CAIE Biology A-level

Topic 10: Infectious diseases

Notes

Bacteria and viruses are the main disease-causing pathogens in humans. Even though they both cause disease, they vary in many ways:

- **Bacteria are prokaryotic cells**; they do not have a nucleus – their genetic information is stored in the form of a **circular strand of DNA**. **Viruses consist of nucleic acid enclosed in a protein coat (capsid)**, sometimes surrounded by a lipid envelope. Their genetic material can take the form of **DNA or RNA.**
- Bacteria **do not require a host to survive,** whereas viruses are entirely **dependent on a host for replication.**
- Viruses are **significantly smaller** than bacteria.
- Bacteria have a cell membrane, cell wall and cytoplasm as well as other structures such as ribosomes, plasmids, flagella and pili, whereas **viruses possess no such structures.**

Disease transmission

Diseases can be classified as **infectious** or **non-infectious**. Infectious diseases are caused by **pathogens** and can be transmitted between organisms by physical contact, through the air, or through **vectors** such as mosquitoes. Non-infectious diseases, such as sickle cell anaemia and lung cancer, are not caused by pathogens and are not spread between organisms.

Infectious disease examples:

Name of disease	Causing pathogen	Pathogen name	How is it transmitted?	How to prevent transmission
Cholera	Bacteria	*Vibrio cholerae*	Water and food sources	Improve sanitation and hygiene
Malaria	Protoctist of the genus *Plasmodium*	*Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale* and *Plasmodium malariae*	Infected female mosquitoes	Reduce the number of mosquitoes (e.g. by destroying their habitats) and prevent biting by using mosquito nets and insect repellent
Tuberculosis	Bacteria	*Mycobacterium tuberculosis* and *Mycobacterium bovis*	Airborne droplets from coughing or sneezing	Use TB vaccine; cover mouth and nose when coughing or sneezing; avoid close contact with infected individuals

HIV/AIDS	Virus	Human Immunodeficiency Virus	Sexually transmitted and in bodily fluids such as blood	Take HIV medication; use condoms; use clean needles; screen blood donations to make sure they are not HIV positive

Tuberculosis, also known as **TB,** is an example of an infectious bacterial disease. TB is caused by a bacterium called ***Mycobacterium tuberculosis*** or ***Mycobacterium bovis*** which infects **phagocytes** in the lungs. The first infection is symptomless as the infected phagocytes are sealed in **tubercles** as a result of an **inflammatory response in** the lungs. However, the bacteria lie dormant inside the **tubercles** because they are not destroyed by the immune system; the tubercles are covered with a **thick, waxy coat.** When the immune system becomes weakened, the bacteria become active again, destroying lung tissue and leading **to breathing problems, coughing, weight loss as well as fever.** TB can potentially lead to death.

An example of a viral infection is **HIV i.e. Human Immunodeficiency Virus** which causes **AIDS.** The first symptoms of HIV include **fevers, tiredness and headaches**. After several weeks, **HIV antibodies** appear in the blood, meaning the person tests HIV-positive. After this period, the symptoms disappear until the **immune system becomes weakened** again, leading to **AIDS.**

Location of diseases:

- **Malaria** - found in hot, humid countries near the equator as these areas have high numbers of mosquitoes to spread the disease.
- **HIV/AIDS** - 95% of infections are in less economically developed countries, mostly situated in sub-Saharan Africa.
- **TB** - occurs in all countries, predominantly in developing and densely populated countries.

To prevent disease, social, economic and biological factors must be considered. Diseases generally spread faster in **densely populated** and **poorly sanitised** areas. Countries with **healthcare systems** and good **education** often have less disease as people are educated on how to prevent the spread of pathogens and can access treatments and vaccines.

Antibiotics

Antibiotics are used to treat bacterial infections by killing bacteria or inhibiting their growth. There are two types of antibiotics:

- **Bactericidal antibiotics** kill bacteria by inhibiting the synthesis of the peptidoglycan cell wall, causing them to burst (e.g. penicillin).
- **Bacteriostatic antibiotics** inhibit the growth of bacteria by stopping protein synthesis and production of nucleic acids so the bacteria can't grow and divide.

Some bacteria become **resistant** to antibiotics as a result of **natural selection**. The bacteria which are not killed by the antibiotic possess a **selective advantage** – resistance which enables them to survive and reproduce. Therefore, the allele for **antibiotic resistance** is passed on to their offspring thus creating a **resistant strain.**

Moreover, there is an ongoing **evolutionary race** between organisms and pathogens as **pathogens evolve adaptations** which enable them to survive and reproduce. For instance, the rapidly changing antigen coat of HIV means that the virus is not recognised and destroyed by the immune system.

Resistance to antibiotics results in **antibiotic resistant bacterial infections** in **hospitals** such as **MRSA.** Antibiotics **do not work** in killing **viruses** because viruses lack the bacterial structures (like cell walls or 70S ribosomes) that antibiotics target. Furthermore, viruses insert themselves into the cell and replicate rapidly.

Hospitals have developed various ways of controlling the spread of antibiotic resistant infections, for example:

- New patients are screened at **arrival, isolated and treated if they are infected** to prevent the spread of bacteria between patients.

- **Antibiotics are only used when needed and their course is completed to ensure that all the bacteria are destroyed** and to **minimise the selection pressure** on bacteria to prevent resistant strains from forming.

- All staff must follow the code of practice which includes **strict hygiene regimes** such as **washing hands with alcohol-based antibacterial gels** and wearing suitable clothing which **minimises the transmission of resistant bacteria.**