IGCSE BIOLOGY 0610 · CHAPTER 9 NOTES · ~14 MIN READ

Diseases, immunity & drugs

What a pathogen is, how disease spreads, how your body fights back (skin, phagocytes, antibodies), how vaccines work, cholera, how we control disease and why antibiotic resistance matters.

Pathogens | Transmission | Body defences | Antibodies | Vaccination | Antibiotics | Drug misuse

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No tag = **Core** (everyone) EXTENDED Extended only highlight = comes up again and again

Test yourself at the end

IN 30 SECONDS

- A **pathogen** is an organism that **causes disease**. A **transmissible disease** is one where the pathogen **passes from one host to another**, directly or indirectly.
- Your body has **barriers** that keep pathogens out (skin, mucus, stomach acid) and **white cells** that destroy those that get in. **Phagocytes** engulf them; **lymphocytes** make **antibodies**. EXT
- **Vaccines** train your body to make **memory cells** without the illness. **Antibiotics** kill **bacteria**, never **viruses**, and **overuse creates resistant bacteria**.

BY THE END YOU CAN

- Define pathogen and transmissible disease, and name the main groups of pathogen.
- Describe direct and indirect transmission with examples.
- Describe the body's defences: skin, nose hairs, mucus, stomach acid and white cells.
- Describe how disease is controlled: clean water, hygienic food, personal hygiene, waste disposal and sewage treatment.
- Describe the cause, transmission and effects of cholera.
- State what a drug is and say how antibiotics work and why resistance matters.
- Explain antigens, antibodies, memory cells and the difference between active and passive immunity. EXT
- Explain how vaccination gives long-term protection. EXT
- Explain how antibiotic resistance develops and how to slow it. EXT

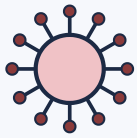
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1 Pathogens and how they spread

What is a pathogen?



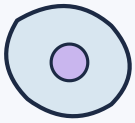
BACTERIA
cholera, TB, pneumonia



VIRUSES
influenza, HIV, measles, COVID-19



FUNGI
athlete's foot, ringworm



PROTOCTISTS
malaria (Plasmodium)

PATHOGEN = an organism that causes disease
TRANSMISSIBLE DISEASE = a disease whose pathogen passes between hosts

Four groups of organism can be pathogens. Know one disease for each.

Pathogen — an **organism that causes disease**.

Transmissible disease — a disease in which the **pathogen can be passed from one host to another**.

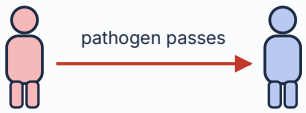
- **Not every disease is transmissible.** Cancer, diabetes and scurvy are **not caught** from anyone.
- Many pathogens are **specific**: the cholera bacterium makes you ill but not your cat.

COMMON MISTAKE

"Antibiotics cure flu." **Flu is caused by a virus.** Antibiotics only work on **bacteria** (see the last section).

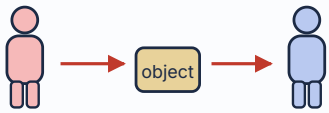
Direct and indirect transmission

DIRECT TRANSMISSION



touching, kissing, sex
blood (shared needles, transfusions)
mother to baby (placenta, breast milk)
bites and scratches

INDIRECT TRANSMISSION



contaminated food and water
surfaces (door handles)
air: coughs and sneezes (droplets)
vectors: mosquitoes, flies

Direct = the pathogen goes straight from one host to the next.
Indirect = it travels on or in something in between (food, water, air, surface, animal).

wash hands · cook food · clean water · cover coughs · control vectors

Direct: pathogen goes straight from host to host. Indirect: it travels on or in something in between.

- **Direct transmission: contact** (touching, kissing), **body fluids** (blood, semen), and **mother to baby** across the placenta or in breast milk.
- **Indirect transmission: contaminated food and water**, **surfaces** (door handles), the **air** (droplets from coughs and sneezes) and **vectors**: animals such as **mosquitoes** that carry the pathogen from host to host.

