AQA Biology GCSE

Topic 3: Infection and Response

Notes

Content in bold is for higher tier only.

Content is for both separate science and double award students unless indicated in heading.

Communicable Diseases (3.1)

Communicable (Infectious) Diseases (3.1.1)

Pathogens, which include viruses, bacteria, protists and fungi, are microorganisms that cause infectious disease. They can infect plants or animals, spreading through either direct contact, by water or by air.

1. **Viruses**
    - Very small
    - They move into cells and use the biochemistry of it to make many copies of itself
    - This leads to the cell bursting and releasing all of the copies into the bloodstream
    - The damage and the destruction of the cells makes the individual feel ill
2. **Bacteria**
    - Small
    - They multiply very quickly through dividing by a process called **binary fission**
    - They produce toxins that can damage cells
3. **Protists**
    - Some are **parasitic**, meaning they use humans and animals as their hosts (live on and inside, causing damage)
4. **Fungi**
    - They can either be single celled or have a body made of **hyphae** (thread-like structures)
    - They can produce **spores** which can be spread to other organisms

The ways they are spread:

- **Direct contact**- touching contaminated surfaces
  Examples: kissing, contact with bodily fluids, direct skin to skin, microorganisms from faeces, infected plant material left in field
- **By water**- drinking or coming into contact with dirty water
- **By air**- pathogens can be carried in the air and then breathed in (a common example is the **droplet infection**, which is when sneezing, coughing or talking expels pathogens in droplets which can be breathed in)

The damage that disease causes to populations can be reduced by limiting the spread of the pathogens.

- Improving hygiene: Hand washing, using disinfectants, isolating raw meat, using tissues and handkerchiefs when sneezing
- Reducing contact with infected individuals

- Removing vectors: Using pesticides or insecticides and removing their habitat
- Vaccination: By injecting a small amount of a harmless pathogen into an individual's body, they can become immune to it so it will not infect them. This means they cannot pass it on.

Viral Diseases (3.1.2)

Viruses are particularly dangerous as they can enter all types of cells, and scientists are yet to develop medicines to cure them.

Measles

Symptoms: Fever and red skin rash, can lead to other problems such as pneumonia (lung infection), encephalitis (brain infection) and blindness.

How it is spread: Droplet infection

How it is being prevented: Vaccinations for young children to reduce transmission

HIV

Symptoms: Initially flu-like symptoms, then the virus attacks the immune system and leads to AIDS (a state in which the body is susceptible to many different diseases)

How it is spread: By sexual contact or exchange of bodily fluids such as blood

How it is being prevented:

- The spread- Using condoms, not sharing needles, screening blood when it is used in transfusions, mothers with HIV bottle-feeding their children instead of breastfeeding
- The development to AIDS- Use of **antiretroviral drugs** (stop the virus replicating in the body)

Tobacco mosaic virus (a plant pathogen affecting many species of plants including tomatoes)

Symptoms: Discolouration of the leaves, the affected part of the leaf cannot photosynthesise resulting in the reduction of the yield.

How it is spread: Contact between diseased plants and healthy plants, insects act as vectors.

How it is being prevented: Good field hygiene and pest control, growing TMV-resistant strains.

Bacterial Diseases (3.1.3)

Bacterial diseases are on the rise as they are becoming resistant to antibiotics.

Salmonella food poisoning (bacteria that live in the gut of different animals, which we ingest when we eat the meat)
Symptoms: Fever, stomach cramps, vomiting, diarrhoea (all caused by the toxins they secrete).

How it is spread: These bacteria can be found in raw meat and eggs, unhygienic conditions.

How it is being prevented: Poultry are vaccinated against Salmonella, keeping raw meat away from cooked food, avoid washing it, wash hands and surfaces when handling it, cook food thoroughly.
Gonorrhoea
Symptoms: Thick yellow or green discharge from the vagina or penis, pain when urinating.

How it is spread: It is a sexually transmitted disease spread through unprotected sexual contact.

