

Infectious diseases: summary notes

These revision notes cover Topic 10 (Infectious diseases) of the Cambridge International AS & A Level Biology 9700 syllabus. They cover the five named diseases: cholera, malaria, tuberculosis (TB), HIV/AIDS and measles. For each one you will find the pathogen that causes it, how it is transmitted, how it can be prevented and controlled, and why it matters worldwide. The notes then cover antibiotics: how penicillin works, why antibiotics have no effect on viruses, how antibiotic resistance evolves and what can be done to reduce it. Worked examples show you how to answer data and extended-response questions. A glossary and a quick-check quiz with full answers are at the end.

1. What is an infectious disease?

Learn these definitions word-for-word

Infectious disease: a disease caused by a pathogen that can be passed from one person to another (it is transmissible).

Pathogen: an organism (or virus) that causes infectious disease, such as a bacterium, virus, protist or fungus.

Vector: an organism that carries a pathogen from one host to another, for example the female *Anopheles* mosquito, which carries *Plasmodium*.

Transmission: the way a pathogen passes from an infected host to an uninfected host.

Non-infectious diseases, such as sickle cell anaemia, lung cancer or coronary heart disease, are **not** caused by pathogens and cannot be caught from another person. A common exam trap is to call a disease "infectious" just because many people in one area have it.

Pathogens are spread in a small number of ways. Knowing them helps you predict how a disease can be controlled:

- **Food and water** contaminated with faeces (the faecal–oral route): cholera.
- **Airborne droplets** from coughs, sneezes and breathing out: TB and measles.
- **Vectors:** malaria (female *Anopheles* mosquito).
- **Exchange of body fluids** (blood, semen, vaginal fluid, breast milk): HIV. Malaria can also be spread by blood.

2. The five named diseases: overview

Disease	Pathogen	Type of pathogen	Main method of transmission
Cholera	<i>Vibrio cholerae</i>	Bacterium (prokaryote)	Drinking water or eating food contaminated with faeces from an infected person

Malaria	<i>Plasmodium falciparum</i> , <i>P. vivax</i> , <i>P. ovale</i> , <i>P. malariae</i>	Protoctist (single-celled eukaryote)	Bite of an infected female <i>Anopheles</i> mosquito (vector); also blood transfusion, shared needles, mother to fetus across the placenta
Tuberculosis (TB)	<i>Mycobacterium tuberculosis</i> and <i>Mycobacterium bovis</i>	Bacterium (prokaryote)	<i>M. tuberculosis</i> : airborne droplets. <i>M. bovis</i> : unpasteurised milk or undercooked meat from infected cattle
HIV/AIDS	Human immunodeficiency virus (HIV)	Virus (a retrovirus with RNA)	Body fluids: unprotected sex, shared needles, infected blood or blood products, mother to child (placenta, birth, breast milk)
Measles	Measles virus (a morbillivirus)	Virus (RNA)	Airborne droplets; also direct contact with nose and throat secretions

Genus names are written with a capital letter and species names in lower case. In print they are in italics; in handwriting, underline them. After the first full use you may shorten the genus to its initial, as in *V. cholerae*.

3. Cholera

Cause

Cholera is caused by the bacterium *Vibrio cholerae*, a curved, rod-shaped bacterium with a single flagellum. Most of the bacteria that are swallowed are killed by stomach acid. The ones that survive reach the small intestine. Each uses its single flagellum to move through the mucus, attaches to the epithelial cells and multiplies. The bacteria release a **toxin**. The toxin makes the epithelial cells secrete chloride ions (Cl^-) into the lumen of the intestine. This lowers the water potential of the gut contents, so water moves out of the cells and blood into the lumen by osmosis. The result is severe watery diarrhoea and very rapid dehydration and loss of ions, which can kill within hours if not treated.

Transmission

- Faecal–oral route: faeces from an infected person get into drinking water, or food is washed or prepared with contaminated water.
- Raw or undercooked seafood from contaminated water.
- Some infected people have no symptoms (**carriers**) but still pass the bacteria out in their faeces.