MEMORY TRICK

Direct = **D**irectly from person to person. **I**ndirect = an **I**ntermediate (object, food, water, air or animal) carries it.

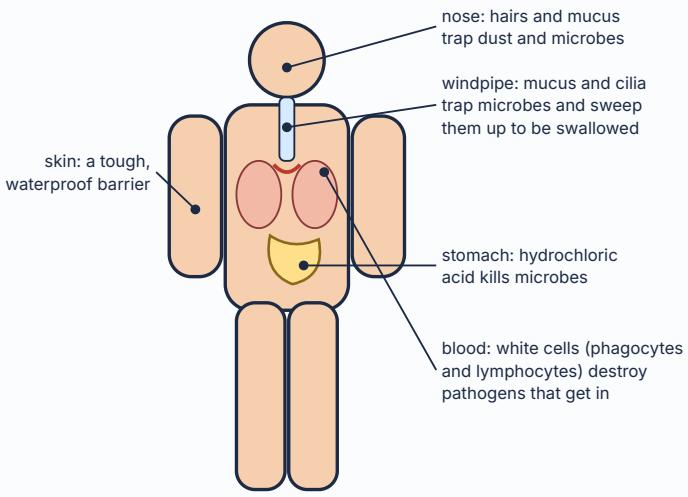
EXAM TIP

In an exam, **name what carries the pathogen** ("contaminated water", "droplets in the air"). "By touching" alone is not enough for indirect.

- Link: HIV and other STIs are spread by **direct** contact (sex, blood, mother to baby).

2 Body defences

Your first and second lines of defence



1st line: barriers that keep pathogens out · 2nd line: white cells that destroy those that get in

Barriers keep most pathogens out. White cells destroy the ones that get in.

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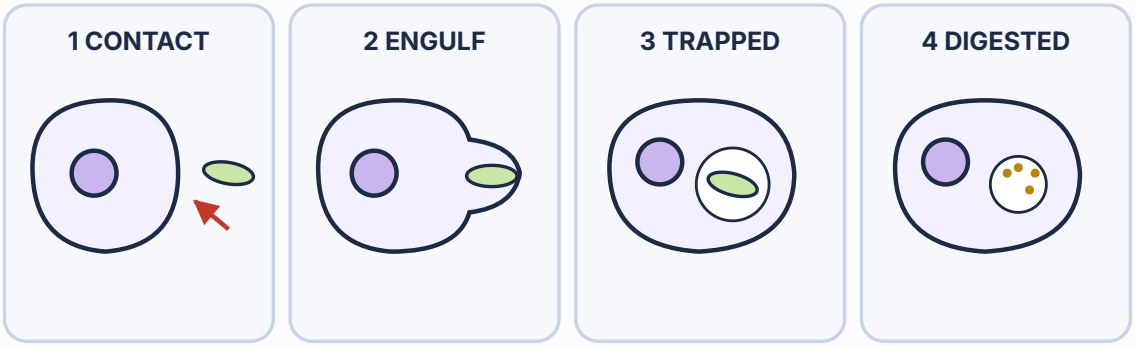
Defence	How it protects you
skin	a tough, **waterproof barrier**; a cut seals with a **blood clot** and scab
nose hairs and mucus	**trap** dust and microbes before they reach the lungs
mucus and cilia in the windpipe	mucus **traps** microbes; cilia **sweep** it up to the throat to be swallowed
stomach acid	**hydrochloric acid** kills most microbes in food and drink
white blood cells	**destroy** pathogens that get inside the body (below)

- More on mucus and cilia in the airways: gas exchange and breathing.

MEMORY TRICK

Barriers keep them **out**; white cells **kill** the ones that get **in**.

