

Pollution and conservation

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Read first: [Nutrient cycles and populations](#), [Food supply and habitat destruction](#)

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What you need to know

This topic is about how people pollute water and air, and how we can stop species and resources from running out. It turns up on every paper: one or two multiple-choice questions on Papers 1 and 2, and parts of longer questions on Papers 3 and 4, often with a graph, a table of river animals or a flowchart to read first. By the end of it you should be able to:

Pollution

1. Describe what **untreated sewage** and **too much fertiliser** do to rivers, lakes and seas.
2. Describe the harm done by **plastics that do not break down** (non-biodegradable plastics), in water and on land.
3. Name where **methane** and **carbon dioxide** in the air come from, and describe their effects: an **enhanced greenhouse effect** and **climate change**.
4. **Extended only:** explain **eutrophication** step by step: more nitrate and other ions → producers grow faster → more of them die and are decomposed → decomposers carry out more aerobic respiration → dissolved oxygen falls → organisms that need that oxygen die.

Conservation

5. Describe a **sustainable resource**: one produced as quickly as it is removed from the environment, so it never runs out.
6. State that **forests** and **fish stocks** are resources that can be conserved and managed sustainably.
7. Explain why species become **endangered** or **extinct**: climate change, habitat destruction, hunting, overharvesting, pollution and introduced species.
8. Describe how endangered species can be conserved: **monitoring and protecting** species and their habitats, **education**, **captive breeding programmes** and **seed banks**.
9. **Extended only:** explain how **forests** are conserved using education, protected areas, quotas and replanting.
10. **Extended only:** explain how **fish stocks** are conserved using education, closed seasons, protected areas, controlled net types and mesh sizes, quotas and monitoring.

11. **Extended only:** give the reasons for conservation programmes: keeping or raising **biodiversity**, cutting **extinctions**, protecting **vulnerable ecosystems**, and keeping ecosystems working (**nutrient cycling**, and supplies of **food, drugs, fuel and genes**).
12. **Extended only:** describe how **artificial insemination (AI)** and **in vitro fertilisation (IVF)** are used in captive breeding.
13. **Extended only:** explain the risks to a species when its population shrinks and it loses **genetic variation**.

Food supply, monocultures and deforestation belong to Food supply and habitat destruction; the nitrogen and carbon cycles are in Nutrient cycles and populations.

Understand it

Sewage and fertiliser in water

Sewage is the waste water from toilets, drains and animal sheds: faeces, urine and dirty water. **Untreated** sewage has not been cleaned before it reaches a river. It does three kinds of harm:

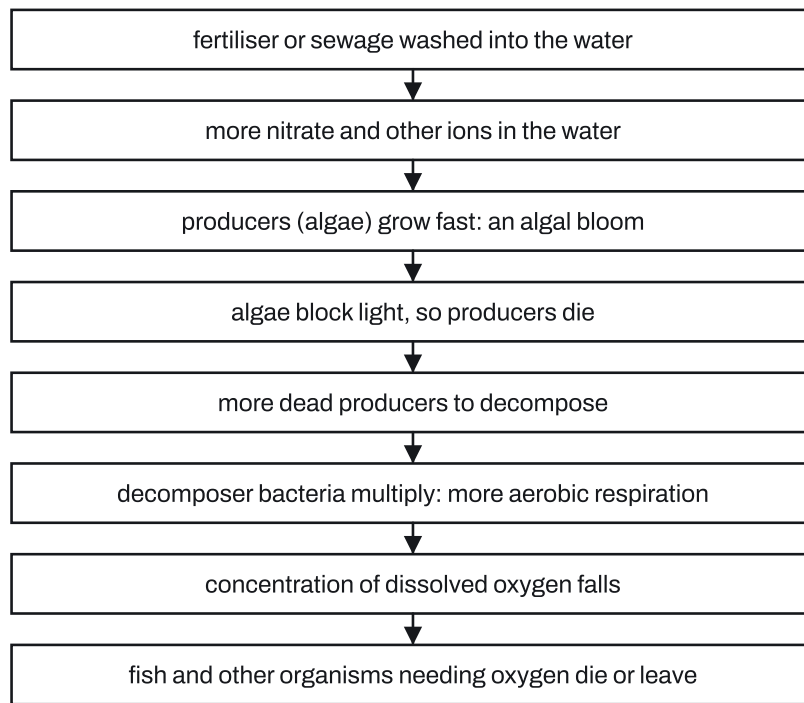
- It carries **pathogens** (disease-causing bacteria and viruses), so people and animals that drink or swim in the water can catch diseases. This is why sewage must be treated before it is released.
- It is full of **organic matter** that bacteria feed on. The bacteria multiply and respire aerobically, using up the **dissolved oxygen** in the water.
- It releases **nitrate and phosphate ions** as it breaks down, which feed algae, just like fertiliser.