Prevention and control

- Proper sewage treatment and keeping sewage apart from drinking water supplies.
- Treating water supplies with chlorine, or boiling drinking water.
- Good hygiene: washing hands with soap after using the toilet and before preparing food.
- Oral cholera vaccines give some protection for a few years, but not complete protection. They are used mainly in outbreaks and for high-risk groups.
- Treatment: **oral rehydration therapy** (a solution of glucose and salts in clean water) replaces lost water and ions. Glucose helps sodium ions, and then water, to be absorbed from the gut. Antibiotics can shorten the illness but rehydration is what saves lives.

Why cholera is hard to eliminate

Cholera spreads quickly wherever sanitation fails: crowded cities without piped water, refugee camps, and areas hit by floods, earthquakes or war. The 2022 floods in Pakistan, for example, were followed by outbreaks of cholera and other water-borne diseases. The bacterium mutates, so there are several strains, which limits how well vaccines work. The real long-term solution is clean water and sanitation, which are expensive to build in poor regions.

4. Malaria

Cause

Malaria is caused by protoctists of the genus *Plasmodium*. Four species commonly infect humans. *P. falciparum* causes the most deaths. Because *Plasmodium* is a eukaryote with a complex life cycle, drugs and vaccines against it are harder to develop than for many bacteria.

Transmission and life cycle (in outline)

You do not need to learn the life cycle in detail for 9700. It is shown here to explain why malaria is hard to control and why vaccines are difficult to make.

The malaria cycle described in words (this replaces a diagram):

Stage	Where it happens	What happens
1	Mosquito feeding on an infected person	A female <i>Anopheles</i> mosquito takes a blood meal and sucks up <i>Plasmodium</i> gametocytes (which become gametes in the mosquito's gut).
2	Mosquito gut	Gametes fuse. The zygote develops and produces many infective stages, which move to the mosquito's salivary glands.
3	New human host	When the mosquito feeds again it injects saliva (which contains an anticoagulant) along with the parasites.
4	Human liver	Parasites enter liver cells and multiply.
5	Human red blood cells	Parasites invade red blood cells, multiply and burst out in repeated cycles. This causes fever. Some develop into gametocytes, ready to be taken up by another mosquito.

Only **female** mosquitoes transmit malaria, because only females feed on blood; they need the protein to make eggs. Malaria can also pass directly from blood to blood: through transfusions, shared needles, and from mother to fetus across the placenta.

Prevention and control

Target	Method
Mosquito larvae	Drain or cover standing water where mosquitoes breed; spread oil on water surfaces so larvae cannot breathe; put fish that eat larvae into ponds and irrigation channels; use larvicides.
Adult mosquitoes	Spray insecticide on the inside walls of houses; use insecticide-treated bed nets.

Stopping bites	Sleep under bed nets; use repellents; wear long sleeves at dusk and dawn; put mesh on windows.
The parasite in humans	Take antimalarial drugs as prophylaxis (to kill the parasites before they cause disease) and give prompt diagnosis and treatment. Artemisinin-based combination therapies are the standard treatment.
Vaccination	Malaria vaccines for young children (RTS,S and R21) are now recommended by the WHO in areas where malaria is common. They give partial protection only.

Why malaria is hard to control

- Mosquitoes have become resistant to some insecticides (for example DDT and pyrethroids).
- *Plasmodium* has become resistant to several drugs, for example chloroquine.
- The parasite spends much of its time inside liver cells and red blood cells, where it is hidden from antibodies.
- It has several stages, each with different antigens, and it can change its surface antigens. This makes a fully effective vaccine very difficult to produce.
- Mosquitoes breed in any small pool of water, and in warm, wet climates breeding goes on all year.
- Poor countries may not be able to afford nets, spraying, drugs or health workers. Climate change may spread mosquito habitats to new areas.

5. Tuberculosis (TB)

Cause

TB is caused by the bacteria *Mycobacterium tuberculosis* and, less often, *Mycobacterium bovis* (the cattle form). The bacteria usually infect the lungs. They are taken in by phagocytes but can survive and multiply inside them. Many infected people have **latent (inactive) TB**: the bacteria stay walled off in the lungs, cause no symptoms and are not passed on. Roughly a quarter of the world's population is thought to carry latent TB. The infection can become **active** years later if the immune system is weakened, for example by HIV, malnutrition, old age or diabetes. Active TB slowly destroys lung tissue and can spread to other organs.