Phagocytes: the non-specific killers



phagocyte meets a pathogen | it wraps round the pathogen | the pathogen is inside a vacuole | enzymes break it down

Phagocytosis: non-specific. Phagocytes engulf and digest ANY pathogen they meet.

A phagocyte flows around a pathogen and digests it. It does this to any pathogen it meets.

- **Phagocytosis** = a **phagocyte** (a type of white blood cell) **engulfs** a pathogen and **digests it with enzymes**.
- It is **non-specific**: the same phagocyte attacks **any** type of microbe it finds.
- Phagocytes are found **in the blood** and can squeeze **out of the capillaries** into tissues to reach an infection (blood cells).

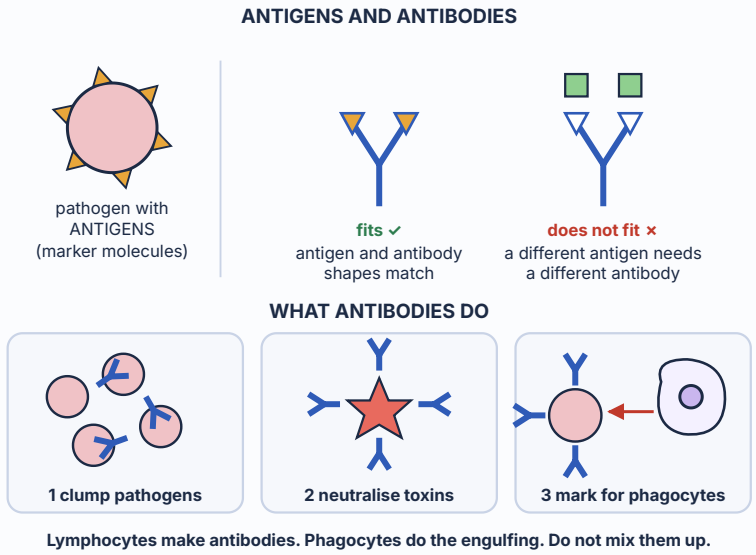
COMMON MISTAKE

"White cells eat microbes." **Only phagocytes engulf. Lymphocytes** do something different: they make **antibodies**.

3 Immunity EXT

Antigens and antibodies

EXTENDED



Lymphocytes make antibodies. Phagocytes do the engulfing. Do not mix them up.

EXT Each antigen has its own shape. An antibody fits only the antigen that matches.

Antigen — EXT a **marker molecule on the surface** of a cell or pathogen. Your body treats a foreign antigen as an invader.

Antibody — EXT a **protein made by lymphocytes** that **binds to a specific antigen** and helps destroy the pathogen.

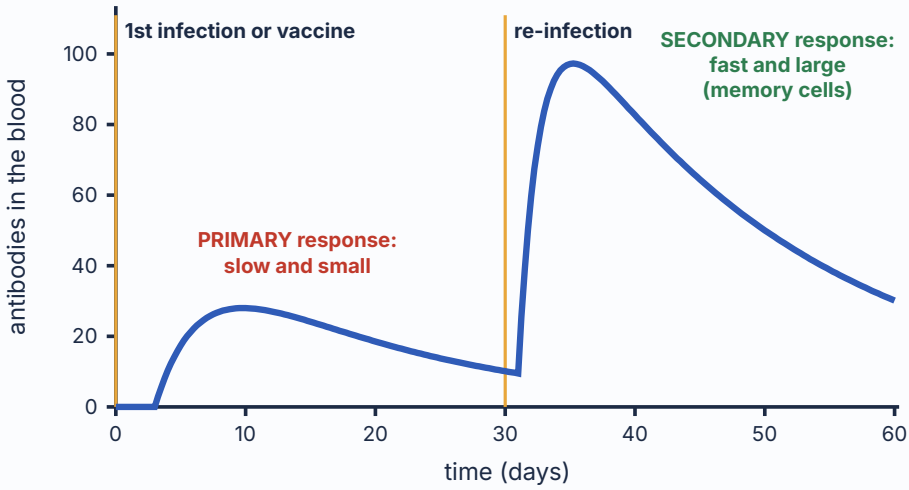
- EXT When a pathogen enters, a **lymphocyte with a matching shape** is activated and makes **many antibodies**. Antibodies **clump pathogens together**, **neutralise toxins** and **mark pathogens** so phagocytes find them easily.
- EXT Antibodies are **specific**: one type fits **one antigen** only. That is why you need a separate vaccine for each disease.

