

10.1.1 Immunity: antibodies, vaccination and the cholera chain

Name: _____ Class: _____ Date: _____

Total: 34 marks

KEY WORDS antibodies 抗体 • disease 疾病 • pathogen 病原体 • ions 离子 • cholera 霍乱

Objective

Sheet 10.1 taught you what a **pathogen** 病原体 is, how it spreads and how the body keeps it out. This sheet is the Supplement half of 10.1, and it is where most of the marks are: **antigens** 抗原 and **antibodies** 抗体, **active** and **passive immunity** 免疫, how **vaccination** 疫苗接种 works, and the **cholera** 霍乱 chain. Every one of these is answered by writing a chain of steps in the right order, so this sheet trains the chains. This sheet covers syllabus 10.1.

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
- 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 Worked examples

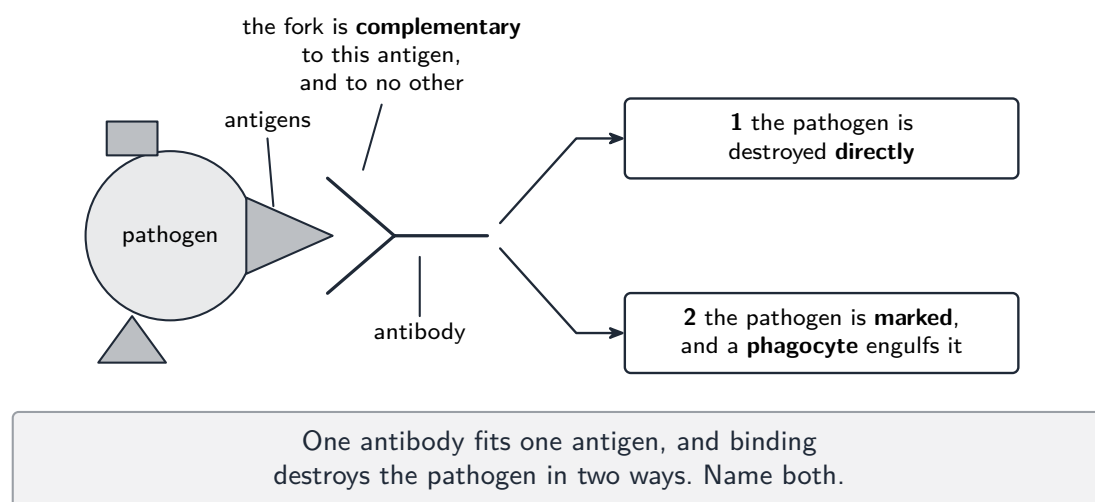
Study these first. Each one shows a **method** that a question later on this sheet needs.

■ 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.

■ 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.

■ Active and passive: one row decides everything

	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

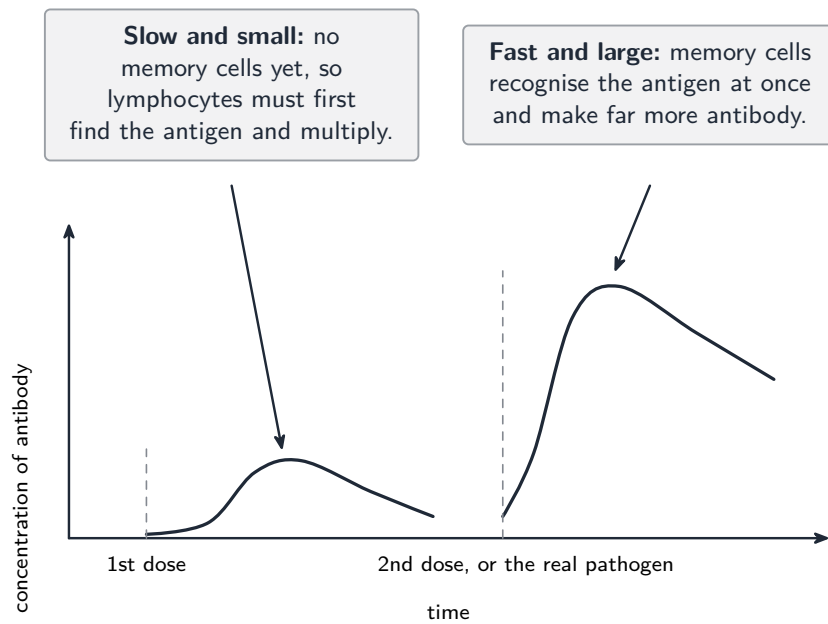
← this row decides the one below it

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.
- 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.

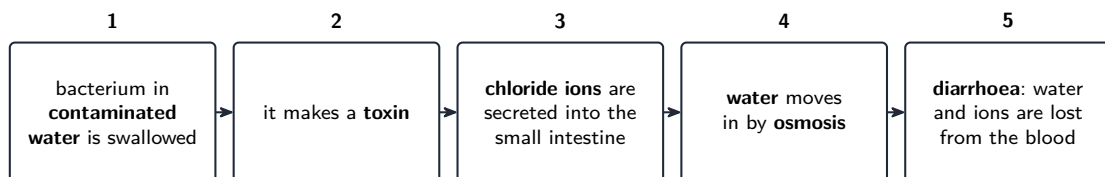
■ Vaccination, in the steps the mark scheme lists



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.

■ Cholera, one arrow at a time



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

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.

2 Practice

Now use the methods above.

2.1 State what an antigen is, and where on a pathogen it is found. [2]

2.2 Describe the **two** ways in which an antibody leads to the destruction of a pathogen it has bound to. [2]

2.3 Name the type of white blood cell that produces antibodies. [1]

2.4 These four stages of vaccination are in the wrong order. Write the letters in the correct order. [2]

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

2.5 A baby receives antibodies in its mother's breast milk. Name this type of immunity, and explain why it is short-term. [3]

2.6 Describe how the cholera bacterium causes diarrhoea. [4]

3 Exam-style questions

3.1 A person is given an injection of ready-made antibodies against a snake venom. Which row is correct? [1]

	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

3.2 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.

(a) Describe **two** differences between the response to the first dose and the response to the second dose. [2]

(b) Explain why the second response is different. [3]

(c) The vaccine contains weakened pathogens. Explain why a weakened pathogen can still produce immunity. [2]

3.3 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.

(a) State the type of organism that causes cholera, and how it is transmitted. [2]

(b) Explain how treating sewage reduces the number of cholera cases. [3]

(c) Explain how vaccinating most of the population protects the people who were **not** vaccinated. [3]

(d) 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. [2]

(e) The number of cases fell to 150 the next year. Calculate the percentage decrease. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

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

2.2

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

2.3

- a **lymphocyte**

2.4

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

2.5

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

2.6

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

3.1 D

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

3.2

(a)

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

(b)

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

(c)

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

3.3

(a)

- a **bacterium**
- transmitted **indirectly, in contaminated water**

(b)

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

(c)

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

(d)

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

(e)

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

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

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