Transmission

- *M. tuberculosis*: droplets breathed out, coughed or sneezed by a person with active lung TB and breathed in by others. Spread is most likely where people live, sleep or work in crowded, poorly ventilated rooms for long periods.
- *M. bovis*: drinking unpasteurised milk, or eating undercooked meat, from infected cattle.

Prevention and control

- **BCG vaccine**, made from a live attenuated (weakened) strain of *M. bovis*. It is given to babies in countries where TB is common, including Pakistan. It protects children well but is much less reliable in adults.
- **Contact tracing**: finding and testing the people who have been close to a patient, then treating anyone infected.

- **Treatment** with a combination of several antibiotics for at least six months. Under **DOTS** (directly observed treatment, short course), a health worker watches the patient take each dose, so the course is completed.
- Better housing with less overcrowding and better ventilation, and better nutrition.
- Pasteurising milk; testing cattle and slaughtering infected animals; meat inspection.

Why TB is still a major problem

TB is one of the world's biggest single infectious killers, and Pakistan is one of the countries with the highest number of cases. Reasons include:

- The long treatment course. Patients often feel better after a few weeks and stop taking their drugs. This encourages **multidrug-resistant TB (MDR-TB)**, which is much harder and more expensive to treat.
- The link with HIV: people with HIV are far more likely to develop active TB, and TB is a leading cause of death in people with HIV.
- Latent infections are a large "hidden reservoir" of bacteria that can become active later.
- Poverty, crowded housing, malnutrition and migration all increase spread.

6. HIV/AIDS

Cause

HIV (human immunodeficiency virus) is a **retrovirus**. Its genetic material is RNA, and it carries the enzyme **reverse transcriptase**, which makes a DNA copy of the viral RNA. This DNA is inserted into the host cell's DNA. HIV infects **helper T lymphocytes** (T cells with the CD4 receptor protein), and some macrophages. Over years the number of helper T cells falls. Without helper T cells, B cells and killer T cells are not properly activated, so the immune system fails.

AIDS (acquired immune deficiency syndrome) is not a single disease. It is a set of **opportunistic infections** and cancers that develop because the immune system has collapsed, for example TB, pneumonia and certain cancers. A person is said to have HIV from the moment of infection. They are said to have AIDS only once the immune system is badly damaged.

Transmission

HIV cannot survive for long outside the body. It is passed only in body fluids:

- Unprotected sexual intercourse (vaginal or anal).
- Sharing needles or syringes, for example among people who inject drugs, or where medical equipment is reused without sterilising it.
- Transfusions of unscreened blood or blood products.
- From mother to child across the placenta, during birth, or in breast milk.

HIV is **not** spread by touching, sharing cups or towels, or mosquito bites.

Prevention and control

- Using condoms; reducing the number of sexual partners.
- Needle-exchange schemes; using sterile, single-use needles in clinics.

- Screening all donated blood for HIV and heat-treating blood products.
- HIV testing and counselling, so people know their status and do not pass the virus on.
- **Antiretroviral therapy (ART)**: drugs such as reverse transcriptase inhibitors slow the virus's replication. They do not cure HIV, but they keep the viral load very low. A person whose viral load is kept undetectable does not pass HIV on through sex. ART in pregnancy, and safe feeding choices, greatly reduce mother-to-child transmission.
- Pre-exposure prophylaxis (PrEP): antiretroviral drugs taken by uninfected people at high risk.

Why there is no HIV vaccine

- HIV mutates very quickly, because reverse transcriptase makes many copying errors, so its surface antigens keep changing.
- It attacks helper T cells, the very cells needed to organise an immune response.
- Viral DNA hides in the host's DNA as a provirus, out of reach of antibodies.

Social factors also matter. Stigma may stop people being tested or seeking treatment. Lifelong drug treatment is costly. Talking openly about sex can be difficult in some cultures, which makes education harder.