MEMORY TRICK

Antigen = **ANTI**body **GEN**erator: the thing that **triggers** antibody production.

Primary and secondary response

EXTENDED



EXT The second time you meet the same pathogen, the response is much faster and bigger.

- EXT **First infection (primary response):** it takes **days** to find the right lymphocyte and make enough antibodies. You may **feel ill** meanwhile. Some lymphocytes become **memory cells** that **stay in the blood**.
- EXT **Second infection (secondary response):** memory cells recognise the antigen at once and make **antibodies faster, in larger amounts**. The pathogen is destroyed **before you feel ill**.

EXAM TIP

Describing a graph: say **how fast** (starts sooner, rises steeply), **how high** (peak is much higher) and **how long** (stays high longer).

Active and passive immunity

EXTENDED

ACTIVE IMMUNITY

your OWN lymphocytes make
the antibodies
gained by infection
OR by vaccination
memory cells are made
LONG-LASTING
takes days to start working

PASSIVE IMMUNITY

antibodies come READY-MADE
from another person
breast milk, across the placenta,
or an injection of antibodies
NO memory cells made
SHORT-TERM
works immediately

Active = you make them. Passive = you are given them.

EXT Active: your own lymphocytes make the antibodies. Passive: antibodies are given to you ready-made.

Feature	Active immunity	Passive immunity
who makes the antibodies?	**your own** lymphocytes	**another person** (or animal)
how gained	**infection**, or **vaccination**	**breast milk**, **across the placenta**, or an injection of antibodies
memory cells?	**yes**	**no**
speed	**slow** (days)	**immediate**
how long?	**long-term** (often years)	**short-term** (antibodies break down)

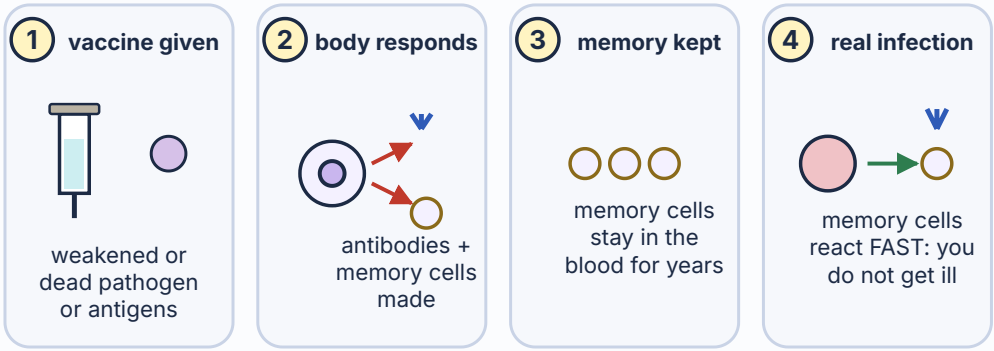
- EXT **A newborn baby** has **passive** immunity from the mother's antibodies (placenta and breast milk) while its own system develops.

MEMORY TRICK

Active = **A**ctivated **A**ll by yourself. **P**assive = you're **P**rotected by someone else's antibodies.

Vaccination

EXTENDED



Vaccination gives ACTIVE immunity without the illness.
If most people are vaccinated, the pathogen has few hosts to spread to (this also protects the few who cannot be vaccinated).

