

Drugs

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Read first: [Diseases and immunity](#)

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What you need to know

This is one of the shortest topics in the syllabus. Anything marked **Extended only** is for Extended candidates, and is tested only on the Extended papers. By the end of this topic you should be able to:

Core

1. **Describe a drug** as any substance taken into the body that modifies or affects chemical reactions in the body.
2. **Describe how antibiotics are used** to treat infections caused by bacteria.
3. **State that some bacteria are resistant to antibiotics**, and that this makes the antibiotics less effective.
4. **State that antibiotics kill bacteria but have no effect on viruses.**

Extended only

5. **Explain how using antibiotics only when essential** slows down the development of resistant bacteria such as MRSA.

What a pathogen is, and how the body defends itself, are in Diseases and immunity. Natural selection in general is in Variation and selection; this note uses it only for antibiotic resistance.

Understand it

What counts as a drug

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

Both halves matter:

- it comes **from outside** and is **taken in** (swallowed, injected, inhaled). Insulin made by your own pancreas is a hormone, not a drug; insulin injected by a person with diabetes is a drug.
- it **changes chemical reactions** in the body. That is what makes it a drug, whether it helps (a medicine) or harms.

Medicines are drugs (antibiotics, painkillers), and so are caffeine, alcohol and nicotine. The definition says nothing about being illegal, harmful or helpful.

Multiple-choice questions put the definition next to others that sound similar:

Definition	It describes
substance taken into the body that modifies or affects chemical reactions	drug
substance made by a gland , carried by the blood, that changes what target organs do	hormone
protein that speeds up a reaction and is not changed by it	enzyme
protein made by lymphocytes that binds to an antigen	antibody

Antibiotics treat bacterial infections

Antibiotics are drugs that **kill bacteria**. A doctor gives them to treat an infection caused by a **bacterium**: cholera, tuberculosis, gonorrhoea, chlamydia, syphilis, an infected wound. Penicillin, made by the fungus *Penicillium*, is an antibiotic.

Extended only: antibiotics can kill bacteria without harming us because they attack parts of **bacterial cells** that human cells don't have; many, for example, damage the bacterial **cell wall**.

Antibiotics do not affect viruses

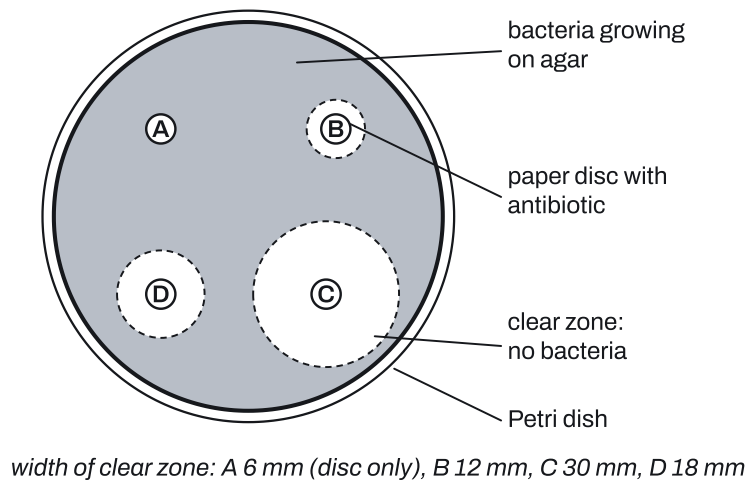
Antibiotics **kill bacteria but do not affect viruses**, so influenza, colds, measles, chickenpox and HIV cannot be treated with antibiotics. Antibiotics also do nothing for diseases that have no pathogen, such as rickets, scurvy or coronary heart disease.

Extended only: the reason is that a virus is not a cell. It is only genetic material inside a **protein coat**, and it reproduces inside the host's own cells. It has **no cell wall** and none of the other bacterial parts that antibiotics act on.

