

Exercise walk-through

10.1.1

Immunity: antibodies, vaccination and the cholera chain

IGCSE Biology

You must be able to

- describe a pathogen and a **transmissible disease** 传染病, and state how pathogens are transmitted by direct contact and indirectly
- describe the body's defences: skin, hairs in the nose, **mucus** 黏液, stomach acid and white blood cells
- explain how a clean water supply, hygienic food preparation, personal hygiene, waste disposal and **sewage treatment** 污水处理 control the spread of disease
- describe active immunity as defence by antibody production in the body
- state that each pathogen has its own antigens, which have specific shapes
- describe antibodies as **proteins** 蛋白质 that bind to antigens, leading to direct destruction of the pathogen or to its marking for destruction by **phagocytes** 吞噬细胞

You must be able to

- state that specific antibodies have **complementary** 互补 shapes that fit specific antigens
- explain that active immunity is gained after an infection or by vaccination, and outline the process of vaccination
- explain the role of vaccination in controlling the spread of disease
- explain passive immunity, including across the **placenta** 胎盘 and in **breast milk** 母乳, and state that **memory cells** 记忆细胞 are not produced in it
- describe cholera, and explain how its **toxin** 毒素 causes diarrhoea and dehydration

1

The method

Method — The Core facts this sheet builds on

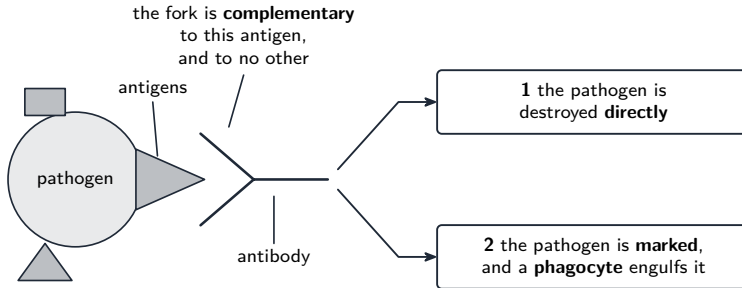
Five lines. Sheet 10.1 taught them; the Supplement questions below assume them.

- 1 A **pathogen** is an organism that causes disease. A **transmissible disease** is one whose pathogen can pass from one **host** 宿主 to another.
- 2 Transmission is **direct** (blood and other body fluids, skin contact) or **indirect** (contaminated surfaces, food, water, animals, air).
- 3 The five body defences: **skin, hairs in the nose, mucus, stomach acid, white blood cells**.
- 4 The five controls on spread: a clean **water supply, hygienic food preparation, good personal hygiene, waste disposal, sewage treatment**.
- 5 A control question is always answered by naming the *route* it blocks: sewage treatment keeps faeces out of drinking water, so a water-borne pathogen such as cholera cannot reach a new host.

Method — An antigen, an antibody, and the two things binding does

- Every pathogen carries **antigens** on its surface, and each kind of antigen has **its own shape**.
- An antibody is a **protein**, made by **lymphocytes** 淋巴细胞, a kind of white blood cell.
- Its binding site is **complementary** to one antigen, so it fits that pathogen and no other. This is why measles antibodies do nothing against cholera.
- Binding leads to destruction in **two** ways, and a question asking “describe what antibodies do” wants both: the pathogen is destroyed **directly**, or it is **marked** so that a **phagocyte** engulfs it.

Method — An antigen, an antibody, and the two things binding does



One antibody fits one antigen, and binding destroys the pathogen in two ways. Name both.

Method — Active and passive: one row decides everything

Work from the middle row outwards. If the body made the antibodies itself, memory cells were made too, so the protection is long-term. If the antibodies arrived ready-made from someone else, no memory cells were made, so it fades.

Worked example. A newborn baby is protected against measles for a few months, although it has never been vaccinated. Name this type of immunity and explain why the protection does not last.

- 1 Name it: **passive immunity** – the antibodies came from the mother, across the **placenta** and in **breast milk**.
- 2 Explain the “does not last”: the baby’s own body did **not** make the antibodies, so **no memory cells** were produced.
- 3 Finish the chain: the antibodies are gradually broken down and are not replaced, so the protection fades.

Method — Active and passive: one row decides everything

- This is the **importance of breast-feeding** 母乳喂养 for an **infant** 婴儿: a newborn's own **development** of active immunity takes months, and until then the mother's antibodies in breast milk are its main defence against the pathogens it meets.