EXT A vaccine gives the antigens without the disease, so memory cells are ready for the real infection.

- EXT A **vaccine** contains a **weakened or dead pathogen** (or just its **antigens**). Your lymphocytes make **antibodies** and **memory cells without you getting the disease**.
- EXT When the **real pathogen** arrives, memory cells make a **fast, large secondary response**, so you **do not become ill**.
- EXT **Vaccination = active immunity.** It is long-term protection because memory cells stay in the blood.
- EXT If **most people** are vaccinated, the pathogen has **few hosts to spread to**, so even people who **cannot be vaccinated** are better protected.

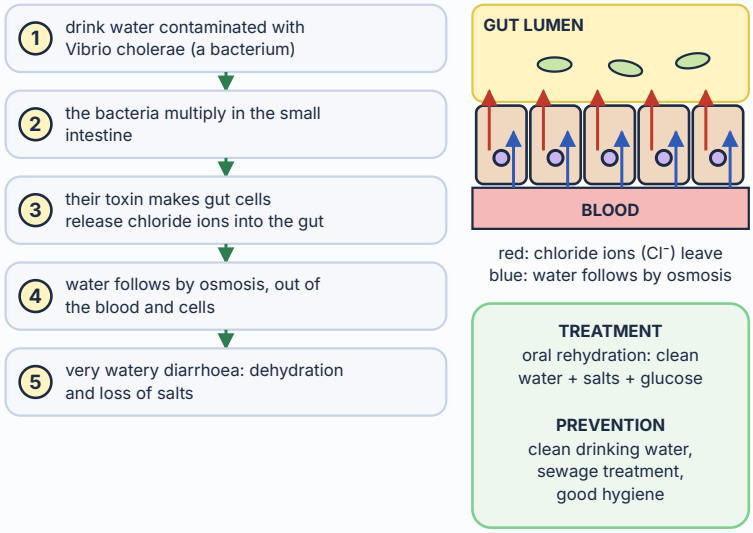
COMMON MISTAKE

"A vaccine is an injection of antibodies." **No.** A vaccine contains **antigens** (so you make your own antibodies = active). Injected antibodies are **passive** immunity.

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4 Cholera: a waterborne disease

Cause, spread and effects



Follow the five steps from contaminated water to dehydration.

- **Cause:** the **bacterium Vibrio cholerae**. It is **transmitted indirectly** in **water (and food) contaminated with faeces** from an infected person.
- **Effects:** the bacteria multiply in the **small intestine** and release a **toxin**. The gut **loses large amounts of water**, giving **severe watery diarrhoea**, **dehydration** and loss of salts. Without treatment this can be **fatal**.
- EXT **How the toxin works:** it makes the gut lining cells **release chloride ions** into the gut. The gut contents now have a **lower water potential** than the blood, so **water leaves the blood by osmosis** into the gut (osmosis).
- **Treatment: oral rehydration** (water, salts and glucose). **Prevention: clean drinking water**, **sewage treatment** and **good hygiene**.

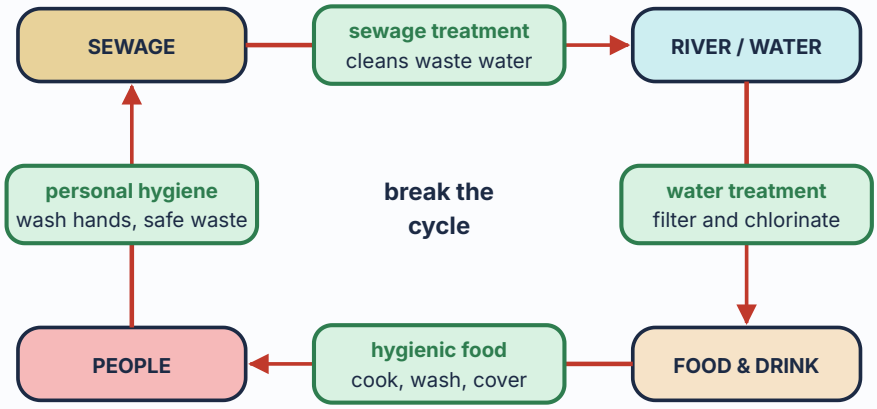
EXAM TIP

In the exam link the **toxin → gut → water loss → dehydration** chain. Do not just write "it gives you diarrhoea".