Disease caused by	Treated by antibiotics?
a bacterium (cholera, TB, gonorrhoea, syphilis)	yes , unless the bacteria are resistant
a virus (influenza, measles, HIV)	no
no pathogen (rickets, scurvy, heart disease)	no

Testing antibiotics on an agar plate

To find which antibiotic works best against a type of bacterium, spread the bacteria over nutrient **agar** in a Petri dish. Place paper discs, each soaked in a different antibiotic, on top, and leave the dish somewhere warm. Bacteria grow everywhere except where the antibiotic has spread out from a disc and killed them, leaving a **clear zone**.



- The **largest clear zone** means the antibiotic killed the most bacteria: it is the **most effective** antibiotic (C above).
- **No clear zone** means the bacteria grew right up to the disc: they are **resistant** to that antibiotic (A above).

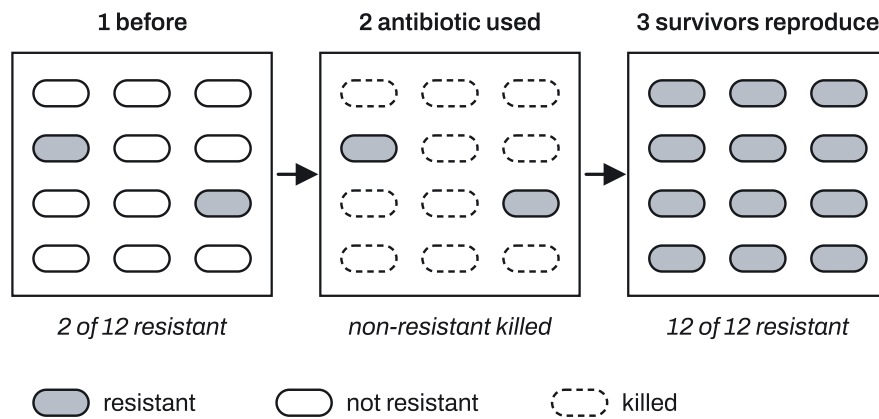
Antibiotic resistance

Some bacteria are **resistant** to an antibiotic: it no longer kills them. An infection caused by resistant bacteria is hard to treat, because the antibiotic is **less effective** or doesn't work at all. It is the **bacteria** that are resistant, never the person and never the antibiotic. Resistance is **not** immunity: immunity is the body's defence (antibodies, memory cells), while resistance is a feature of the bacteria.

Extended only: MRSA (methicillin-resistant *Staphylococcus aureus*) is a bacterium that is resistant to several antibiotics, which makes MRSA infections difficult to treat.

Extended only: resistance develops by **natural selection**:

1. In a population of bacteria there is **variation**. A **random mutation** gives a few bacteria an allele that makes them **resistant**. The antibiotic does not cause the mutation.
2. When the antibiotic is used, it **kills the non-resistant bacteria**. The **resistant ones survive**.
3. The survivors **reproduce**.
4. They **pass on the allele for resistance** to their offspring.
5. Over many generations the **proportion of resistant bacteria** in the population **increases**, until the antibiotic hardly works.



Extended only: no person chooses which bacteria survive, so this is **natural** selection, not artificial selection.

Using antibiotics only when essential

Extended only: every time an antibiotic is used, it **selects** for resistant bacteria: it kills the others and leaves the resistant ones to multiply. The **more often** antibiotics are used, the more chances there are for resistant bacteria to be selected and to spread. So using antibiotics **only when essential** means **less natural selection** for resistant bacteria: resistant strains such as MRSA develop more slowly, and antibiotics stay effective for longer. In practice:

- **Extended only:** don't use antibiotics for viral infections (they have no effect on the virus, but still select for resistance among the bacteria in the body);
- **Extended only:** only use them for **bacterial infections that need them**, when a doctor prescribes them;
- **Extended only:** don't give antibiotics routinely to healthy farm animals;
- **Extended only:** use the **right antibiotic** for the bacterium, and **complete the course** as prescribed;
- **Extended only:** don't share antibiotics or keep leftovers for later.

