** | Influenza | Influenza viruses (viral) | Direct transmission and airborne | Fever, coughing, muscle pains, headache, sore throat |
| | Salmonella | *Salmonella* (bacterial) | Contaminated water and food | Abdominal cramps, diarrhea, vomiting |
| | Athlete's foot | Caused by multiple species, including *Trichophyton, Epidermophyton* and *Microsporum* (fungal) | Direct contact | Itching, redness or ulcers on feet |
| | Malaria | *Plasmodium falciparum (and others)* (protist) | Through a **vector*** in the form of a female mosquito | Damage to blood and liver |
| | HIV | Human Immunodeficiency Virus (viral) | Bodily fluids | Destroys white blood cells, leads to AIDS |
| **Plant diseases** | Tobacco mosaic virus | Tobacco mosaic virus (viral) | Direct contact or via human handling | Mosaic pattern on leaves, stunted growth. Does not result in plant death |
| | Ash dieback | *Hymenoscyphus fraxineus* (fungal) | Airborne, movement of diseased ash plants and infected logs | Leaf loss, bark lesions |
| | Crown gall disease | *Agrobacterium tumefaciens* (bacterial) | Bacteria can remain in soil and infect the plant through fresh wounds | Wart-like growths on stem which can restrict growth, young plants may die |

* a **vector** is an organism that can carry a disease **without being infected** itself.

# How do organisms protect themselves against pathogens?

**Defences against infection**

The human body has a range of different **non-specific** defence systems to protect itself from foreign pathogens. These defences include:

- **Mechanical barriers** - this includes hairs in the nose and skin.
- **Chemical barriers** - includes mucus, stomach acid and tears.
- **Bacterial barriers** - where bacteria (e.g. in the gut) helps to kill foreign pathogens.

These defences are **present constantly** and are not triggered as a **response** to a specific pathogen, unlike an **immune response** which is triggered once the pathogen has infected the body.

**Platelets and blood clotting**

**Platelets** are cell fragments found in the blood that promote **blood clotting**. They are **adapted** by being **very small** and **lacking a nucleus** (making them not true cells), which makes them flexible and able to move easily through narrow capillaries. Clotting is crucial when blood vessels are damaged as it stops excessive blood loss and prevents pathogens from entering and infecting the body through cuts. When the platelets reach a cut in a blood vessel, they release several **chemicals** which begin a chain reaction to form a mesh over the cut in order to seal it. They also **change shape and become sticky**, which helps them clump together to seal the cut.

**The human immune system**

The immune system is a system that works to **protect the body from disease** by **destroying foreign pathogens** once they have entered the body. These pathogens are destroyed by **white blood cells**, which can detect the difference between self and non-self by using **receptors** found on their cell surface to identify **antigens** on pathogens. Once a pathogen is identified, white blood cells can carry out two responses:

1. The white blood cell **engulfs** the pathogen and **digests** it inside of the cell, making it harmless.
2. The white blood cell releases chemicals which trigger the **release of antibodies** to disable the pathogen. They can also **label** it meaning that other white blood cells will attack it instead.

**Antibodies** are **Y-shaped proteins** that are released once a pathogen has been identified by a white blood cell. They travel to the site of the pathogen through the blood and **bind to the antigens** on the surface to **neutralise** it. Antibodies clump foreign cells together (**agglutination**), making them **too big** to enter and destroy cells.

Each antibody is **specific** to a particular antigen, meaning that it will **only bind to one type of antigen**. When a pathogen infects the body, the body produces a **complementary** antibody in order to neutralise it. After the infection, a small number will remain as **memory cells** so that if the same pathogen enters the body again, it can be killed **more quickly**.

**Plant defences (biology only)**

Plants also have barriers to prevent foreign pathogens from entering the organism. This includes:

- **Physical barriers** - pathogens find it hard to pass through these to enter the organism. This includes the cell wall and waxy cuticle.
- **Antimicrobial substances** - some plants, such as garlic and ginger, use antimicrobial agents to prevent pathogens which are not stopped by their physical barriers. These can also be

produced in response to an infection by a pathogen to destroy it, as plants do not have circulating immune cells or produce antibodies.

It is important to humans that plants can protect themselves from pathogens so that food production is maintained. In some cases, crops are **genetically modified** to decrease the risk of disease, which **ensures food security**.

# How can we prevent the spread of infections?

Reducing the spread of communicable diseases are important both in human, animal and plant populations. Diseases can result in **loss of life, destruction of habitats and ecosystems and loss of food sources**, therefore it is important to reduce the spread of disease.