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5 Controlling the spread of disease

Breaking the cycle



Control = barriers between the pathogen and the next host

Cholera spreads in a cycle. Each barrier cuts it.

- **Clean water supply:** water is **filtered** to remove solids and **chlorinated** to kill microbes.
- **Sewage treatment: screens** remove large objects, solids **settle** as sludge, **bacteria break down** the organic matter and the water is **cleaned** before it returns to rivers. This stops **faeces contaminating drinking water**.
- **Hygienic food preparation:** wash hands and food, **cook thoroughly**, keep food **covered and cold**, keep raw and cooked food **apart**.
- **Personal hygiene: wash hands** after the toilet and before eating; cover coughs and sneezes.
- **Waste disposal: rubbish and sewage** are removed or buried. Uncollected waste breeds **flies and rats**, which are **vectors**.

WORKED EXAMPLE

In severe cholera a patient can lose 1 litre of water per hour. How much is that in one day, and why is oral rehydration urgent?

1. 1 day = 24 hours
2. 1 × 24 = **24 litres** per day
3. an adult's body holds only about 40 litres of water, so this is **more than half** of it
4. **fast water and salt replacement is life-saving**

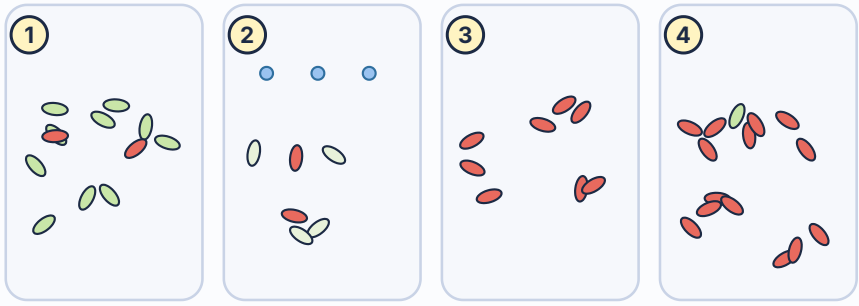
6 Drugs

What is a drug?

Drug — any **substance taken into the body** that **modifies or affects chemical reactions in the body**.

- Drugs can be **medicines** (painkillers, antibiotics) or **harmful** substances. Whether a drug helps or harms depends on **the drug, the dose and the person**.

Antibiotics



a mutation makes a few bacteria resistant | antibiotic kills the non-resistant bacteria | resistant survivors reproduce | population is now mostly resistant

This is NATURAL SELECTION: the antibiotic is the selection pressure. To slow resistance: use antibiotics only when needed, finish the course, never use them for viruses (e.g. MRSA is resistant to many antibiotics).

Antibiotics select for resistant bacteria. This is natural selection in action.

- **Antibiotics** (such as penicillin) **kill bacteria** or stop them growing. They **do not work against viruses**, because viruses live **inside our cells** and use our cell machinery. Do **not** take antibiotics for **colds and flu**.
- **Resistance:** a **mutation** can make a bacterium **resistant** to an antibiotic. When the antibiotic kills the rest, the **resistant survivors reproduce**, so the **whole population becomes resistant**. The antibiotic **no longer works**.
- EXT **Resistance is natural selection:** the antibiotic is the **selection pressure**, resistant bacteria **survive and pass on the allele** (natural selection).
- EXT **Slowing resistance:** use antibiotics **only when really needed**, **complete the whole course**, and never for **viral** infections. **MRSA** is a bacterium **resistant to many antibiotics**, so infections are very hard to treat.