7. Measles

Cause and transmission

Measles is caused by the **measles virus**, an RNA virus (a morbillivirus). It is one of the most infectious diseases known. It spreads in airborne droplets and aerosols from the nose and throat of an infected person. The virus can stay in the air of a room for some time after the infected person has left. People are infectious for a few days before the rash appears, so they spread it before anyone knows they are ill.

Most healthy children recover, but measles can kill, especially children who are **malnourished** (particularly those short of vitamin A) or who have weak immune systems. Complications include pneumonia and encephalitis (inflammation of the brain). Measles also temporarily weakens the immune system, which leaves children open to other infections.

Prevention and control

- **Vaccination** with a live attenuated vaccine (measles alone, or the MMR vaccine against measles, mumps and rubella). Two doses give long-lasting protection.
- Because measles is so infectious, about **95%** of the population must be immune for **herd immunity** to protect those who cannot be vaccinated, such as very young babies.
- Isolating cases, and vaccinating unvaccinated contacts within about 72 hours of exposure (post-exposure vaccination) during an outbreak.
- Vitamin A supplements for children with measles reduce the risk of death.

Why measles still kills

The virus has only one stable antigenic type and humans are its only host. In theory, then, it could be eradicated, as smallpox was. It still causes outbreaks because:

- Vaccination coverage falls below the 95% needed. Reasons include conflict, poor access to clinics, missing the second dose, and vaccine hesitancy caused by misinformation.
- The vaccine must be kept cold (a "cold chain") from factory to patient. This is hard in hot, remote regions without reliable electricity.
- Crowded conditions, such as refugee camps and dense urban housing, allow very rapid spread.
- Migration can bring the virus into communities where many people have not been vaccinated.

8. Prevention and control: biological, social and economic factors

When a question says **discuss** the control of these diseases, give points on both sides and group them as biological, social or economic. Worked example 6 shows how to do this.

Factor	Examples
Biological	Pathogen mutation and antigenic variation (HIV, malaria); drug resistance (TB, malaria); insecticide resistance in vectors; pathogens hiding inside host cells or in latent form (malaria, TB, HIV); carriers without symptoms (cholera, TB); very high infectivity (measles); co-infection (HIV with TB).
Social	Overcrowding; poor sanitation; stigma (HIV, TB); low awareness or misinformation (vaccine hesitancy); patients not completing treatment; war and displacement; migration; cultural attitudes to discussing sex.
Economic	Cost of water treatment and sewers; cost of drugs, especially long or lifelong courses (TB, HIV); cost of cold chains, nets and spraying; shortage of trained health workers and laboratories; lost income when adults are ill, which keeps families poor and at greater risk.

Global importance: a quick comparison

Figures are rounded WHO estimates for recent years, and they change each year. You are not expected to recall them. They are here to show why these diseases matter and to help you interpret data questions.

Disease	Approximate global burden	Where it is concentrated
TB	Over 1 million deaths per year; about 10 million new cases per year	South and South-East Asia, Africa; Pakistan is a high-burden country
Malaria	About 250 million cases and about 600 000 deaths per year, mostly children under five	Sub-Saharan Africa (most deaths); also South Asia
HIV/AIDS	About 40 million people living with HIV; several hundred thousand deaths per year	Sub-Saharan Africa, especially southern and eastern Africa
Measles	Around 100 000 deaths per year, mostly unvaccinated young children	Countries with low vaccine coverage or conflict
Cholera	Millions of cases and tens of thousands of deaths per year (many cases unreported)	Areas without safe water: parts of Africa, South Asia, Haiti, Yemen; after floods and wars

9. Antibiotics

Antibiotic: a substance (originally produced by a living microorganism) that kills bacteria or stops

their growth, without harming the cells of the infected host.

Antibiotics that kill bacteria are **bactericidal**. Those that stop bacteria growing and reproducing are **bacteriostatic**.