Fertiliser contains mineral ions, especially **nitrate** (plants use nitrate to make **amino acids and proteins**). When a farmer puts on more than the crop can absorb, or heavy rain falls soon after, the extra is washed off the fields or through the soil into streams and lakes (**run-off** and **leaching**). Manure and animal slurry do the same.

The overall effects of both on an aquatic ecosystem: **algae and water plants grow very fast**, the water loses **oxygen, fish and other animals die** or leave, **biodiversity falls** and food chains break down. With sewage, **disease** also spreads.

Eutrophication, step by step

Extended only: The name for the chain of events caused by extra ions in water is **eutrophication**. Learn it as a chain, because the mark scheme gives one mark per link.

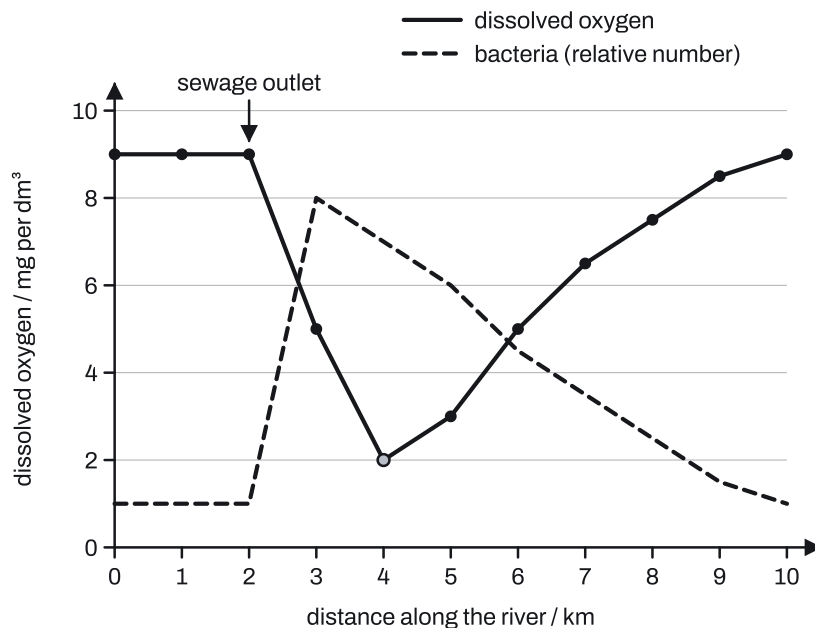


1. **More ions.** Fertiliser, manure or sewage adds **nitrate** (and phosphate) ions to the water.
2. **More producers.** Algae and water plants use the ions to make proteins, so they **grow and reproduce fast**. A thick green layer of algae (an **algal bloom**) can cover the surface.
3. **Producers die.** The algae shade the water below, so plants lower down get too little **light** to photosynthesise and die. Short-lived algae also die in huge numbers.
4. **More decomposition. Decomposers** (mainly bacteria) feed on all the dead plant and algal material, and their population rises.
5. **More aerobic respiration.** The growing number of bacteria respire **aerobically**, taking oxygen out of the water.
6. **Less dissolved oxygen.** Oxygen is used faster than it can dissolve back in from the air.
7. **Death.** Fish, insect larvae and other animals that need **dissolved oxygen** for respiration **die** or move away.

The key idea: the oxygen is used up by **decomposers respiring**, not by the fish and not because the algae stop photosynthesising. When manure or sewage enters the water, bacteria also start decomposing it straight away, which uses oxygen too.

Reading a river below a sewage outlet

Scientists often measure the water at several places along a river, above and below where sewage or fertiliser comes in.



- **Above the outlet** the oxygen is high and steady and the bacteria are few.
- **Just below the outlet** the bacteria increase rapidly as they feed on the sewage, and the oxygen falls **quickly**, over a short distance.
- **Further downstream** the sewage has been used up, the bacteria die back, and oxygen dissolves back in from the air, so the oxygen **rises slowly** over a long distance until it is back to where it started.

Indicator species tell you how clean the water is without any chemical tests:

Clean water (lots of oxygen)

stonefly nymphs, mayfly nymphs, freshwater shrimps, caddisfly larvae

Polluted water (little oxygen)

bloodworms, sludge worms, rat-tailed maggots

The clean-water animals need a lot of dissolved oxygen, so they are **the least tolerant of pollution** and disappear first. Bloodworms and sludge worms survive with little oxygen, so where they are common and the others are missing, the water is polluted. Lichens do the same job for air: few kinds of lichen grow in polluted city air, and more kinds appear further out into the countryside. In the same way, some water animals only survive within a narrow **pH** range, so acid pollution removes them.