Key facts and formulas

There is no formula list in the IGCSE Biology exam. Everything below must be learnt.

Formula	Status
Drug = any substance taken into the body that modifies or affects chemical reactions in the body	Learn it
Antibiotics treat bacterial infections; they kill bacteria but do not affect viruses	Learn it
Some bacteria are resistant to antibiotics, which reduces the effectiveness of antibiotics	Learn it
Agar plate: largest clear zone = most effective antibiotic; no clear zone = bacteria resistant	Learn it

Formula	Status
Percentage change = $\frac{\text{new} - \text{original}}{\text{original}} \times 100$; mean = total ÷ number of values	Learn it
Extended only: mutation → resistant bacteria survive the antibiotic → reproduce → pass on the resistance allele → proportion resistant increases (natural selection)	Learn it
Extended only: using antibiotics only when essential → less natural selection for resistant bacteria such as MRSA	Learn it

How to do it

We tagged 57 questions for this topic (2021–2025, Papers 1–4; 51 different, since some multiple-choice questions appear on more than one paper). 13 of them mix types, so the counts add up to 75.

Question type	Questions
Say what antibiotics can treat	27
Explain antibiotic resistance	12
Read and calculate from data on antibiotics and resistance	12
Define a drug	11
Limit the development of resistance (Extended only)	10
Compare antibiotics on an agar plate	3

1. Say what antibiotics can treat (27 questions)

1. Ask **what causes the disease**. Bacterium → antibiotics work. Virus → they don't. No pathogen (a deficiency disease, heart disease) → they don't.
2. For a **statement** question, test each statement against the four Core facts: antibiotics are **drugs**; they **kill bacteria**; they **don't affect viruses**; they **don't work against resistant bacteria**.

Variations you will meet:

- **"Which statement describes the effect of antibiotics?":** they kill bacteria and don't affect viruses. Reject "kill all pathogens", "kill all harmful microorganisms" and "kill bacteria and viruses".
- **Statements that sound right but aren't:** antibiotics are **not** made by white blood cells or platelets; they don't treat rickets or scurvy; they don't treat every transmissible disease.
- **A table of diseases and the pathogens that cause them:** pick every disease caused by a bacterium, and leave out the viral ones.
- **"State the type of organism antibiotics kill":** **bacteria**. "Pathogens" or "microorganisms" is not specific enough.

- **"Why can't this disease be treated with antibiotics?":** it isn't bacterial, the pathogen is a virus, **or** the bacteria are resistant. All three can be right.
- **Extended only: "Explain why antibiotics are not used to treat viral infections":** viruses are not cells and have none of the parts antibiotics attack (no cell wall), so antibiotics have no effect on them.
- **Extended only: "How do some antibiotics kill bacteria?":** they damage the **cell wall**. A protein coat belongs to a virus, not a bacterium.

2. Explain antibiotic resistance (12 questions)

Some bacteria are **resistant**, so the antibiotic doesn't kill them and becomes **less effective**. That is the answer to "suggest why this antibiotic kills fewer bacteria each year" or "why has its effectiveness gone down?": **the bacteria have become resistant**.

Extended only: "Explain how bacteria become resistant" (4–5 marks) is the natural selection chain, one idea per mark:

1. random **mutation** gives some bacteria resistance, so there is **variation**;
2. the antibiotic **kills non-resistant** bacteria, and **resistant** ones **survive**;
3. the survivors **reproduce**;
4. they **pass on** the resistance **allele**;
5. the **proportion** of resistant bacteria **increases: natural selection**.

Variations you will meet:

- **"State the meaning of antibiotic resistance":** the antibiotic is less effective against those bacteria, or no longer kills them.
- **Extended only: natural or artificial selection?** Natural: no person chooses which bacteria breed.
- **Extended only: why scientists are worried** about resistance: resistant infections are hard or impossible to treat, they can spread, and new antibiotics are needed.
- **Extended only: MRSA** is hard to treat because it is **resistant to some antibiotics**; not because it is a virus or resistant to antibodies.