How penicillin works

Penicillin was the first widely used antibiotic. It is made by the fungus *Penicillium*. It works only on bacteria that are **growing and dividing**:

1. A bacterial cell wall is made of **peptidoglycan**: long polysaccharide chains joined by short peptide cross-links. These cross-links make the wall strong.
2. As a bacterium grows, enzymes called autolysins make small breaks in the wall so new peptidoglycan can be added. Other enzymes, the **transpeptidases**, then form new cross-links.
3. Penicillin binds to the transpeptidases and **inhibits** them, so new cross-links cannot form.
4. Autolysins keep making breaks, so the wall becomes weaker and weaker.
5. The cytoplasm of the bacterium has a lower water potential than its surroundings. Water enters by **osmosis**, and the weakened wall cannot resist the pressure.
6. The cell bursts (**osmotic lysis**) and the bacterium dies.

Penicillin does not harm human cells, because animal cells have no cell wall and no peptidoglycan. Penicillin therefore acts selectively.

Why antibiotics do not affect viruses

Antibiotics target structures and processes that are found in bacteria but not in human cells, for example peptidoglycan cell walls, 70S ribosomes and bacterial enzymes. Viruses:

- have no cell wall (so nothing for penicillin to act on);
- have no ribosomes of their own and no metabolism of their own;
- replicate **inside host cells**, using the host's ribosomes, enzymes and ATP.

An antibiotic therefore has no target in a virus. Any drug that stopped viral replication by blocking host processes would also harm the host's own cells. This is why antibiotics are useless against measles or HIV, and why antiviral drugs (such as reverse transcriptase inhibitors) have to target virus-specific enzymes instead.

Doctors do sometimes give antibiotics to patients with viral illnesses, such as HIV or measles. The antibiotics are there to treat or prevent **secondary bacterial infections**, not to act on the virus.

How antibiotic resistance develops

Antibiotic resistance: the ability of a bacterium to survive and reproduce in the presence of an antibiotic that would normally kill it or inhibit its growth.

Resistance evolves by **natural selection**:

1. **Variation**: a random **mutation** happens in the DNA of one bacterium. For example, a gene may now code for an enzyme (**penicillinase**, a type of β -lactamase) that breaks down penicillin. The mutation is **not** caused by the antibiotic; it arises by chance.
2. **Selection pressure**: when the antibiotic is used, susceptible bacteria are killed. The resistant

bacterium survives.

3. **Reproduction**: the resistant bacterium now has less competition. It divides by binary fission and passes the resistance allele to all its offspring (**vertical transmission**).
4. The **frequency of the resistance allele** in the population rises over many generations, until most of the population is resistant.
5. Resistance genes are often carried on **plasmids**. Plasmids can pass between bacteria, even of different species, by **conjugation** (**horizontal transmission**). This spreads resistance very quickly.

Bacteria can divide as often as every 20 to 30 minutes, so resistance can spread through a population within days.

Consequences of resistance

- Infections that were once easy to treat become hard or impossible to treat, for example MRSA (methicillin-resistant *Staphylococcus aureus*), MDR-TB, and extensively drug-resistant (XDR) typhoid, which has spread in Pakistan since 2016.
- Patients stay ill for longer, spend more time in hospital and are more likely to die.
- More expensive "last-resort" antibiotics are needed, and these often have more side-effects.
- Routine surgery, cancer chemotherapy and care of premature babies all depend on antibiotics working. They become riskier.

How to reduce the impact of antibiotic resistance

- Prescribe antibiotics only when they are really needed, and never for viral infections such as colds or flu.
- Stop selling antibiotics without a prescription. In many countries, including Pakistan, they can still be bought over the counter.
- Use tests to identify the bacterium and choose a **narrow-spectrum** antibiotic that targets it, rather than a broad-spectrum one.
- Patients should take the full dose exactly as prescribed, and should not save leftover tablets or share them.
- Use combinations of antibiotics (as for TB). A bacterium is much less likely to carry mutations that make it resistant to several drugs at once.
- Rotate the antibiotics used in hospitals, and keep some antibiotics in reserve for resistant infections only.
- Good hygiene in hospitals: hand washing, cleaning, and isolating patients with resistant infections.
- Reduce the use of antibiotics in farming, especially their use to make healthy animals grow faster.
- Vaccination and clean water reduce the number of infections, so fewer antibiotics are needed.
- Fund research into new antibiotics and other treatments.