Plastics that do not break down

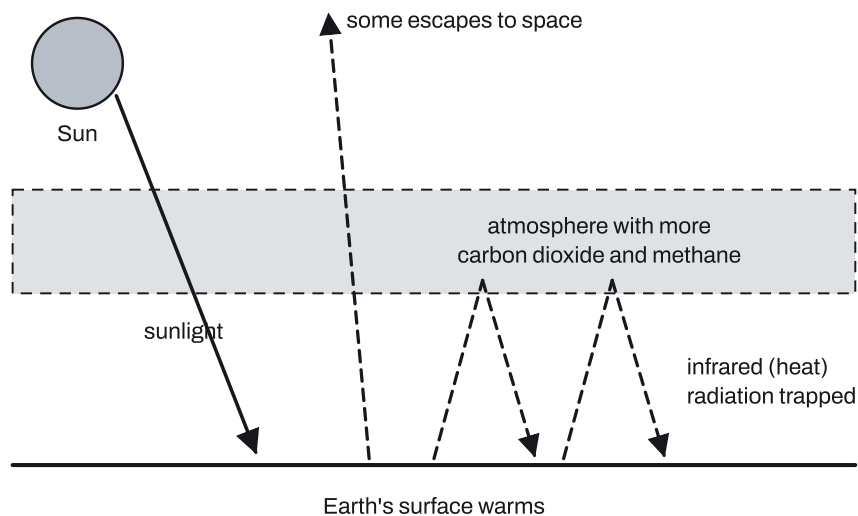
Most plastics are **non-biodegradable**: decomposers cannot break them down, so they last for hundreds of years. Big pieces break into tiny fragments (**microplastics**) but never disappear.

- **In water:** animals **mistake plastic for food** and eat it; it fills their stomachs, so they starve, or it blocks the gut. Animals get **tangled** in nets, bags and rings, so they cannot swim or feed, and **drown or suffocate**. Tiny plastic pieces are taken in by plankton, which are eaten by fish, which are eaten by birds, so microplastics **pass along food chains** and build up in the animals at the top. Floating plastic can also block light from producers.

- **On land:** litter kills animals in the same ways (eaten, or trapping them); it does not rot, so it builds up in soil and landfill sites; toxic chemicals from it can leak into the soil and water.

Methane, carbon dioxide and the enhanced greenhouse effect

Some gases in the air, mainly **carbon dioxide** and **methane**, let sunlight through but absorb the **infrared (heat) radiation** that the warmed ground gives off, and send some of it back towards the Earth. This natural **greenhouse effect** keeps the Earth warm enough for life.



People are adding **more** of these gases, so **more** heat is trapped: this is the **enhanced greenhouse effect**. It leads to **global warming** and **climate change**.

Gas	Where the extra comes from
carbon dioxide	burning (combustion) of fossil fuels (coal, oil, natural gas) in power stations, vehicles and factories; deforestation : fewer trees photosynthesise, so less carbon dioxide is taken out of the air, and felled trees are burned or decomposed, which releases it
methane	cattle and other livestock (made by microorganisms in their guts); rice paddy fields (decomposers in the waterlogged soil); rotting waste in landfill sites

Carbon dioxide is taken out of the air by **photosynthesis**, so planting trees helps.

Effects of climate change: higher average temperatures; **ice caps and glaciers melting**; **rising sea levels** and **flooding** of low land; more **extreme weather** (storms, droughts); habitats change faster than species can adapt, so some species become **extinct** and biodiversity falls.

Sustainable resources

A **sustainable resource** is one that is **produced as quickly as it is removed** from the environment, **so it does not run out**. Fish and trees can be sustainable because they reproduce and grow back, **but only if we take no more than grows back**. Fossil fuels are **not** sustainable: they took millions of years to form, so once

used they are gone. "Sustainable" does not mean "can be reused or recycled".

Forests and fish stocks are the two resources the syllabus names. Neither is sustainable **automatically**: they only stay sustainable if they are **managed**.

Extended only: conserving forests

Method	How it helps
education	people learn why forests matter and how to use them without destroying them, so they support the rules
protected areas (national parks, reserves)	no felling is allowed there, so habitats and species survive
quotas	a legal limit on how many trees can be cut down, so no more are taken than can regrow
replanting	a new tree is planted for each one felled, so the forest grows back

Cutting down **only selected trees** (rather than clearing whole areas) also helps.

