WJEC (Wales) Biology GCSE

Topic 2.8: Disease, Defence and Treatment

Notes

('Higher Tier only' in **bold**)

Micro-organisms

Micro-organisms are microscopic organisms - they can only be seen under a microscope.

There are four types of micro-organism:

- Bacteria
- Fungi (not all fungi are micro-organisms)
- Viruses
- Protists

Micro-organisms can be beneficial to humans, e.g. gut bacteria aid in the digestion of food, skin flora compete with pathogens for resources, reducing infection.

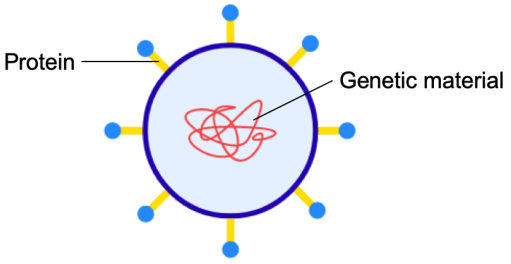
Structure of bacteria

Bacteria are single-celled organisms. Their structure differs from eukaryotic cells as they do not have a nucleus or membrane-bound organelles. They contain the following:

- Chromosomal DNA
- Plasmid DNA
- Cytoplasm
- Cell wall (made of murein)
- Cell membrane

Structure of viruses

Viruses are smaller than bacteria. Their structure consists of a central core of genetic material surrounded by a protein coat. They do not contain a cytoplasm, nor a cell membrane.



Communicable disease

A pathogen is a disease-causing organism. Pathogens are often micro-organisms such as bacteria, viruses and fungi.

Communicable diseases are caused by pathogens and can be passed directly between individuals in a variety of ways:

- Direct skin-to-skin contact
- Body fluids (saliva, semen, blood etc.)
- Drinking contaminated water

- Eating contaminated food
- Animal vectors
- Aerosol infection - airborne pathogens spread by inhaling infected droplets

Examples of communicable diseases:

Disease	Pathogen	Transmission	Effects	Prevention
HIV/AIDS	Human immunodeficiency virus.	Spread by direct contact with infected body fluids e.g. blood, semen, breast milk.	Destroys white blood cells making the individual immunodeficient and increasingly susceptible to other diseases. Leads to AIDS.	Use of condoms and protected sex. Needle exchange. Screening blood for HIV. Deterring infected mothers from breastfeeding.
Chlamydia	*Chlamydia trachomatis* bacteria.	Spread through sexual contact or direct contact with infected genital fluids.	May cause pain when urinating, abnormal discharge, testicular pain and bleeding between periods. In some cases it may result in infertility.	Use of condoms and protected sex. Screening.
Malaria	*Plasmodium* protist.	Spread by mosquito vectors which pick up the plasmodium protist when feeding on the blood of an infected organism and transmit malaria to other organisms during feeding.	Flu-like symptoms, damage to red blood cells, liver damage. In some cases it may be fatal.	Mosquito nets. Insect-repellant. Cover arms and legs. Antimalarial tablets. Draining stagnant water where mosquitoes breed.

Defence mechanisms

The body has two lines of defence against pathogens.

The non-specific defence system is the first line of defence, preventing pathogens from entering the body e.g. skin (protective surface barrier), blood clotting (platelets seal wounds preventing entry of pathogens into the blood).

The immune system is the body's defence against pathogens once they have entered the body. It is specific to each type of pathogen and aims to prevent or minimise disease.

Pathogens are destroyed by white blood cells (WBCs). These have specialised receptors that can detect foreign pathogens. There are two main types of WBC:

- Phagocytes which engulf and digest pathogens.
- Lymphocytes which secrete antibodies (see below) and antitoxins (neutralise toxins produced by the pathogen).

Antigens

Antigens are molecules on the surface of all cells that are recognised by the immune system. Pathogens have unique antigens on their surface. WBCs have specialised receptors which can detect these foreign antigens on pathogens, triggering an immune response.

Antibodies

Antibodies are proteins produced by lymphocytes in response to a foreign antigen. Each antibody is specific to an antigen and binds to it. Antibodies cause the pathogen to clump together, disabling them and facilitating ingestion by phagocytes.

Memory cells

Memory cells are lymphocytes that remain in the body after a pathogen has been destroyed. They provide immunity: if the body is re-infected, antibodies are produced more rapidly and the pathogen is destroyed before it can produce disease symptoms.