3. Read and calculate from data on antibiotics and resistance (12 questions)

1. **Read the axes** first: what is plotted, and the units (doses per 1000 people per day, percentage of infections that are resistant). Read values carefully off the gridlines.
2. **Percentage change** = $\frac{\text{new} - \text{original}}{\text{original}} \times 100$. The original is the **earlier** value. Say whether it is an increase or a decrease, and round as asked.
3. **Describe** a graph: the overall trend, peaks and when they happen, any levelling off or fall, with **values and units** quoted from both axes.
4. **Suggest reasons** for a change using this topic: more antibiotic use → more resistant infections; fewer doses or a new antibiotic → fewer resistant infections.

For example, if resistant infections rise from 250 to 400 per 100 000 people, the percentage increase is

$$\frac{400 - 250}{250} \times 100 = 60\%.$$

Variations you will meet:

- **Largest change between two years:** work out each difference and pick the biggest, rather than judging by eye.
- **Difference** between two bars, or **which two bars are the same:** read both bars to the gridline.
- **A percentage change of more than 100%:** from 1000 to 4500 is $\frac{3500}{1000} \times 100 = 350\%$. Don't divide by the new value.
- **A table of which antibiotic works on which bacterium:** for two infections at once, choose an antibiotic that works against **both**.
- **Two lines on one graph**, each with its own *y*-axis: read each line against its own axis, and look for a delay between the peaks.
- **The concentration of an antibiotic in the blood** over time: describe the shape (rises, peaks, falls), and quote values with units from both axes.
- **A mean** from repeated readings: add them and divide by how many there are. Five reaction times of 0.28, 0.31, 0.26, 0.33 and 0.27 s have a mean of $1.45 \div 5 = 0.29$ s.

4. Define a drug (11 questions)

Learn the definition: **any substance taken into the body that modifies or affects chemical reactions in the body**. In multiple choice, reject options where the substance is **made in the body** (hormone, enzyme, antibody), where it **must be illegal**, or where it is **any substance** taken in with nothing about chemical reactions. In a written answer, give both halves: taken into the body, and modifies or affects chemical reactions.

5. Limit the development of resistance (10 questions)

Extended only: every one of these questions was on an Extended paper.

1. **Give the rule:** use antibiotics **only when essential**.
2. **Say why it works:** fewer uses mean less natural selection for resistant bacteria, so fewer resistant bacteria survive, reproduce and spread.
3. If asked to **describe ways**, give one precise action per mark from "Using antibiotics only when essential": not for viral infections; only for bacterial infections that need them; not routinely for healthy livestock; the right antibiotic; complete the course; don't share them.

Variations you will meet:

- **Extended only: multiple choice:** "use antibiotics only to treat bacterial infections" limits resistance. Using them often, to prevent infection, for all infections or for viral infections all **increase** it, and so does giving them regularly to healthy livestock.

- **Extended only: "Why should antibiotics be used only when essential?":** it **reduces the natural selection** of resistant bacteria.
- **Extended only: why intensive livestock farms use antibiotics:** many animals are kept close together, so bacterial diseases spread easily between them; antibiotics treat or prevent these infections, which is one reason resistance is a concern on farms.
- **Extended only: suggest why resistant infections fell:** fewer doses of that antibiotic, antibiotics taken as instructed or only when needed, new antibiotics or other treatments, vaccination.

6. Compare antibiotics on an agar plate (3 questions)

1. Find the disc with the **largest clear zone** (no bacterial growth): that antibiotic is the **most effective**.
2. A disc with **no clear zone**, or the smallest, is the antibiotic the bacteria are **most resistant** to.
3. In an explanation, say it in those words: "the **largest clear zone**, so it killed the most bacteria".

If a later test shows a smaller clear zone for the same antibiotic, the bacteria have become more resistant to it.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **M1** method mark: for a correct method, even if the numbers slip.
- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

Example 1

A doctor sees four patients.