How it is being prevented: By using contraception such as condoms and antibiotics (used to be treated with penicillin but many resistant strains are developing).

Fungal Diseases (3.1.4)

Rose black spot
Symptoms: Purple or black spots on leaves of rose plants, reduces the area of the leaf available for photosynthesis, leaves turn yellow and drop early

How it is spread: The spores of the fungus are spread in water (rain) of by wind

How it is being prevented: By using **fungicides** or stripping the plant of affected leaves (have to be burnt)

Protist Diseases (3.1.5)

Malaria (caused by protist pathogens that enter red blood cells and damage them)
Symptoms: Fevers and shaking (when the protists burst out of blood cells)

How it is spread: The vector is the female Anopheles mosquito, in which the protists reproduce sexually. When the mosquito punctures the skin to feed on blood, the protists enter the human bloodstream via their saliva.

How it is being prevented: Using insecticide coated insect nets while sleeping, removing stagnant water to prevent the vectors from breeding, travellers taking antimalarial drugs to kill parasites that enter the blood.

Human Defence System (3.1.6)

The **non-specific defence system** works to prevent pathogens from entering the body.

1. The skin
   - Acts as a physical barrier
   - It produces **antimicrobial secretions** to kill pathogens
   - Good microorganisms known as **skin flora** compete with the bad microorganisms for space and nutrients
2. The nose
   - Has hairs and **mucus** (sticky substance) which prevent particles from entering your lungs
3. The trachea and bronchi
   - Secrete mucus in order to trap pathogens
   - Cilia (hair-like structures on cells) beat to waft mucus upwards so it can be swallowed
4. The stomach
   - Produces hydrochloric acid that kills any pathogens in your mucus, or food and drink

The specific immune system acts to destroy any pathogens which pass through the non-specific immune system to the body. A large part of the specific immune system is white blood cells, which can act in three different ways:

Mode of action	How it protects you
Phagocytosis (engulfing and consuming pathogens)	This destroys them, meaning they can no longer make you feel ill.
Producing **antibodies**	Each pathogen has an **antigen** on their surface, which is a structure which a specific **complementary antibody** can bind to. Once antibodies begin to bind to the pathogen, the pathogens start to clump together, resulting in it being easier for white blood cells to find them. If you become infected again with the same pathogen, the specific complementary antibodies will be produced at a faster rate. The individual will not feel the symptoms of the illness. They are said to be **immune**.
Producing **antitoxins**	They neutralise the toxins released by the pathogen by binding

	to them.

Vaccination (3.1.7)

Vaccinations involve making an individual immune to a certain disease- they are protected against it before they have been infected. By immunising a large proportion of the population, the spread of the pathogen is reduced as there are less people to catch the disease from (called **herd immunity**).

Naturally, when you are infected with a pathogen, you feel ill until white blood cells manufacture the correct specific antibody to combat it. Upon a secondary infection, the antibodies can be produced much quicker, so the pathogen can be destroyed and the symptoms are not felt. Vaccinations replicate the first infection so that when the person is exposed to the real disease they do not feel any symptoms, just like in a secondary infection.

- The vaccine contains a dead or inactivated form of the pathogen
- This stimulates white blood cells to produce antibodies complementary to the antigens on the pathogen

Advantages of vaccination	Disadvantages of vaccination
They have eradicated many diseases so far (e.g smallpox) and reduced the occurrence of many (e.g rubella).	They are not always effective in providing immunity.
Epidemics (lots of cases in an area) can be prevented through herd immunity.	Bad reactions (such as fevers) can occur in response to vaccines (although very rare).

Antibiotics and Painkillers (3.1.8)

Antibiotics are medicines that kill bacterial pathogens inside the body, without damaging body cells. They cannot kill viruses as they use body cells to reproduce, meaning any drugs that target them would affect body tissue too. **Painkillers** (such as aspirin) only treat the symptoms of the disease, rather than the cause.

- Antibiotics can be taken as a pill, syrup or directly into the bloodstream
- Different antibiotics are effective against different types of bacteria, so receiving the correct one is important
- Their use has decreased the number of deaths from bacterial diseases
- An example is **Penicillin**

The great concern is that bacteria are becoming **resistant** to antibiotics.