10. Worked examples

Worked example 1: incidence rate

A district has a population of 2 400 000. In one year, 360 new cases of TB are recorded. Calculate the incidence of TB per 100 000 people. [2]

Step 1: Find the number of cases per person: $360 \div 2\,400\,000 = 0.000\,15$

Step 2: Multiply by 100 000: $0.000\,15 \times 100\,000 = 15$

Answer: 15 new cases per 100 000 people per year.

Check: 2 400 000 is 24 lots of 100 000, and $360 \div 24 = 15$. ✓

Worked example 2: percentage change

In a village, reported malaria cases fell from 1840 in the year before insecticide-treated nets were handed out to 1150 in the year after. Calculate the percentage decrease. [2]

Step 1: Find the decrease: $1840 - 1150 = 690$

Step 2: Divide by the **original** value: $690 \div 1840 = 0.375$

Step 3: Convert to a percentage: $0.375 \times 100 = 37.5\%$

Answer: 37.5% decrease.

Common error: dividing by the new value ($690 \div 1150 = 60\%$) is wrong. Also, a follow-up question may ask whether the nets *caused* the fall. The data only show a correlation: rainfall, drug treatment or spraying might also have changed.

Worked example 3: growth of a resistant population

A single penicillin-resistant bacterium survives a course of treatment. Assume it and all its offspring divide every 30 minutes and none die. Calculate how many resistant bacteria there will be after 6 hours. [2]

Step 1: Number of divisions = 6 hours $\div$ 0.5 hours = 12 generations

Step 2: The number doubles each generation, so number = 1×2^{12}

Step 3: $2^{12} = 4096$

Answer: 4096 resistant bacteria (about 4.1×10^3).

Worked example 4: zone of inhibition

A paper disc soaked in an antibiotic was placed on an agar plate spread with bacteria. After incubation, a clear circular zone with a diameter of 18 mm formed around the disc. Calculate the area of the clear zone. Give your answer to 3 significant figures. [2]

Step 1: Radius = diameter $\div$ 2 = $18 \div 2 = 9$ mm

Step 2: Area = $\pi r^2 = \pi \times 9^2 = \pi \times 81$

Step 3: $\pi \times 81 = 254.47 \dots \text{ mm}^2$

Answer: 254 mm² (3 s.f.).

A larger clear zone suggests the bacteria are more susceptible to that antibiotic. Zone size also depends on how easily the antibiotic diffuses through the agar, so compare different antibiotics with care. For a fair comparison, the discs should be the same size, the concentrations the same, and the plates incubated at the same temperature for the same time. For safety, incubate school plates at 25 °C or below, so that human pathogens (which grow best near 37 °C) are unlikely to grow. Tape the lid on with a few strips of tape, without sealing it all the way round, and do not open the plate after incubation.

Worked example 5: extended response

Explain how a population of bacteria can become resistant to penicillin. [5]

Model answer (one mark per point, up to the maximum):

1. A random mutation occurs in a bacterial gene or allele ...
2. ... for example, one coding for penicillinase, an enzyme that breaks down penicillin.
3. Penicillin acts as a selection pressure: it kills the susceptible (non-resistant) bacteria.
4. The resistant bacteria survive, so there is less competition ...
5. ... and they reproduce by binary fission, passing the resistance allele on to their offspring.
6. Over many generations the frequency of the resistance allele in the population increases.
7. The resistance gene may be on a plasmid, which can be passed to other bacteria by conjugation.

Avoid saying that bacteria "become immune", or that the antibiotic "causes" the mutation. Immunity is a property of the host's immune system, and mutations are random.