Patient	Illness	Caused by
P	influenza	virus
Q	tuberculosis	bacterium
R	ricketts	lack of vitamin D
S	infected cut	bacterium

- (a) Antibiotics are drugs. State what is meant by the term *drug*. **[2]**
- (b) State which patients could be treated with antibiotics. Explain your answer. **[3]**
- (c) Patient S takes an antibiotic, but the infection doesn't get better. Suggest why. **[1]**

- (a) Any substance taken into the body **B1** that modifies or affects chemical reactions in the body **B1**.
- (b) Q and S **B1**. Their illnesses are caused by bacteria, and antibiotics kill bacteria **B1**. Influenza is caused by a virus, and antibiotics don't affect viruses; rickets has no pathogen at all **B1**.
- (c) The bacteria are resistant to that antibiotic **B1**.

Example 2

A student spread one type of bacterium over agar in a Petri dish and placed four paper discs on it, each soaked in a different antibiotic, A to D. The diagram in "Testing antibiotics on an agar plate" shows the dish after 48 hours. The table gives the width of the clear area around each disc; each disc is 6 mm across.

Antibiotic	A	B	C	D
Width of clear area / mm	6	12	30	18

- (a) State which antibiotic would be the best treatment for a disease caused by this bacterium. Explain your choice. **[2]**
- (b) State which antibiotic the bacteria are resistant to. Give a reason. **[1]**
- (c) Calculate how many times wider the clear area around C is than the clear area around B. **[1]**
- (d) Bacteria of the same type, taken from a different patient, give a clear area of only 8 mm around disc C. Suggest what this shows about these bacteria. **[1]**
- (a) C **B1**: it has the largest clear zone, so it killed the most bacteria **B1**.
- (b) A: the bacteria grew right up to the disc, so there is no clear zone beyond the 6 mm disc **B1**.
- (c) $30 \div 12 = 2.5$ times **B1**.
- (d) They are resistant to antibiotic C (C is less effective against them) **B1**.

Example 3

Extended only: the table shows the number of antibiotic prescriptions and the percentage of *Staphylococcus aureus* infections that were MRSA in one country.

Year	2010	2012	2014	2016	2018
Antibiotic prescriptions per 1000 people per day	25	26	22	17	15
Percentage of infections that were MRSA	12	15	14	10	8

- (a) Calculate the percentage change in the number of prescriptions from 2010 to 2018. **[2]**
- (b) Calculate the percentage change in the percentage of infections that were MRSA from 2012 to 2018. Give your answer to two significant figures. **[2]**

(c) Explain how MRSA developed resistance to antibiotics. [4]

(d) Using the data, explain how using antibiotics only when essential limits the development of resistant bacteria such as MRSA. [3]

(a) $\frac{15 - 25}{25} \times 100$ **M1** = -40% (a decrease of 40%) **A1**.

(b) $\frac{8 - 15}{15} \times 100 = -46.66 \dots$ **M1** = -47% to 2 s.f. **A1**.

(c) A random mutation gave some *S. aureus* bacteria resistance **B1**. When antibiotics were used, the non-resistant bacteria were killed and the resistant ones survived **B1**. The resistant bacteria reproduced and passed on the allele for resistance **B1**, so the proportion of resistant bacteria increased by natural selection **B1**.

(d) Each use of an antibiotic kills non-resistant bacteria and leaves resistant ones to reproduce **B1**. Using antibiotics less means less natural selection for resistant bacteria **B1**. The data fit this: as prescriptions fell after 2012, the percentage of MRSA infections fell too, from 15% to 8% **B1**.

Common mistakes

These come from the examiner reports for 2021–2025.

