Disease and Immunity

Pathogens and transmissible disease, malaria, HIV and AIDS, cholera, alcohol and tobacco, drugs and antibiotics, and active and passive immunity including vaccination.

10.1 Disease

A pathogen is a disease-causing organism. A transmissible disease is a disease in which the pathogen can be passed from one host to another.

How pathogens are transmitted

- **Direct contact**, including through **blood** or other body fluids (for example HIV, passed in blood or sexual fluids).
- **Indirectly**:
  - from **contaminated surfaces or food** (for example cholera from contaminated water or food),
  - from **animals** (for example a mosquito, which is a **vector**),
  - through the **air** (for example in droplets from a cough or sneeze).

The body's barriers to pathogens

Barrier	How it protects
skin	a physical barrier; the surface is dry and tough, and blood clots seal cuts
hairs in the nose and **mucus**	trap pathogens and dust in the nose and airways; cilia sweep the mucus away
stomach acid	kills most pathogens in the food and drink that is swallowed

Malaria

- **Malaria** is caused by a **parasite** (a *Plasmodium* protoctist) that lives in red blood cells and the liver.
- It is transmitted by the **female *Anopheles* mosquito**, which acts as a **vector**: the mosquito picks up the parasite when it feeds on an infected person's blood, and passes it into the blood of the next person that it bites.

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Controlling mosquitoes. The mosquito's life cycle has eggs, larvae and pupae in **still water**, and adults that fly. Control measures include:

- **draining** or covering standing water (removes breeding sites);
- putting **oil** on the surface of ponds (the larvae and pupae cannot breathe);
- introducing **fish** that eat the larvae;
- using **insecticides** on adults and in homes;
- using **mosquito nets** and **repellent** to prevent bites.

HIV and AIDS

- **HIV** (human immunodeficiency virus) is a **viral pathogen**.
- It is transmitted by **sexual contact**, by **blood** (sharing needles, infected blood transfusions) and from **mother to baby** (across the placenta, during birth or in breast milk).
- HIV infection may lead to **AIDS** (Acquired Immune Deficiency Syndrome), when the immune system is so weak that the person gets many infections.
- **Control:** using **condoms**, not sharing needles, screening blood donations, and giving **antiviral drugs** to infected people, including pregnant women to protect the baby.

Cholera

- **Cholera** is caused by a **bacterium**, transmitted in **contaminated water** (and food).
- The bacterium makes a **toxin** that causes cells in the small intestine to **secrete chloride ions** into the gut. The water potential in the gut falls, so water moves **by osmosis** from the blood into the gut. The result is severe **diarrhoea**, **dehydration** and **loss of ions** from the blood.
- **Controlling the spread:** a **clean water supply** (treated with chlorine), **hygienic food preparation**, **good personal hygiene** (washing hands), proper **waste disposal** and **sewage treatment**. Treatment is by oral rehydration (water with salts and glucose).

Alcohol

Effects of excessive consumption of alcohol: **reduced self-control**, it is a **depressant** (slows the nervous system), it slows **reaction times**, and it can cause **damage to the liver** (cirrhosis). There are also **social implications**, such as accidents, violence and effects on families and work.

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Tobacco smoke

Component	Effect
nicotine	an addictive drug; increases heart rate and blood pressure
tar	a sticky substance that damages the lungs, coats the cilia and causes **cancer**
carbon monoxide	combines with haemoglobin, reducing the amount of oxygen the blood can carry

Smoking is strongly associated with **bronchitis**, **emphysema**, **lung cancer** and **heart disease**. **Smoking during pregnancy** is associated with a **reduced birth weight** of the baby (because the blood carries less oxygen to the fetus).

10.1 Antibiotics

A **drug** is any substance taken into the body that **modifies or affects chemical reactions** in the body.

- **Antibiotics** (for example penicillin) are used to treat **bacterial infections**. They **kill bacteria** (or stop them growing) but **do not affect viruses**, so they do not work against colds, flu or HIV.
- **Antibiotic resistance.** Some bacteria are resistant because of a gene **mutation**. When antibiotics are used, the resistant bacteria survive and reproduce, and so the resistant strain spreads (this is **natural selection**). **MRSA** is a bacterium that is resistant to many antibiotics.
- To **reduce** the development of resistance: use antibiotics **only when essential**, and always **complete the course** so that all the bacteria are killed.

10.1 Immunity

- Each pathogen has its own **antigens**: molecules (usually proteins) on its surface that have **specific shapes**.
- **Antibodies** are **proteins** made by **lymphocytes**. Each antibody has a **complementary shape** that fits **one specific antigen**. The antibody binds to the antigen, which leads to **direct destruction** of the pathogen, or **marks it** for destruction by **phagocytes**.

Active immunity

> **Active immunity is defence against a pathogen by antibody production in the body. It is gained after an infection by the pathogen, or by vaccination.**

After the first infection, **memory cells** are produced, which remember the antigen. If the same pathogen enters again, the memory cells make the right antibodies **very quickly** in large amounts, so the person does not become ill: they are **immune**. This gives **long-term** immunity.

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Vaccination

1. A **weakened or dead pathogen**, or its **antigens**, is given (injected or swallowed).
2. The antigens **stimulate an immune response**: the **lymphocytes** make **antibodies**.
3. **Memory cells** are produced that give **long-term immunity**.

Vaccination protects the individual without them having the disease. If a large proportion of the population is vaccinated, the pathogen spreads less, so the **spread of transmissible disease is controlled**, and even people who are not vaccinated are protected.

Passive immunity

> **Passive immunity is short-term defence against a pathogen by antibodies acquired from another individual, such as across the placenta from the mother to the fetus, or in breast milk.**

The person's own lymphocytes are not stimulated, so **no memory cells are produced** and the protection does not last. **Breast-feeding** is important because the baby gets antibodies from the mother's milk, which protects the infant before its own immune system is fully developed.

	Active immunity	Passive immunity
antibodies made by	the person's own lymphocytes	another individual
memory cells	yes	no
how long	long-term	short-term
examples	infection, vaccination	placenta, breast milk

HIV and the immune system

HIV infects and destroys **lymphocytes**, so their numbers **decrease** and the body is **less able to make antibodies**. The immune system is weakened, and the person is more likely to get infections that they would normally fight off.

> TRY IT
>
> Why do antibiotics not help when someone has influenza?

Influenza is caused by a **virus**, and antibiotics **do not affect viruses** (they kill bacteria only).

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15.1 Drugs

A **drug** is any substance taken into the body that **modifies or affects chemical reactions** in the body.

Misused drugs: heroin

Heroin is a powerful drug that acts on the nervous system. It is **addictive**: the body comes to depend on it, and stopping causes **withdrawal symptoms**. Its effects include a **reduced reaction time** and slowed breathing and heart rate. It is dangerous because users risk **overdose** and, if needles are shared, infections such as **HIV**.

Alcohol and tobacco

- **Alcohol** slows down the nervous system, so it **increases reaction time** and impairs judgement. Over time it can cause **liver damage** and addiction.
- **Tobacco smoke** contains **nicotine** (addictive), **tar** (causes lung cancer) and **carbon monoxide** (reduces the oxygen carried by the blood). It also causes **chronic bronchitis and emphysema**, and **heart disease**.

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