Worked example 6: discussing control of a disease

Discuss the biological, social and economic factors that make it difficult to control TB. [6]

Model answer (one mark per point, up to the maximum; for full marks include points from more than one group and at least one limitation or counter-point):

Biological

1. The bacteria survive inside phagocytes, and latent infections form a hidden reservoir that can become active years later.
2. Drug-resistant strains (MDR-TB) are much harder to treat.
3. The BCG vaccine protects children well but is unreliable in adults.
4. HIV weakens the immune system, so latent TB becomes active and new infections spread.
5. TB spreads in airborne droplets, often before the patient has been diagnosed.

Social

1. Patients feel better after a few weeks and stop taking their drugs before the course is finished.
2. Overcrowded, poorly ventilated housing helps droplet spread.
3. Stigma delays testing and treatment.
4. Migration and displacement interrupt treatment and contact tracing.

Economic

1. Treatment needs several drugs for at least six months, and DOTS needs many trained health workers, which is expensive.
2. MDR-TB treatment costs far more than standard treatment.
3. Poverty leads to malnutrition, which weakens immunity.
4. Testing cattle and pasteurising milk to control *M. bovis* costs money.

Limitation or counter-point

1. Control measures do work when they are funded: for example, DOTS increases the number of patients who finish treatment. Their success therefore depends on money and on health systems, not only on the biology.

"Discuss" means more than listing. Group your points and show that you have weighed them. A list of six biological points with no social or economic factors is unlikely to get full marks.

Key terms

Term	Definition
Infectious disease	A disease caused by a pathogen that can be transmitted from one person to another.
Pathogen	An organism (or virus) that causes infectious disease.
Vector	An organism that carries a pathogen from one host to another.
Carrier	An infected person who shows no symptoms but can pass the pathogen on.
Transmission	The passing of a pathogen from an infected host to an uninfected host.
Retrovirus	An RNA virus that uses reverse transcriptase to make DNA from its RNA, which is then inserted into the host's DNA.
Opportunistic infection	An infection that causes disease mainly in people whose immune system is weakened.
Latent infection	An infection in which the pathogen stays in the body in an inactive form without causing symptoms.
Attenuated	Weakened so that it stimulates an immune response but does not cause disease (used in the BCG and measles vaccines).
Herd immunity	Indirect protection of unvaccinated people that happens when a large enough proportion of the population is immune, so the pathogen cannot spread.
Oral rehydration therapy	Treatment of dehydration by drinking a solution of glucose and salts in clean water.
Antibiotic	A substance that kills or inhibits the growth of bacteria without harming host cells.
Peptidoglycan	The polymer in bacterial cell walls, made of polysaccharide chains cross-linked by short peptides.
Transpeptidase	The enzyme that forms cross-links in peptidoglycan; it is inhibited by penicillin.
Osmotic lysis	Bursting of a cell caused by water entering it by osmosis.

Antibiotic resistance	The ability of a bacterium to survive and reproduce in the presence of an antibiotic that would normally kill it or inhibit its growth.
Selection pressure	An environmental factor that gives some individuals a better chance of survival and reproduction than others.
Plasmid	A small circle of DNA in a bacterium, separate from the main chromosome, that can be passed between bacteria.
Conjugation	The transfer of DNA, usually a plasmid, from one bacterium to another through direct contact.
DOTS	Directly observed treatment, short course: a TB control strategy in which a health worker watches the patient take every dose.

Quick check

1. State the name and type of the pathogen that causes cholera. [2]
2. Name the vector of malaria and state why only the female transmits the disease. [2]
3. State **two** ways in which HIV is transmitted, other than sexual intercourse. [2]
4. Describe how *Mycobacterium bovis* can be passed to humans and state **one** way to prevent this. [2]
5. Explain why people with cholera become severely dehydrated. [3]
6. Outline how penicillin kills bacteria. [4]
7. Explain why antibiotics are not effective against the measles virus. [3]
8. A health authority records 1260 cholera cases in a city of 1 800 000 people. Calculate the number of cases per 100 000 people. [2]
9. A doctor at a city clinic notices that her HIV-positive patients develop active TB far more often than her other patients. Suggest reasons for this. [3]
10. Explain why it has proved difficult to develop a fully effective vaccine against malaria. [4]
11. Explain why measles outbreaks still occur even though an effective vaccine exists. [4]
12. After a flood, cholera cases rise quickly in a crowded camp for displaced families. Suggest how the outbreak could be controlled, and explain **one** difficulty in controlling it. [4]
13. Discuss the steps that could be taken to reduce the spread of antibiotic resistance in a country where antibiotics can be bought without a prescription. [6]