**Preventing plant disease**

The spread of plant diseases can be reduced by:

- Regulating movement of infected plants
- Sourcing healthy plants and seeds
- Destroying infected plants
- Polyculture - many varieties of crops are grown in the same space (as opposed to a monoculture), meaning that disease cannot spread between a single species as easily.
- Crop rotation - the variety of crop grown in a certain area is changed each year, preventing pathogens from building up in the soil. Each pathogen can only survive from a specific crop, called the **host**. When other species are grown the pathogen cannot survive.
- Chemical and biological control

**Preventing human and animal disease**

- Contraception - reduces the spread of STDs, such as HIV.
- Sterilising wounds
- Hygiene and sanitation- prevents diseases such as salmonella and cholera, which spread through infected food and dirty water. Disinfecting surfaces and preparing food hygienically prevents the spread of pathogens.
- Restricting travel
- Destruction of infected animals – infected animals must be killed and cremated or buried to prevent the spread of disease. In 2001, over 6 million cows and sheep were killed in the UK to prevent the spread of foot-and-mouth disease, with all animals within 3km of a known case to be slaughtered. There was also a ban on the sale of British pigs, sheep and cattle until the disease was eradicated, and the movement of livestock was restricted.
- **Vaccination** - Vaccines stimulate the **production of antibodies and memory cells** against the target pathogen **without causing illness**, thus leads to immunity. If enough people in a population are immune to a disease, it cannot spread, meaning that people unable to be vaccinated (e.g. due to medical reasons) are not at risk. This is called **herd immunity**.

When choosing a method to prevent the spread of a disease, **the costs, benefits, risks and effectiveness** of each option must be considered. In addition, there are also **ethical issues,** as the importance of free will must be balanced against what is best for society. For example, people who choose not to vaccinate themselves may be putting young children or very ill people who are unable to be vaccinated at risk.

# How can we identify the cause of an infection? (biology only)

**How can diseases be identified?**

It is important to identify diseases in order to treat them correctly. Each pathogen causes different symptoms and infects different cells, therefore they can be identified by observing these symptoms. Some diseases have similar symptoms, so samples of tissue or body fluid can be taken to carry out further tests in order to diagnose the correct pathogen, including:

- **Cell counting** - certain types of cells can be counted to see if they are within the usual range. For example, white blood cells are counted to detect for several conditions, including HIV, influenza and leukaemia.
- **Culture** - microorganisms are encouraged to grow by placing the sample in favourable conditions. With a larger population, it is easier to observe the pathogen under a microscope or use it in other tests. Some microorganisms, however, cannot be cultured or take many weeks to grow.
- **Microscopy and staining** - samples can be stained with dyes that colour microorganisms so that they can be seen more easily. Samples are then observed under a light microscope. Some microorganisms cannot be identified by this method, however, as they may be too small or look similar to many others.
- **Testing with antimicrobials** - different types of antimicrobial kill different pathogens, hence using different antimicrobials on the sample can determine which pathogen is present. This is often done after a culture has been grown. If a certain drug kills the pathogen, they may decide to use that as a treatment if it does not harm the patient.
- **Genome analysis** - genetic material, such as DNA and RNA, can be taken from the microorganism and tested to determine which species the pathogen is.

**Multiple tests** may be done to identify the microorganism, and **some tests work better on certain pathogens**, meaning that the doctor must decide which tests to carry out based on the likely pathogen present.

**Aseptic techniques**

When handling samples and carrying out identification tests, **aseptic techniques** must be used to **avoid contamination**, which may influence the test results and misdiagnose the patient. These techniques also **prevent the spread of pathogens** by keeping microorganisms from a sample contained.

Aseptic techniques include:

- Wiping down surfaces with **antibacterial cleaner** both **before and after** handling the sample.
- **Flaming or sterilising** any equipment before using to transfer the sample.
- **Flaming culture bottle necks** before use to prevent airborne bacteria entering the vessel.
- Keeping all vessels containing the sample **open for a minimum amount of time**.
- **Closing windows and doors** to limit air currents.
- **No eating or drinking** near the sample.
- **Washing hands** before handling the sample.

