# 26.1 Defence against disease

Name: _____ Class: _____ Date: _____ **Total: 28 marks**

**KEY WORDS** pathogen • antigen • antibody • phagocyte • memory cell • herd immunity

## Objective

Build the skills to answer exam questions on **defence against disease** : pathogens, barriers and clotting, innate and adaptive immunity, antibodies, vaccines, HIV and antibiotics.

**You must be able to:**

- describe pathogens and the first line of defence, including blood clotting
- compare innate and adaptive immunity, and explain the roles of phagocytes and lymphocytes
- explain how antibodies and memory cells are made, and how vaccines and herd immunity work
- explain the effect of HIV on the immune system, and why antibiotic resistance is a problem
- explain the evolution of antibiotic resistance and the risk of zoonoses, using data

## 1 Key knowledge and worked examples

### ■ Defence against disease

**Pathogens** are organisms or viruses that cause disease: bacteria, viruses, fungi, protists. **First line:** the **skin** (tough outer layer of dead cells) and **mucous membranes** (sticky mucus traps microbes). **Blood clotting** seals cuts: platelets release clotting factors, which start a cascade ending with **thrombin** converting **fibrinogen** into insoluble **fibrin** threads that trap blood cells.

| **innate immunity** | **adaptive immunity** |
|---|---|
| present from birth, non-specific | develops after exposure, specific |
| **phagocytes** engulf pathogens | **lymphocytes** respond to particular **antigens** |
| the same response each time | faster and stronger the second time (**memory cells**) |

**Antibody production:** a phagocyte presents the antigen; a **helper T-cell** activates the matching **B-cell**; the B-cell divides (**clonal selection**) into **plasma cells**, which secrete antibodies, and **memory cells**. **Antibodies** bind antigens, making pathogens clump and marking them for phagocytes.

**HIV** infects helper T-cells; as their number falls, B-cells cannot be activated, so the body cannot fight infections (**AIDS**). HIV spreads in blood, sexual fluids and from mother to baby.

**Vaccines** contain antigens (weakened or killed pathogens, or mRNA coding for an antigen); they cause memory cells to form. **Herd immunity:** when enough people are immune, the pathogen cannot spread, which protects those who cannot be vaccinated. **Antibiotics** kill bacteria or stop their growth but do **not** affect viruses.

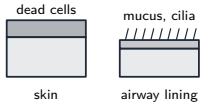
**HL extension:** antibiotic **resistance** evolves by natural selection: a random mutation gives resistance; antibiotics kill the others; resistant bacteria multiply. **Zoonoses** are diseases that pass from animals to humans (e.g. COVID-19, rabies).

**Worked example.** If each infected person infects $R_0 = 4$ others, about $1 - \frac{1}{4} = \mathbf{75}\%$ of people must be immune for herd immunity.

**Answer shapes:** antigen → helper T-cell → B-cell clones → plasma cells (antibodies) and memory cells.

## 2 Practice

**2.1** Describe how the skin and mucous membranes protect the body against pathogens. [2]

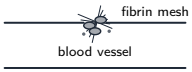




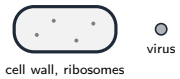



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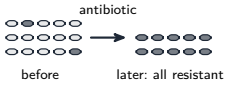
**2.2** Explain how blood clots at a cut. [3]




**2.3** Explain why antibiotics can treat bacterial infections but not viral infections. [3]




**2.4** Explain how antibiotic resistance spreads in a bacterial population. [2]




**2.5** State what is meant by a zoonosis, with one example. [2]





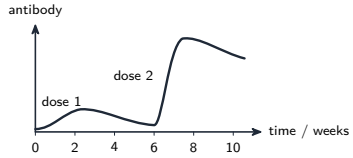

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## 3 Exam-style questions

**3.1** The graph shows the concentration of antibodies in the blood after two doses of a vaccine.

(a) Compare the responses to the first and second doses. [2]

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



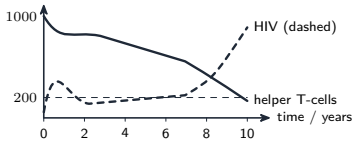

(c) State what a vaccine contains. [1]

(d) Explain how herd immunity protects people who cannot be vaccinated. [2]

**3.2** HIV infects helper T-cells. The graph shows the number of helper T-cells and the amount of HIV in a patient over 10 years without treatment.

(a) Describe the change in helper T-cell count. [2]

(b) Explain why the patient becomes ill with other infections when the count is very low. [3]




(c) State two ways in which HIV is transmitted. [2]

(d) Distinguish between innate and adaptive immunity. [1]



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## Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

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

**2.1**

the skin is a tough physical barrier of dead cells; mucus traps pathogens in the airways, and cilia move it away

**2.2**

platelets gather at the cut and release clotting factors; a cascade activates thrombin, which converts fibrinogen into fibrin; fibrin threads form a mesh that traps blood cells, sealing the cut

**2.3**

antibiotics block processes found in bacteria, e.g. cell wall formation or protein synthesis; viruses have no metabolism of their own / use the host cell; so there is nothing for antibiotics to act on, and they would harm the host if they blocked host processes

**2.4**

a random mutation gives some bacteria resistance; the antibiotic kills the non-resistant ones, so resistant bacteria survive and reproduce: natural selection

**2.5**

an infectious disease that passes from animals to humans; e.g. COVID-19 / rabies / bird flu / Ebola

**3.1**

(a) second response is faster; and produces much more antibody

(b) the first dose produced memory cells; on the second exposure, memory cells recognize the antigen quickly; they divide rapidly into plasma cells that secrete more antibodies

(c) antigens / weakened or killed pathogens / mRNA coding for an antigen

(d) when most people are immune, the pathogen cannot pass from person to person; so it is unlikely to reach those who are not immune

**3.2**

(a) falls over the ten years; from about 1000 to below 200 per $mm^3$

(b) helper T-cells are needed to activate B-cells; so few plasma cells / antibodies are made; the body cannot fight other pathogens, so opportunistic infections develop (AIDS)

(c) any two: sexual intercourse; sharing needles / blood; from mother to baby at birth or in breast milk

(d) innate is non-specific and present from birth; adaptive is specific to an antigen and has memory



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