Answers

1. *Vibrio cholerae* (1); a bacterium (1).
2. Female *Anopheles* mosquito (1); only females feed on blood (they need protein to produce eggs), so only they take up and inject *Plasmodium* (1).
3. Any two: sharing needles or syringes; transfusion of unscreened blood or blood products; from mother to fetus across the placenta; during birth; in breast milk (2).
4. By drinking unpasteurised milk or eating undercooked meat from infected cattle (1). Any one: pasteurising milk; cooking meat thoroughly; testing cattle and slaughtering infected animals; meat inspection (1).

5. The bacteria release a toxin that causes intestinal epithelial cells to secrete chloride ions into the lumen (1); this lowers the water potential in the lumen (1); water leaves the cells and blood by osmosis and is lost as watery diarrhoea (1).
6. Penicillin inhibits transpeptidase enzymes (1), so cross-links between peptidoglycan chains cannot form in growing bacteria (1); the cell wall is weakened (1); water enters by osmosis and the cell bursts (osmotic lysis) (1).
7. Antibiotics act on bacterial structures or processes, such as the peptidoglycan cell wall or 70S ribosomes (1); viruses have no cell wall and no ribosomes or metabolism of their own (1); they replicate inside host cells using the host's machinery, so the antibiotic has no target (1).
8. $1260 \div 1\,800\,000 = 0.000\,7$ (1); $0.000\,7 \times 100\,000 = 70$ cases per 100 000 (1).
9. HIV infects and destroys helper T cells (1); so B cells and killer T cells are not activated and the immune response is weak (1); latent TB bacteria are no longer contained and become active, and new infections are not controlled (1).
10. Any four: *Plasmodium* is a eukaryote with many different antigens (1); its antigens differ between stages of the life cycle (1); it can change its surface antigens (antigenic variation) (1); it spends time inside liver cells and red blood cells, where antibodies cannot reach it (1); there are several species of *Plasmodium* (1); the parasite is only briefly in the blood plasma after a bite, giving little time for an immune response (1); current vaccines (RTS,S and R21) give only partial protection and need several doses (1).
11. Any four: measles is extremely infectious, so about 95% coverage is needed for herd immunity (1); coverage falls below this because of vaccine hesitancy or misinformation (1); poor access to health care, war or displacement (1); children miss the second dose (1); the vaccine needs a cold chain, which is hard to maintain in hot or remote areas (1); crowded conditions and migration allow rapid spread among unvaccinated people (1); babies are too young to be vaccinated (1).
12. Any three control measures: supply safe drinking water by chlorinating it or by boiling it (1); provide latrines and keep sewage away from water sources (1); promote handwashing with soap and safe food preparation (1); treat cases quickly with oral rehydration therapy to reduce deaths (1); run an oral cholera vaccine campaign (1). Any one difficulty: carriers have no symptoms but still spread the bacteria; overcrowding and damaged water and sewage systems make hygiene hard; clean water and sanitation are costly to supply quickly; the vaccine gives only partial, short-lived protection (1). Maximum 4.
13. Any six, well explained: make antibiotics prescription-only and enforce this (1); educate the public and doctors that antibiotics do not work on viral infections such as colds or flu (1); use tests to identify the bacterium and prescribe a narrow-spectrum antibiotic (1); patients should take the full course exactly as prescribed and not share or store leftover antibiotics (1); use combinations of drugs, so bacteria are unlikely to be resistant to all of them (1); keep some antibiotics in reserve and rotate those in use (1); improve hospital hygiene and isolate patients with resistant infections (1); reduce antibiotic use in livestock (1); improve vaccination, water and sanitation, so fewer infections need treating (1). For full credit in a *discuss* question, include at least one limitation. For example: enforcing prescription laws is difficult and may reduce access to medicine for poor people who cannot afford a doctor; tests cost money and take time (1).