**Monoclonal antibodies and diagnostic testing**

**Monoclonal antibodies are identical antibody clones made from one parent cell. They can be cultured in a laboratory and used in diagnostic tests, such as pregnancy tests. In pregnancy tests, they are used to detect the presence of HCG, a hormone only produced during pregnancy. If HCG is present in the urine, it will bind to the monoclonal antibodies and result in a colour change, indicating pregnancy. As antibodies are specific, the type used in pregnancy tests will only bind to HCG.**

**Monoclonal antibodies can be used in a variety of other similar tests, where they can diagnose HIV, AIDS and cancer, amongst many other diseases. For each test, a different monoclonal antibody must be used which will bind to a specific molecule only found when the patient is positive for that disease. Tests using monoclonal antibodies are much easier and faster to carry out, and also give more accurate results. This means that patients can be treated faster and more accurately.**

**Producing monoclonal antibodies:**

1. **A specific antigen is injected into an animal, such as a mouse.**
2. **The animal has an immune reaction to the antigens, and antibody-producing cells are taken from the animal.**
3. **These cells are fused with tumour cells to make hybridoma cells. Tumour cells do not produce antibodies but will divide indefinitely. This means that the new cells will both divide continuously and make monoclonal antibodies.**
4. **The hybridoma cells divide to produce more monoclonal antibodies. Cells producing the correct antibody are selected and cultured.**

# How can lifestyle, genes and the environment affect health?

Non-communicable diseases can develop due to a range of both **lifestyle and genetic factors**. Factors that may increase the risk of one or many diseases are known as **risk factors**. Risk factors increase the likelihood of a person developing a disease but do not directly cause it, and people can still develop a disease even if they have a healthy lifestyle with a low level of risk. Risk factors include:

- **Unhealthy diet** - eating a high amount of saturated fat can cause high blood pressure and lead to fatty deposits in arteries, which increases the risk of developing cardiovascular disease. A high sugar diet can lead to type-2 diabetes, where the body becomes resistant to insulin and cannot regulate blood-sugar levels.

- **Lack of exercise** - an inactive lifestyle can lead to obesity, which increases the risk of cardiovascular disease, cancer and diabetes. People who exercise regularly have a lower pulse and recovery rate which puts less strain on the heart and blood vessels.

- **Age** - generally, as age increases so does the risk of developing diseases. Some diseases, however, are more common in lower age groups.

- **Inherited risks** - Some diseases, such as heart and circulatory diseases, can run in families and are passed on in the DNA.

- **Environmental risk factors** - Some environmental factors can increase the risk of certain diseases. For example, UV radiation can increase the risk of skin cancer by causing DNA mutations.

- **Drugs and smoking** - smoking increases the risk of lung cancer and coronary heart disease, among many other diseases. It damages the lining of blood vessels, reduces the amount of oxygen in the blood, raises blood pressure and increases the likeliness of blood clots which lead to heart attacks and strokes. Other drugs including alcohol can increase the risk of heart disease, cancers and liver diseases.

**Interactions between diseases**

Different diseases **interact** with each other, and some **diseases can trigger others**:

- Autoimmune diseases such as lupus **weaken the immune system**, making it more likely for other diseases to infect the body.
- **Viruses** can be a trigger for cancers, and HIV targets cells in the immune system, leading to AIDS and increasing the risk of tuberculosis and tumours.
- Some diseases can also **prevent another from developing**, for example, sickle cell anaemia prevents malaria by distorting the shape of red blood cells.

# How can we treat disease?

Humans have developed hundreds of different medicines which can work by **curing a disease**, **reducing the symptoms**, or by **decreasing the length** of sickness. Medicines such as painkillers reduce the symptoms of a disease. Painkillers work by **blocking pain receptors**, meaning that symptoms such as headaches are lessened. Other medicines, for example **antibiotics and antiviral drugs**, work to cure the patient by killing the pathogen or inhibiting its growth.

**Antibiotics and bacterial resistance**

Antibiotic drugs are used to treat **bacterial** infections. Some antibiotics kill bacteria by **destroying their cell wall**, leading to the cell **bursting**, whilst others **inhibit the growth** of the bacteria. **Viruses cannot be killed by antibiotics** as they do not grow and reproduce in the same way as bacteria, and do not have the same structure.

Some bacterial strains become **resistant** to antibiotics as a result of **natural selection**:

1. A **mutation** occurs in a bacterial cell which makes it resistant to an antibiotic.
2. When that antibiotic is administered, this cell is not killed, whereas cells which have not become resistant are killed.
3. The resistant cell can therefore survive and reproduce, producing more resistant bacteria.

Resistance to antibiotics results in antibiotic resistant bacterial infections in hospitals, such as MRSA. It is therefore important to try and slow the development of resistant bacterial strains. This can be done by **only using antibiotics for serious infections**, and **always completing the full course of antibiotics** to make sure that all of the bacteria are killed.