- **Mutations** can occur during reproduction resulting in certain bacteria no longer being killed by antibiotics
- When these bacteria are exposed to antibiotics, only the **non-resistant** one die
- The resistant bacteria survive and reproduce, meaning the population of resistant bacteria increases
- This means that antibiotics that were previously effective no longer work

To prevent the development of these resistant strains we can:

1. Stop overusing antibiotics- this unnecessarily exposes bacteria to the antibiotics
2. Finishing courses of antibiotics to kill all of the bacteria

Discovery and Development of Drugs (3.1.9)

Many drugs were initially discovered in plants and microorganisms. New drugs today are mainly synthesised by chemists. They need to be tested for **toxicity**, **efficacy** (how well they carry out their **role**) and dose, using **preclinical testing** and **clinical trials**.

Plants

The chemicals that plants use to kill pests and pathogens can be used to treat symptoms or human diseases.

Examples:

- Aspirin is used as a painkiller (originates from willow)
- Digitalis is used to treat heart problems (originates from foxgloves)

Microorganisms

- Penicillin
  - Alexander Fleming was growing bacteria on plates
  - He found mould (***Penicillium* mould**) on his culture plates, with clear rings around the mould indicating there was no longer any bacteria there
  - He found that the mould was producing a substance called penicillin, which killed bacteria

Any new drugs being developed need to be tested to ensure they are safe and effective.

Preclinical testing: using cells, tissues and live animals

Clinical testing: using volunteers and patients

- It is first tested on healthy volunteers with a low dose to ensure there are no harmful side effects
- The drugs are then tested on patients to find the most effective dose
- To test how well it works, patients are split into two groups with one group receiving the drug and one receiving a **placebo** (appears to look like the drug but has no active ingredient so no effect) so the effect of the new drug can be observed

- These can be **single-blind** (only the doctor knows whether the patient is receiving the drug) or **double blind** (neither the patient or doctor knows whether they are receiving the drug, removing any biases the doctor may have when they are recording the results).

The results then need to be **peer reviewed** by other scientists to check for repeatability.

Monoclonal Antibodies (3.2 - Biology Only)

Producing Monoclonal Antibodies (3.2.1)

Monoclonal antibodies are identical antibodies, that have been produced from the same immune cell. As a result of their ability to bind to only one protein antigen, they can be used to target chemicals and cells in the body and so have many different medical uses, e.g. in pregnancy testing.

How are they produced:

1. **Scientists obtain mice lymphocytes (a type of white blood cell that make antibodies but cannot divide), which have been stimulated to produce a specific antibody.**
2. **They are combined with tumour cells (do not make antibodies but divide rapidly), to form a cell called a hybridoma.**
3. **The hybridoma can divide to produce clones of itself, which all produce the same antibody.**
4. **The antibodies are collected and purified.**

Uses of Monoclonal Antibodies (3.2.2)

Examples of the uses of monoclonal antibodies include in pregnancy tests, in laboratories to measure the levels of hormones or chemicals, in research and in the treatment of some diseases.

1. **Pregnancy tests**
   A hormone called human chorionic gonadotrophin (hCG) is present in the urine of women who are pregnant.
   - **There are two sections of the stick.**
   - **The first section has mobile antibodies complementary to the hCG hormone- these antibodies are also attached to blue beads.**
   - **The second section has stationary antibodies complementary to the hCG hormone which are stuck down to the stick.**
   - **The individual urinates on the first section, and if hCG is present it binds to the mobile antibodies attached to blue beads to form hCG/antibody complexes.**

- They are carried in the flow of liquid to the second section.
- The stationary antibodies then bind to the HCG/antibody complexes.
- As they are each bound to a blue bead, results in a blue line.
- This indicates that you are pregnant.