Extended only: conserving fish stocks

Method	How it helps
education	people who fish and people who buy fish learn which species are at risk, and choose others
closed seasons	no fishing at certain times of year, usually the breeding season , so fish can reproduce
protected areas	no-fishing zones, often breeding and nursery grounds, where fish can breed and young fish can grow
controlled net types and mesh size	a large enough mesh lets young, small fish escape , so they survive to breed; some net types that catch everything or damage the sea bed are banned
quotas	a legal limit on the mass or number of fish each boat can catch, so no more are taken than are replaced
monitoring	counting and sampling fish populations, so quotas and rules can be changed if numbers fall

Only catching **large** fish works because the young ones have not yet bred; catching only females would be the **least** sustainable rule, because females produce the eggs. Fish farms and restocking with young fish also reduce the pressure on wild stocks.

Why species become endangered

A species is **endangered** when its numbers are so low that it could die out; it is **extinct** when none are left. The main causes are:

- **habitat destruction:** land cleared for farming, housing, roads and mining, so the species loses its food, shelter and breeding sites;
- **climate change:** the habitat becomes too hot, too dry or floods, faster than the species can adapt;
- **hunting, poaching and overharvesting:** killing or collecting animals and plants faster than they can reproduce (overfishing is overharvesting);
- **pollution:** water, air or land pollution poisons organisms or destroys their habitat;
- **introduced species:** a species brought in from somewhere else competes for food and space, eats native species, or brings a new disease, and often has no natural predators to control it.

Loss of food, disease, and slow breeding also add to the risk. Large mammals are especially at risk because they need big areas, breed slowly and are hunted.

How endangered species are conserved

- **Monitoring and protecting species and habitats:** count and track the population; make laws that ban hunting and trade; protect and restore habitats in reserves and national parks; remove introduced species and predators.
- **Education:** teach local people and visitors why the species matters, so they stop hunting it, protect its habitat and support conservation.
- **Captive breeding programmes:** breed the animals in zoos or wildlife centres, where they are safe and well fed, then **release** them back into the wild when the habitat is safe.
- **Seed banks:** store the **seeds of plants** (dried, at low temperature) so a species can be grown again if it dies out in the wild. Seed banks are for **plants only**, never animals.

Extended only: In a seed bank, seeds are collected from **many different populations** of each species, so the store holds as much **genetic variation** as possible, and plants grown from them are more likely to survive changes in the environment or new diseases. The seeds are kept **cold and dry**, so their enzymes work slowly, **respiration is very slow**, and they stay alive for many years. Samples are germinated now and then to check they are still alive.

Why conservation matters

Extended only: Conservation programmes are set up to:

- **keep or raise biodiversity:** the number of different species in an area;
- **reduce extinction:** once a species is gone, it cannot be brought back;
- **protect vulnerable ecosystems**, such as coral reefs and rainforests, which are home to many other species;
- **keep ecosystems working:** every species has a place in food webs and in **nutrient cycling** (for example decomposers return minerals to the soil), and ecosystems give people **food, drugs** (many medicines come from plants), **fuel** and useful **genes** for breeding new crops.

Artificial insemination and IVF in captive breeding

Extended only: Captive animals often do not mate, or the best mate lives in another zoo. Two methods help:

Artificial insemination (AI):

1. **Sperm (semen) is collected** from a chosen male.
2. It can be **frozen and stored**, or transported to another zoo or country, so a male far away, or even one that has died, can be the father.
3. When the female is about to **ovulate** (sometimes after a hormone treatment), the sperm is **inserted into her vagina or uterus**.
4. **Fertilisation happens inside her body**, and the pregnancy continues as normal.

In vitro fertilisation (IVF):

1. **Eggs are removed** from the female's **ovaries** (after a hormone treatment so several mature at once).
2. **Sperm is added** to the eggs in a dish: **fertilisation happens outside the body**, forming zygotes.
3. Each zygote **divides by mitosis** to form an **embryo** (a ball of cells).
4. The embryo is **implanted** into the lining of the **uterus** of the female, or of a surrogate female.

The difference to remember: in AI only sperm is handled and fertilisation is inside the female; in IVF both eggs and sperm are handled and fertilisation is outside.

Why a small population is at risk

Extended only: When a population falls to a small number, or a captive breeding programme starts from only a few animals:

- there is **less genetic variation**: fewer different alleles in the population;
- the animals are closely related, so there is more **inbreeding**;
- offspring are more likely to be **homozygous recessive** for harmful alleles, so **inherited diseases** and infertility become more common;
- with little variation, the population is **less able to adapt** to a change in the environment or to survive a **new disease**, since there may be no individuals that are resistant;
- it is **harder to find a mate**, so fewer young are born;
- one disaster (a disease, fire or drought) could wipe out the whole population: the risk of **extinction** is higher.