**Cardiovascular disease treatments**

There are a range of different treatments that can be used to treat cardiovascular disease. Each patient is assessed and treated differently depending on how **severe** the disease is and the **costs and benefits** for the patient.

1. **Altering the patient's lifestyle** - this includes altering the diet, increasing physical activity levels and quitting smoking and drinking. This treatment is cheap and often effective, however is not enough to treat more severe cases.

2. **Use of drugs** - statins are drugs that lower cholesterol. People with cardiovascular disease can take these to decrease the risk of heart attacks and strokes by reducing the amount of fatty deposits in their arteries. There are also other types of drugs that help by reducing blood pressure, widening blood vessels and thinning the blood to prevent clots. These drugs must be taken daily, are often required for life and can also have negative side effects.

3. **Stents** - stents are small, hollow tubes that can be inserted into blood vessels to widen them. This improves blood flow and prevents the risk of vessels being blocked. Stents require surgery to insert but involve no major incisions, making the operation much less risky than a heart transplant or bypass surgery. There is also a shorter recovery time and no risk of rejection.

4. **Heart transplant** - in some cases medicine is not effective and the heart becomes irreparably damaged, meaning that it cannot pump blood around the body. This means that the heart must be replaced by a healthy heart. This process requires major surgery and has the risk of the new heart being rejected. Donor hearts are also difficult to source as they must be the right size and have a similar blood and tissue type to the patient.

As all of these treatments are difficult to implement and come with risks, it is much better to reduce the risk of a disease **before it develops**. Treatments may also affect patients differently. For example, some drugs may have no effect on some patients, whilst others may have an adverse reaction to the same drug.

**Development of new medicines**

New potential drugs are being discovered all the time, and the advancement of technology and microbiology has brought huge improvements to drug discovery and development; more substances can now be tested, and the **genomes and proteins** of pathogens can be studied in detail to find potential medicines that target them specifically. Any potential drugs must be **trialled** to find their potential **side effects**, **effectiveness** at targeting the disease, and the **dosage** needed. This is a lengthy and costly process with many stages that takes over 10 years and 1.5 billion pounds on average. Lots of drugs are discarded during this if they have no effect or damage human cells, with only one drug in every 5000 being successful.

The stages of drug development:

1. **Screening** - To begin with, large varieties of substances can be screened to see their effect on a target chemical or pathogen. Those that show a positive reaction are taken for further testing and **modifying**, as it is unlikely that a perfect medicine will be found at this stage.

2. **Pre-clinical trials** - Once a potential medicine is selected, pre-clinical trials begin. The drug is first tested using computer programs to predict how it will interact with human cells, before being tested on cultures of human tissue grown in a laboratory to assess whether there is any harmful effect on the tissue. Drugs that pass this stage are then used in animal trials to determine a safe dose for humans and to look for any side effects.

3. **Clinical trials** - If a drug passes the pre-clinical trial stages, it can be used on healthy humans in clinical trials to make sure that it is safe. After this, it is tested on people with the disease to measure its effectiveness.

Some participants in the clinical trial can be given **placebo** drugs which are often made of sugar or water and have no effect on the person. **Blind trials** are conducted where the participants of the trial do not know whether they have been given the drug or a placebo. This improves the accuracy of the test by eliminating bias. However, doctors may act differently towards those with placebo drugs. To remove this possibility, a **double-blind trial** can be conducted where both the patients and doctors do not know who has the placebo drug, which makes the trial more reliable. In comparison, a trial in which both the doctor and patient know the treatment is called an **open-label trial**. Using placebo drugs on people with a disease holds **ethical questions** about whether a sick person should be given a false treatment that will not help them to improve.

**Monoclonal antibodies in treatments (biology only)**

**Monoclonal antibodies can be produced to treat diseases such as cancer. They have a very low risk of adverse reactions which makes them preferable to other treatments such as chemotherapy and radiotherapy, which have many side effects. Most cancer medicines target rapidly dividing cells since cancer cells divide very quickly, however this means that healthy fast-dividing cells, such as hair and intestinal cells, are also damaged. Monoclonal antibodies target specific cancer cells, meaning that healthy host cells are not destroyed.**

**Cancer treatment procedure:**

1. **Monoclonal antibodies are produced. These are specific to a particular antigen on the cancer cell.**
2. **The monoclonal antibodies are injected into the blood. Here they bind to the target cancer cells.**
3. **Once the antibody has attached to a cancer cell, it labels it, meaning that white blood cells will attack and destroy the cell. Antibodies can also carry radioactive or toxic substances to cancer cells to kill them.**