Method — Active and passive: one row decides everything

Name this type of immunity and explain why the protection does not last

	active immunity	passive immunity
whose antibodies?	your own body makes them	made by another body
how do you get it?	an infection, or a vaccination	across the placenta , or in breast milk
memory cells?	yes	no
how long does it last?	long-term	short-term

← this row decides the one below it

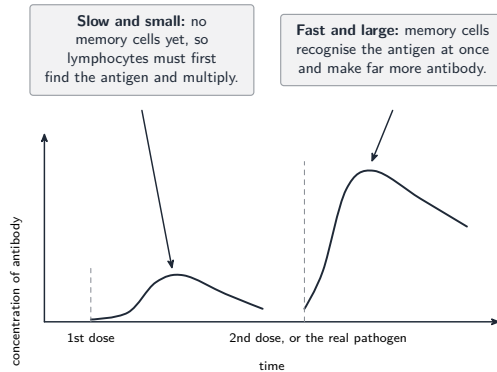
Method — Vaccination, in the steps the mark scheme lists

Four steps. Write them in this order and the marks follow.

- 1 **Weakened pathogens, or their antigens**, are put into the body. They cannot cause the disease.
 - 2 The antigens **stimulate lymphocytes**, which produce **antibodies**.
 - 3 **Memory cells** are produced and stay in the body for years.
 - 4 If the real pathogen arrives later, the memory cells make antibodies **faster and in much greater quantity**, so the person does not become ill.
- The “second response is bigger” mark is always **memory cells**. “The body is used to it” earns nothing.
 - Why vaccination controls spread: if **most** of a population is vaccinated, there are too few people the pathogen can infect, so it cannot pass easily from host to host and even the unvaccinated are protected.

Method — Vaccination, in the steps the mark scheme lists

Write them in this order and the marks follow



Method — Cholera, one arrow at a time

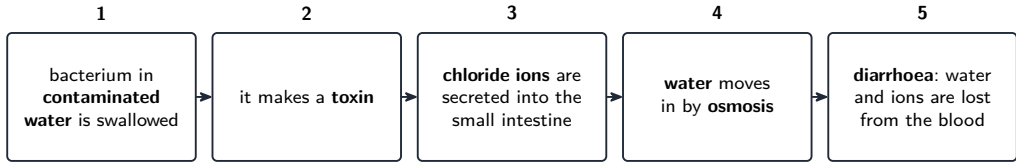
Cholera is caused by a **bacterium** 细菌 and transmitted in **contaminated water** 污染的水. The examinable answer is the chain under the figure, and each arrow is a separate mark:

toxin → chloride ions into the intestine → water in by osmosis → diarrhoea

- The water moves by **osmosis** 渗透, because secreting the ions makes the contents of the intestine a **more concentrated** solution than the cells around it.
- Finish with the consequence: **dehydration** 脱水, and a loss of **ions** 离子 from the blood.
- The control for cholera is the water supply, not a body defence – treat the sewage and the pathogen never reaches a new host.

Method — Cholera, one arrow at a time

Cholera is caused by a bacterium 细菌 and transmitted in contaminated water 污染的水.



Write the chain in this order. Every arrow is worth a mark, and "the toxin causes diarrhoea" skips three of them.

2

Practice

Practice 2.1 ■ 2 marks

State what an antigen is, and where on a pathogen it is found.

Solution 2.1

Worked steps

- an antigen is a **molecule with its own specific shape** that the body recognises as foreign **B1**
- it is found on the **surface** of the pathogen **B1**

Practice 2.2 ■ 2 marks

Describe the **two** ways in which an antibody leads to the destruction of a pathogen it has bound to.

Solution 2.2

Method: An antigen, an antibody, and the two things binding does — p.6

Worked steps

- the pathogen is **destroyed directly** (B1)
- or it is **marked**, so that a **phagocyte** engulfs and destroys it (B1)

Practice 2.3 ■ 1 mark

Name the type of white blood cell that produces antibodies.

Solution 2.3

Method: An antigen, an antibody, and the two things binding does — p.6

Worked steps

- a lymphocyte **B1**

Practice 2.4 ■ 2 marks

These four stages of vaccination are in the wrong order. Write the letters in the correct order.

- A** memory cells are produced
- B** lymphocytes produce antibodies
- C** weakened pathogens are put into the body
- D** the antigens are recognised

Solution 2.4

Method: Vaccination, in the steps the mark scheme lists — p.11

- A memory cells are produced
- B lymphocytes produce antibodies
- C weakened pathogens are put into the body
- D the antigens are recognised

Worked steps

- C, D, B, A **B2**
- one mark for C first and A last, the second for the whole order being right

Practice 2.5 ■ 3 marks

A baby receives antibodies in its mother's breast milk. Name this type of immunity, and explain why it is short-term.