Key facts and formulas

"Learn it" means you must remember it: the exam gives no formulas for this topic.

Formula	Status
Sewage and fertiliser add nitrate ions; sewage also carries pathogens	Learn it
Eutrophication: more ions → faster growth of producers → more producers die and are decomposed → more aerobic respiration by decomposers → less dissolved oxygen → organisms needing oxygen die	Learn it
Greenhouse gases: carbon dioxide (combustion of fossil fuels, deforestation) and methane (cattle, rice fields, landfill)	Learn it
More greenhouse gases → enhanced greenhouse effect → climate change	Learn it
Sustainable resource: produced as quickly as it is removed, so it does not run out	Learn it
Causes of endangerment: climate change, habitat destruction, hunting, overharvesting, pollution, introduced species	Learn it
Conserving species: monitoring and protecting species and habitats, education, captive breeding, seed banks	Learn it
Percentage change = $\frac{\text{new} - \text{original}}{\text{original}} \times 100$	Learn it
Percentage of a total = $\frac{\text{part}}{\text{total}} \times 100$	Learn it
1 cm = 10 mm	Learn it

How to do it

We tagged 114 questions for this topic (2021–2025, Papers 1–4; 109 different questions, as 5 are repeats of a question on another paper). 31 of them mix more than one type, so the counts add up to 165.

Question type	Questions
Eutrophication and the effects of fertiliser and sewage in water	26
Sustainable resources: fish stocks and forests	22
Ways to conserve endangered species	19
Reading and calculating from pollution and conservation data	18
Greenhouse gases and the enhanced greenhouse effect	17
Why species become endangered or extinct	14
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Question type	Questions
Sources and effects of water pollution	11
Reasons for conservation programmes	7
Plastic pollution	7
Risks of a small or falling population	6
Artificial insemination and IVF	5

1. Eutrophication and the effects of fertiliser and sewage in water (26 questions)

- Core, "describe the effects"** (2–3 marks): algae and plants grow faster; oxygen in the water falls; fish and other animals die; biodiversity falls; for sewage, disease spreads.
- Extended, "explain eutrophication"** (up to 6 marks): write the chain in order, one link per sentence, and use the key words:
 - fertiliser, manure or untreated sewage is **washed into** the water;
 - more nitrate ions** (and other ions);
 - faster growth of producers** (an algal bloom);
 - algae **block light**, so plants below cannot photosynthesise and **die**;
 - more decomposition** of the dead producers by bacteria, whose numbers **increase**;
 - more aerobic respiration** by the decomposers;
 - less dissolved oxygen** in the water;
 - death** (or migration) of fish and other organisms **that need dissolved oxygen**.

Variations you will meet:

- "What causes the fall in dissolved oxygen?"** The answer is **increased aerobic respiration by decomposers**, not by fish, and not less respiration. A "how does eutrophication kill fish" question has the same answer: **decomposer bacteria lower the oxygen concentration**.
- Put the stages in order**, or fill the gaps in a flowchart: an increase in nitrate ions comes first, then producer growth, then decomposition, then a **decrease** in dissolved oxygen, then death. For example, a step X before "increased growth of producers" is an **increase in nitrate ions**, and a step Y before "death of organisms" is a **decrease in dissolved oxygen**.
- Graphs of a lake over time**: the biomass of **producers** rises first, then that of **decomposers**, and the concentration of **oxygen** falls.
- Untreated sewage in a river for weeks**: **bacteria increase, oxygen decreases, fish decrease**.
- A context**, such as chicken faeces or animal slurry spread near a lake: apply the same chain, starting with "washed into the lake by rain". Add that the manure itself is decomposed by bacteria, and that faeces carry pathogens.
- Reducing the risk**: use less fertiliser, do not spread it just before heavy rain, and keep it away from the water's edge. If fertiliser use drops, there is less eutrophication, so more organisms survive.
- "State one substance plants make using nitrate ions"**: **amino acids** or **proteins**.

2. Sustainable resources: fish stocks and forests (22 questions)

1. **Define** (2 marks): **produced as quickly as it is removed** from the environment (1), **so that it does not run out** (1).
2. **Extended, "explain how fish stocks can be conserved"** (up to 6 marks): name each method and say **how** it helps: quotas (limit the catch), closed seasons (fish can breed), protected areas (breeding grounds), net types and **mesh size** (young fish escape and grow up to breed), monitoring (numbers counted so rules can change), education; also fish farming and restocking.
3. **Extended, forests**: education, protected areas, quotas, replanting; cutting only selected trees.