WORKED EXAMPLE

A culture of 500 bacteria is treated with an antibiotic. 495 die. The survivors then divide every 30 minutes. Find the % resistant before, after the antibiotic, and the number after 3 hours.

1. survivors = 500 − 495 = **5**
2. before: 5 ÷ 500 × 100 = **1% resistant**
3. after the antibiotic only resistant ones are left, so **100% resistant**
4. 3 hours = 180 min ÷ 30 = **6 divisions**
5. **number = 5 × 2^6 = 5 × 64 = 320 resistant bacteria**

Drug misuse: be aware

- Not every drug taken is a medicine. **Misuse** harms the body and often causes **addiction**. This part is general knowledge; check whether your exam board asks for it.

Substance	Main harm
tobacco smoke	**tar** causes lung cancer and damages cilia; **carbon monoxide** reduces the oxygen carried by blood; **nicotine** is addictive and raises heart rate
alcohol	slows reactions and judgement (a **depressant**); long-term **liver damage**; addiction
heroin and other opiates	highly addictive; **overdose** can stop breathing; **sharing needles** spreads **HIV** and hepatitis

- **Worried about drugs or smoking?** Speak to a **doctor, parent or teacher**. Help is available and early help works best.

7 Test yourself

Test yourself — cover the answers first

QUICK CHECK

1. Define pathogen.
2. Define transmissible disease.
3. Give one example of direct transmission.
4. Give one example of indirect transmission.
5. Name two ways the body stops pathogens entering.
6. What is phagocytosis?
7. Which bacterium causes cholera?
8. How is cholera spread?
9. What is a drug?
10. Why do antibiotics not cure flu?
11. EXT What is an antigen?
12. EXT What cells make antibodies?
13. EXT Why does a second infection make you less ill?
14. EXT Is breast milk active or passive immunity?

EXAM-STYLE

15. Explain how stomach acid protects the body from disease. [2]
16. Explain why cholera causes dehydration. [3]
17. Describe how clean water and sewage treatment reduce the spread of cholera. [3]
18. EXT Explain how a vaccine protects you against a disease. [4]
19. EXT Explain how antibiotic resistance develops in bacteria. [4]
20. EXT Compare active and passive immunity. [3]

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Show answers

1. an organism that causes disease
2. a disease in which the pathogen can be passed from one host to another
3. touching or contact, body fluids, mother to baby
4. contaminated food or water, droplets in the air, or a vector such as a mosquito
5. skin, nose hairs and mucus, stomach acid
6. a phagocyte engulfs a pathogen and digests it
7. Vibrio cholerae
8. by water or food contaminated with faeces
9. a substance taken into the body that modifies or affects chemical reactions in the body
10. flu is caused by a virus, and antibiotics only act on bacteria
11. a marker molecule on the surface of a pathogen or cell that triggers antibody production
12. lymphocytes
13. memory cells make antibodies faster and in larger amounts
14. passive
15. the stomach contains hydrochloric acid
    which kills pathogens in food and drink
16. the toxin makes the gut lose ions (chloride)
    water leaves the blood by osmosis into the gut
    causing watery diarrhoea and loss of water
17. sewage treatment stops faeces contaminating water
    water is filtered and chlorinated
    so the bacteria cannot be swallowed in drinking water
18. it contains weakened or dead pathogen or antigens
    lymphocytes make antibodies
    memory cells are made and stay in the blood
    on real infection antibodies are made faster and in larger amounts, so you do not become ill
19. a mutation gives a bacterium resistance
    the antibiotic kills the non-resistant bacteria
    the resistant bacteria survive and reproduce
    so the population is mostly resistant
20. active: your own lymphocytes make antibodies and memory cells are made; long-term
    passive: antibodies are given from another person, no memory cells, short-term
    active is slow to start, passive works immediately

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