Vaccinations

Many diseases **(both bacterial and viral)** can be prevented by the use of vaccines. This involves the deliberate exposure of an individual to foreign antigens which triggers an immune response and provides immunity.

How vaccination works:

1. **Dead, weakened or inactivated pathogens are given to the patient.**
2. **The antigens initiate an immune response resulting in the production of antibodies**
3. **Memory cells are produced which remain in the body, providing long-term immunity**

The individual does not contract the disease that they are being immunised against.

Boosters (additional doses of vaccine) are often necessary to increase the number of memory cells and provide life-long immunity.

Vaccination can be a contentious issue. Before making a decision, it is important to weigh up the costs and benefits.

Some parents may choose not to vaccinate their children because...

- Concerns about potential side effects/adverse reactions.
- Religious or cultural objections.
- Not guaranteed to work.
- May cause upset to children.
- May believe that vaccines are linked to other diseases such as autism, asthma etc.

However, it is important that parents weigh up the potential risks and costs associated with not having their children vaccinated, including:

- Risk to the individual child of contracting a potentially life threatening infection (e.g. meningitis) .
- If fewer members of a population are vaccinated against a disease, the 'herd immunity' for that disease in that population decreases. This means that diseases, such as measles can spread throughout a population more easily. This has serious implications for those that are unable to be vaccinated as they will no longer benefit from a population's herd immunity.
- Not all sources of information available are accurate or based on validated, up-to-date science.

Antibiotics

Antibiotics are substances produced by living organisms (e.g. fungi) that kill or inhibit the growth of bacteria (no effect on viruses).

The first antibiotic, penicillin, was discovered by Alexander Fleming in 1928.

Due to overprescription and antibiotic misuse (e.g. not completing the entire course), bacteria are becoming increasingly resistant to antibiotics.

MRSA is a highly resistant strain of bacteria commonly found in hospitals. It is described as a 'superbug' as it is resistant to almost all available antibiotics.

Control measures to prevent infection by MRSA:

- New patients screened for MRSA.
- Stringent hygiene measures in hospitals (hospital staff, patients and visitors).

Control measures to prevent the development of new resistant strains:

- Prescribe antibiotics only when necessary.
- Ensure patients complete their antibiotic courses.
- Variation in the types of antibiotics prescribed.

Testing drugs

A drug is a substance that affects chemical processes within the body. New drugs must undergo rigorous testing:

Preclinical trials

- Drug tested on cultured human cells and using computer models to determine its toxicity (potential to cause damage) and efficiency.

- Drug then tested on live animals to establish a safe dose for humans and observe any side effects.

Clinical trials

- Drug first tested on healthy human volunteers to ensure that it is safe to use and has no other unwanted effects on the body.
- Drug then tested on patients with the disease to determine its efficacy. Dosage is slowly increased until an upper limit is established.

There are risks, benefits and ethical issues associated with the development of new drugs. For example, is it ethical to test drugs on live animals? Could new developments in technology (e.g. cultured tissue) supersede animal testing?

Monoclonal antibodies

Monoclonal antibodies are identical antibody clones cultured from one parent lymphocyte cell. This parent cell divides continuously to produce many identical cells, each producing a single antibody.

They are produced in the following way:

1. **Specific antigen injected into an animal e.g. mouse.**
2. **Lymphocytes producing complementary antibodies extracted.**
3. **Lymphocytes are fused with myeloma cells to form hybridoma cells. These hybridoma cells are now capable of replicating rapidly and producing antibodies.**

4. **Hybridoma cells cultured.**
5. **Monoclonal antibodies collected and purified.**

Medical uses of monoclonal antibodies

- Diagnostic tests e.g. for HIV and Chlamydia
  Monoclonal antibody used to detect the presence of antigens specific to a certain pathogen. Attached to a fluorescent dye, radioactive isotope or enzyme. If the antigen is present a change (e.g. fluorescence) can be observed.

- Tissue typing for transplants
  Monoclonal antibodies can be used to match donor organs to patients before transplantation. This reduces the chance of a transplanted organ being rejected.

- Monitoring malaria
  Monoclonal antibody used to detect the presence of antigens specific to the malarial parasite. This can help to track the spread of malaria and can also be used to test the effectiveness of treatments.

- Cancer treatments
  Monoclonal antibodies specific to cancer cells are attached to an anti-cancer drug. This allows chemotherapy drugs to target cancerous cells only.