Variations you will meet:

- **Multiple choice definition**: the correct statement is that the **production rate equals the removal rate**. Wrong options say it includes fossil fuels or non-renewable resources, or that production is smaller than removal.
- **Mesh size**: the holes must be **large enough to allow young fish to escape**. A minimum mesh size is the method that means **mainly large fish are caught**; the reason for catching only large fish is that **smaller fish are too young to breed**. Making the holes **smaller** would harm the stock.
- **The biggest improvement for a falling fish stock**: **fishing quotas** (not genetic modification or selective breeding, which don't protect wild fish).
- **Least sustainable rule**: "only allow **female** fish to be caught".
- **Are fish stocks and forests always managed sustainably?** **No** for both: they **can** be, if managed.
- **Forest multiple choice**: cutting down only selected trees, education and replanting keep a forest sustainable; clearing it for crops does not.
- **Why a fuel is or is not sustainable**: oil and plastics made from it are not, because oil is not replaced; methane made by bacteria from sewage is sustainable because it is **made as fast as it is used** and does not run out; a bioplastic from plant material is sustainable because the plants can be grown as fast as they are used.

3. Ways to conserve endangered species (19 questions)

1. **Name the methods** (1 mark each): **monitoring** and **protecting** the species; **protecting its habitat** (reserves, national parks); **laws** banning hunting, poaching and trade; **education**; **captive breeding programmes**; **seed banks** (plants).
2. For **"describe"**, add a few words to each, such as "captive breeding, then releasing the young into the wild".

Variations you will meet:

- **After reintroducing a species to the wild** (keeping the new population going): protect the habitat; ban hunting; **monitor** or track the animals; **education**; provide food or veterinary care; **remove predators** or **introduced species**.

- **Multiple choice:** **seed banks** are **not** used for animals; **education** increases the chance of conserving a species (climate change, hunting and introducing new species do not); the conservation methods are captive breeding and education, not habitat destruction; monocultures, overharvesting and reducing biodiversity are not conservation.
- **Extended, seed banks:** collect seeds from **many populations** to keep **genetic variation**; X-rays used to check seeds can cause **mutations**; low temperature keeps **respiration** slow, so seeds last longer. When asked why seeds come from many plants, answer about **variation**, not about why seed banks exist.
- **Captive** breeding (breeding in zoos to increase numbers) is not **selective** breeding (choosing parents for useful features).

4. Reading and calculating from pollution and conservation data (18 questions)

1. **Read the axes:** what is plotted, the units and the scale ("thousand", "million tonnes").
2. **Write down the values** you read before calculating.
3. **Calculate:** percentage change = $\frac{\text{new} - \text{original}}{\text{original}} \times 100$; percentage of a total = $\frac{\text{part}}{\text{total}} \times 100$. Round as the question says. For example, a population that rises from 14 000 to 45 000: $\frac{45\,000 - 14\,000}{14\,000} \times 100 = 221.4\%$, which is 221% to the nearest whole number.

Variations you will meet:

- **Describe the data** (2–3 marks): the overall trend ("increases then decreases"), where it changes (the peak and its year), a **comparison** of two lines, and one **data quote with units**.
- **Complete the sentences** from a graph: read single values and years carefully, including values that appear twice (the year when the population was the same as in another year).
- **Unit conversion:** 1 cm = 10 mm, so 0.8 cm is 8 mm.
- **Mass from a concentration:** multiply the concentration by the volume, and give units: 4 mg per dm³ in 2.5 dm³ is 10 mg.
- **Why a value is an estimate:** the ocean or area is too large to measure it all, so only samples are taken and the total is worked out from them.
- **The period with the greatest increase:** the steepest part of the line.

5. Greenhouse gases and the enhanced greenhouse effect (17 questions)

1. **Name the gases:** **carbon dioxide** and **methane** (not nitrogen or oxygen).
2. **Name the sources:** carbon dioxide from **combustion** of fossil fuels and from deforestation; methane from **cattle**, **rice** fields and landfill.
3. **Explain the effect** (Extended): more carbon dioxide and methane **absorb (trap) infrared radiation** from the Earth's surface → **enhanced greenhouse effect** → global warming and **climate change** → ice melting, sea-level rise, flooding, extreme weather, extinctions.