- **Thinking antibiotics kill viruses.** The 2022 and 2023 reports note this on both multiple-choice and written papers. Antibiotics don't affect viruses, and they don't work on diseases with no pathogen either.
- **Answering "pathogens" when asked what antibiotics kill.** The answer is **bacteria**. "Pathogens" is not specific enough, and a list of possibilities isn't credited.
- **Mixing up antibiotics, antibodies and antigens.** Antibiotics are drugs taken into the body; antibodies are proteins made by lymphocytes; antigens are on the pathogen.
- **Believing antibiotics kill resistant bacteria.** They don't; that is what resistant means.
- **Writing "a large area" for an agar plate.** Say "the **largest clear zone**".
- **Describing data without units.** Quote values with their units: "1.5 doses per 1000 people per day", not "1.5".
- **Extended only: saying the antibiotic causes the mutation,** or that bacteria "change to adapt" to it. The mutations are **random**; the antibiotic only selects the bacteria that already have them.
- **Extended only: confusing resistance with immunity,** for example linking the mutation to memory cells. The **bacteria** are resistant; the immune system has nothing to do with it.
- **Extended only: writing about "traits" or "characteristics" being passed on.** Write that resistant bacteria pass on the **allele** for resistance.
- **Extended only: explaining how resistance happened when asked why resistant infections fell.** Read which way the data go, and give reasons for **that** change (fewer doses, new antibiotics, vaccines).

How to get the marks

- **"State"**: one word or phrase: "bacteria", "resistant", "drug". Don't list alternatives.
- **Definitions**: give both halves of "any substance **taken into the body** that **modifies or affects chemical reactions** in the body". In a 2-mark definition, each half earns a mark.
- **Extended only: "explain how resistance develops"**: a chain of linked steps, in order, with the key words: **mutation, variation, resistant bacteria survive, reproduce, allele passed on, natural selection, proportion increases**. Each link can earn a mark.
- **Extended only: "describe ways to limit resistance"**: one precise action per mark ("only use antibiotics for bacterial infections", "complete the course"). "Use fewer antibiotics" on its own is vague; say when.
- **Extended only: "explain"** why using antibiotics only when essential works: link it to **less natural selection** of resistant bacteria.
- **Calculations**: show the working, use the **original** value as the divisor, say "increase" or "decrease", and round as asked. A correct method with a misread value can still earn marks, so always write it out.
- **"Describe" a graph**: overall trend, peaks with their years, values with units. **"Suggest"** means any sensible reason linked to the data, not a fact you must have learnt.

Quick check

1. Complete the definition: a drug is any substance
2. Which of these could be treated with antibiotics: cholera, influenza, scurvy, gonorrhoea, measles? Explain why the others can't.
3. In one hospital the number of patients with a resistant bacterial infection rose from 800 to 2600 in ten years. Calculate the percentage increase.
4. Of 1200 samples of a bacterium tested, 180 were resistant to an antibiotic. Calculate the percentage of samples that were resistant.
5. **Extended only**: a patient with a cold asks for antibiotics. Explain why the doctor refuses, and why giving antibiotics for colds would harm other patients in the future.

Answers

1. ... taken into the body that modifies or affects chemical reactions in the body.
2. Cholera and gonorrhoea, which are caused by bacteria. Influenza and measles are caused by viruses, which antibiotics don't affect; scurvy is caused by a lack of vitamin C, with no pathogen at all.
3. $\frac{2600 - 800}{800} \times 100 = 225\%$.
4. $\frac{180}{1200} \times 100 = 15\%$.
5. A cold is caused by a virus, and antibiotics don't affect viruses, so it wouldn't help. Using antibiotics when they aren't essential kills non-resistant bacteria in the body and lets resistant ones survive and reproduce, so resistant bacteria are selected and spread; later bacterial infections are harder to treat.

Past questions to try

- **0610/42/M/J/23 Q3**: percentage change from a graph of antibiotic use and resistant infections, and how resistance develops (Extended).
- **0610/42/F/M/22 Q4**: antibiotic discs on an agar plate, how resistance develops and how to limit it (Extended).
- **0610/33/O/N/21 Q8**: what antibiotics treat, the meaning of resistance and a graph of resistance to three antibiotics (Core).
- **0610/22/F/M/24 Q32**: which actions increase the chance of antibiotic resistance (Extended).