2. In laboratories to measure and monitor
    - They can be used to measure and monitor levels of hormones or chemicals in the blood.
    - The monoclonal antibodies are modified so that they will bind to the molecule you are looking for.
    - The antibodies are also bound to a fluorescent dye.
    - If the molecules are in the sample then the antibodies bind to it, and the dye can be observed.
    - An example is screening donated blood for HIV infections.

3. In research to find or identify certain molecules on a cell or tissue
    - The same method as above is applied, and scientists look for a build up of the fluorescence.

4. In the treatment of disease, e.g. cancer
    Cancer cells have antigens on their cell membranes known as tumour markers (not found on normal body cells), which can be targeted. There are three main ways to treat cancers using monoclonal antibodies.
    a) Producing monoclonal antibodies that bind to the tumour markers in order to stimulate the immune system to attack the cell.
    b) Using monoclonal antibodies to bind to receptor sites on the cell surface membrane of the cancer cells. This means growth-stimulating molecules cannot bind, stopping the cell from dividing.
    c) Using monoclonal antibodies to transport toxic drugs, chemicals or radioactive substances as they can only bind to cancer cells.

Advantages of using monoclonal antibodies	Disadvantages of using monoclonal antibodies
They only bind to specific cells, meaning healthy cells are not affected.	It is difficult to attach monoclonal antibodies to drugs.
They can be engineered to treat many different conditions.	They are expensive to develop.
We are now able to produce mouse-human hybrid cells to reduce the chance of triggering an immune	As they were produced from mice lymphocytes, they often triggered an immune response when used in

response.	**humans.**

Plant Disease (3.3 - Biology Only)

Detection and identification of plant diseases (3.3.1)
Plants can also be affected by viral, bacterial and fungal pathogens.

The common signs of plant diseases are:

- **Stunted growth: indicating nitrate deficiency**
- **Spots on leaves: indicating black spot fungus on roses**
- **Areas of decay: black spot fungus on roses, blights on potatoes**
- **Abnormal growths: crown galls caused by bacterial infection**
- **Malformed stems or leaves: due to aphid infestation**
- **Discolouration: indicating magnesium deficiency, or tobacco mosaic virus**
- **Pests on leaves: such as caterpillars**

You can identify the disease the plant has by:

- **Using a gardening manual or website**
- **Identifying the pathogen by observing the infected plant in a laboratory**
- **Using monoclonal antibodies in testing its to identify the pathogen**

The plant diseases that need to be learnt are **tobacco mosaic virus** (viral disease), **black spot** (fungal disease) and **aphids** as insects.

Ion deficiencies are a problem in plants.

1. **Nitrate deficiency** can stunt growth
    - Nitrates in the soil convert sugars made in photosynthesis into proteins
    - These proteins are needed for growth
2. **Magnesium deficiency** can cause **chlorosis**
    - Magnesium is needed to make chlorophyll
    - This pigment is green and is vital in photosynthesis
    - If less is being made then parts of the leaves appear green and yellow which is known as chlorosis

Plant Defence Responses (3.3.2)

Plants have a number of physical, chemicals and mechanical adaptations.

Physical defences: To prevent the invasion of microorganisms

- Tough **waxy cuticle** stops entry into leaves
- Cellulose cell walls form a physical barrier into the cells

- Plants have layers of dead cells around stems (such as bark) which stop pathogens entering. The dead cells fall off with the pathogens.

Chemical defences: To deter predators or kill bacteria

- Poisons (e.g from foxgloves, tobacco plants, deadly nightshades, yew) deter **herbivores** (organisms that eat plants)
- Antibacterial compounds kill bacteria, such as mint plant and witch hazel

Mechanical defences

- Thorns and hairs make it difficult and painful for animals to eat them (but do not defend against insects)
- Some leaves can droop or curl when touched which allows them to move away and move insects off their leaves
- **Mimicry** to trick animals
    - Some plants droop to look like unhealthy plants so that animals avoid them
    - Plants can have patterns that appear to look like butterfly eggs, so butterflies do not lay their eggs here in order to avoid competition
    - Species from the 'ice plant family' have a stone and pebble like appearance in order to avoid predation