Variations you will meet:

- **Complete the sentences:** methane contributes to the **enhanced greenhouse effect**; it is released from cattle and **rice** crops; **carbon dioxide** is absorbed by trees in **photosynthesis** and released by the **combustion** of fossil fuels.
- **How deforestation raises carbon dioxide** (Extended): **less photosynthesis**, so less carbon dioxide is removed; felled trees are **burned** or **decomposed**, releasing carbon dioxide; carbon dioxide traps infrared radiation.
- **A graph of emissions:** only agree with statements the data actually show. A graph can show that one gas's emissions were lower than another's; it cannot show which gas has a greater effect on the climate, what happened after the last year plotted, or whether other greenhouse gases existed.
- **Rising sea levels:** caused by air pollution with **carbon dioxide and methane**.
- **Burning plastics or fossil fuels:** the carbon dioxide released causes an enhanced greenhouse effect, climate change, rising sea levels, extreme weather and loss of habitats.

6. Why species become endangered or extinct (14 questions)

1. **Pick from the list:** **habitat destruction** (deforestation, farming, building); **climate change**; **hunting** and **poaching**; **overharvesting** (overfishing); **pollution**; **introduced species**; also disease and lack of food.
2. For "**explain**", add the reason: "habitat destruction removes the food and shelter the animals need".

Variations you will meet:

- "**Other than disease**" (or other than pollution): leave that one out.
- **An introduced species** (Extended): it **competes** with native species for food and space, **eats** them, brings **disease**, disrupts food webs, and has **no natural predators**, so its numbers grow.
- **Large mammals:** they need large areas, eat a lot of food, **breed slowly**, and are hunted for trophies or body parts.
- **Multiple choice:** reasons for endangerment are **habitat destruction and pollution** (monitoring, education and captive breeding are conservation methods). From a bar chart, choose the bar that is **highest overall**, for example **habitat loss**. Building homes in an animal's habitat **decreases** its population; a hunting ban does not.

7. River pollution data and indicator species (13 questions)

1. **Find the pollution source** on the diagram (sewage outlet, factory, farm) and the **direction of flow**. Pollution affects the water **downstream**.
2. **Clean-water species** (stonefly and mayfly nymphs, freshwater shrimps, caddisfly larvae) are found **upstream**; **pollution-tolerant species** (bloodworms, sludge worms) increase **downstream**.
3. **Describe differences** in a table: compare each species between the sites, say which site has more animals overall, and quote numbers.

Variations you will meet:

- **Which species is the least tolerant of pollution?** The one that almost **disappears** where the water is polluted, for example the freshwater shrimp or the mayfly nymph.

- **Which species shows the water is polluted?** A bloodworm or sludge worm.
- **A graph of oxygen along a river:** oxygen is high and steady above the outlet, **drops quickly** just after it, then **rises slowly** back to the starting level. Organisms at the lowest point **die**, because there is too little oxygen for respiration.
- **Where did the fertiliser enter?** Where the **bacteria start to rise** and the **oxygen starts to fall**. Where is a river least affected by fertiliser? **Upstream** of the field.
- **Nitrate concentrations** at points along a river: the farm using too much fertiliser is just **upstream of the biggest jump** in nitrate.
- **pH and lichens:** an organism that cannot live in acidic water only survives at pH **7 or above**; the number of lichen species **increases** with distance from a polluted city centre.

8. Sources and effects of water pollution (11 questions)

1. **Name a water pollutant:** **untreated sewage, fertiliser, plastics, oil, pesticides** (insecticides and herbicides), chemical waste from factories. Don't give an air pollutant.
2. **Pathogens** come from **untreated sewage**, so sewage is treated before it enters rivers to **stop the spread of disease** and make the water safe.
3. **"Discuss the threats to aquatic ecosystems"** (Extended): **name** each threat and **say how** it harms the ecosystem: plastics (eaten, entangle, pass along food chains); sewage and fertiliser (eutrophication, disease); overfishing; introduced species; toxic chemicals.

Variations you will meet:

- Two 2022 papers asked about the **stages of sewage treatment**, and a 2021 paper about chemicals (**hormones**) in a river making male fish develop female features. Neither is in the 2026–2028 syllabus, so you won't be asked them.
- Insecticides and herbicides that reach water kill organisms that were not the target and harm food chains (see Food supply and habitat destruction).

9. Reasons for conservation programmes (7 questions)

1. **Extended:** keep or increase **biodiversity**; **prevent extinction**; protect **vulnerable ecosystems** and habitats; keep **food chains and webs** and **nutrient cycles** working; keep future sources of **food, drugs, fuel and genes**.
2. **For a single species** (such as a tree), think about what **other** organisms get from it: **food, shelter, nesting or breeding sites**, protection from predators, and leaf litter for decomposers (nutrient cycling).

Variations you will meet:

- **Multiple choice "a reason for conserving plant species":** **to obtain drugs for medicinal use**. Plants don't absorb oxygen or decrease rainfall.
- Give **several different** reasons: examiners see "prevent extinction" repeated in several ways but few further points.