Solution 2.5

Method: Active and passive: one row decides everything — p.8

Worked steps

- **passive immunity** (B1)
- the baby's own body did **not** make these antibodies, so **no memory cells** are produced (B1)
- the antibodies are broken down and are not replaced, so the protection fades after a few months (B1)

Practice 2.6 ■ 4 marks

Describe how the cholera bacterium causes diarrhoea.

Solution 2.6

Worked steps

- the bacterium is swallowed in contaminated water and reaches the **small intestine** (B1)
- it produces a **toxin** (B1)
- the toxin causes **chloride ions** to be secreted into the intestine, so **water moves in by osmosis** (B1)
- the result is **diarrhoea**, with loss of water and ions from the blood (B1)

3

Exam-style

Exam-style 3.1 ■ 1 mark

A person is given an injection of ready-made antibodies against a snake venom. Which row is correct?

	type of immunity	memory cells made?	protection
A	active	yes	long-term
B	active	no	short-term
C	passive	yes	long-term
D	passive	no	short-term

Solution 3.1

Method: Active and passive: one row decides everything — p.8

Worked steps

D

- the antibodies were made in another body, so this is **passive** immunity **B1**
- the patient's own lymphocytes were never stimulated, so **no memory cells** were made, which rules out **A**, **B** and **C**

Exam-style 3.2 ■ 7 marks

The graph in the worked examples shows the antibody concentration in a person's blood after a first dose of a vaccine and after a second dose of the same vaccine.

Exam-style 3.2 (a) ■ 2 marks

Describe **two** differences between the response to the first dose and the response to the second dose.

Solution 3.2 (a)

Method: Vaccination, in the steps the mark scheme lists — p.11

Worked steps

- the second response is **faster** – the antibody concentration starts to rise sooner (B1)
- the second response is **larger** – it reaches a much higher concentration; it also lasts longer (B1)

Exam-style 3.2 (b) ■ 3 marks

Explain why the second response is different.

Solution 3.2 (b)

Worked steps

- the first dose produced **memory cells** (B1)
- the memory cells **recognise the antigen at once**, so no time is lost finding the right lymphocyte (B1)
- they divide and produce antibodies **more quickly and in much greater quantity** (B1)

Exam-style 3.2 (c) ■ 2 marks

The vaccine contains weakened pathogens. Explain why a weakened pathogen can still produce immunity.

Solution 3.2 (c)

Worked steps

- the weakened pathogen still carries its **antigens**, which have the same shapes
B1
- so lymphocytes are still stimulated to make antibodies and memory cells, but the pathogen is too weak to cause the disease B1

Exam-style 3.3 ■ 12 marks

In 2021 a country reported 4200 cases of cholera. The government treated the sewage from its largest city, supplied clean drinking water, and began a vaccination programme.

Exam-style 3.3 (a) ■ 2 marks

State the type of organism that causes cholera, and how it is transmitted.

Solution 3.3 (a)

Worked steps

- a **bacterium** (B1)
- transmitted **indirectly, in contaminated water** (B1)

Exam-style 3.3 (b) ■ 3 marks

Explain how treating sewage reduces the number of cholera cases.

Solution 3.3 (b)

Worked steps

- untreated sewage carries the cholera bacterium from an infected person's faeces **B1**
- treating it stops the bacterium reaching the **drinking water supply** **B1**
- so the pathogen cannot be transmitted to a new **host**, and the number of new infections falls **B1**

Exam-style 3.3 (c) ■ 3 marks

Explain how vaccinating most of the population protects the people who were **not** vaccinated.

Solution 3.3 (c)

Worked steps

- vaccinated people produce antibodies and memory cells, so they do not become infected **B1**
- with most of the population immune, there are very few people the bacterium can infect and multiply in **B1**
- so it is far less likely to be passed on, and an unvaccinated person is unlikely to meet it **B1**

Exam-style 3.3 (d) ■ 2 marks

A doctor gives an unvaccinated patient with cholera an injection of antibodies against the cholera toxin. Explain why this patient could still catch cholera again the following year.

Solution 3.3 (d)

Worked steps

- the injected antibodies were made in another body, so this is **passive** immunity and **no memory cells** are produced (B1)
- the patient's own lymphocytes were never stimulated, so there is no long-term protection and the same pathogen can infect them again (B1)

Exam-style 3.3 (e) ■ 2 marks

The number of cases fell to 150 the next year. Calculate the percentage decrease.

Solution 3.3 (e)

Worked steps

- find the decrease, then divide by the **original** number M1

$$\frac{4200 - 150}{4200} \times 100 = \frac{4050}{4200} \times 100 = \mathbf{96.4\%}$$
A1

- dividing by 150 instead of 4200 is the usual mistake; the percentage change is always out of the starting value