10. Plastic pollution (7 questions)

1. **Harm to animals:** **mistaken for food** and eaten, so the gut is blocked and the animal starves; **entanglement**, so it cannot swim or hunt, or is **suffocated or choked**; microplastics **build up** in bodies and **pass along food chains** (plankton → fish → birds).
2. **Why it lasts:** it is **non-biodegradable**, so decomposers cannot break it down.

Variations you will meet:

- **How microplastics reach a bird:** producers (phytoplankton) absorb them → fish eat the producers → birds eat the fish; the plastic is not broken down or excreted.
- **Multiple choice:** **very small fragments** of non-biodegradable plastics **can move up the food chain**. They do not decompose quickly or release carbon dioxide as they decompose, and they don't make producers grow.
- **Reducing plastic pollution:** use less plastic, reuse and **recycle**, dispose of it properly, use **biodegradable** materials, and clean up beaches and seas.

11. Risks of a small or falling population (6 questions)

1. **Extended:** less **genetic variation**; **inbreeding**; more offspring **homozygous** for harmful **recessive alleles**, so more inherited disease; **less able to adapt** to environmental change or a new disease; harder to find a **mate**; higher risk of **extinction**.
2. Answer about the **risks of being few**, not about **why** the numbers fell.

Variations you will meet:

- **A captive breeding programme started from a few animals**, or brothers and sisters bred together: the same points, with inbreeding and genetic disease first.

12. Artificial insemination and IVF (5 questions)

1. **Extended, AI:** sperm **collected** from a male → **frozen/stored** or transported → the female's ovulation is timed → sperm **inserted into the vagina or uterus** → fertilisation inside her body.
2. **Extended, IVF:** eggs **removed from the ovaries** → **sperm added** → **fertilisation** outside the body → zygote divides by **mitosis** to an **embryo** → embryo **implanted** in the uterus.

Variations you will meet:

- **Put the IVF steps in order:** egg removed → sperm added → egg fertilised → embryo implanted.
- **Name the processes** on a diagram from egg and sperm to embryo in the uterus: **fertilisation**, then **mitosis** (cell division), then **implantation**.
- **Multiple choice:** AI is "sperm collected from a male, frozen, and later **inserted into the female**". Removing eggs and fertilising them outside is **IVF**; choosing parents to mate is selective breeding.

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

Students sampled a river above and below a pipe that released untreated sewage. The table shows the number of each animal they found.

Species	Above the pipe	Below the pipe
stonefly nymph	42	0
freshwater shrimp	58	6
bloodworm	3	36
sludge worm	1	64

- (a) Describe the differences between the two sites. **[3]**
- (b) Suggest which species is the least tolerant of pollution. **[1]**
- (c) Calculate the percentage decrease in freshwater shrimps from above the pipe to below it. Give your answer to one decimal place. **[3]**
- (d) State one reason why sewage should be treated before it enters a river. **[1]**
- (a)** Any three: there were more stonefly nymphs and shrimps above the pipe **B1**; there were more bloodworms and sludge worms below the pipe **B1**; stonefly nymphs were found only above the pipe (42 above, none below) **B1**; the biggest change is in sludge worms, from 1 to 64.
- (b)** Stonefly nymph: it is completely absent below the pipe **B1**.
- (c)** Readings 58 and 6 **B1**. $\frac{58 - 6}{58} \times 100 = 89.655 \dots$ **M1** = 89.7% **A1**
- (d)** Untreated sewage contains pathogens, so treating it stops the spread of disease **B1**.

Example 2

The concentration of carbon dioxide in the air at one weather station rose from 315 parts per million in 1960 to 420 parts per million in 2020.

(a) Calculate the percentage increase. Give your answer to the nearest whole number. **[2]**

(b) State one human activity that releases carbon dioxide and one that releases methane. **[2]**

(c) Explain how an increase in these gases can lead to climate change. **[3]**

(a) $\frac{420 - 315}{315} \times 100 = 33.33 \dots$ **M1 = 33% A1**

(b) Carbon dioxide: burning (combustion) of fossil fuels, or deforestation **B1**. Methane: keeping cattle, growing rice, or landfill sites **B1**.

(c) Carbon dioxide and methane absorb (trap) infrared radiation given off by the Earth's surface **B1**; more of these gases gives an enhanced greenhouse effect **B1**; so the Earth's average temperature rises (global warming), changing climate patterns **B1**.

Example 3

The stock of one species of fish in a sea fell from 240 thousand tonnes in 1990 to 84 thousand tonnes in 2005. After new rules were introduced, it rose to 150 thousand tonnes by 2020.

(a) Describe what is meant by a *sustainable resource*. **[2]**

(b) Calculate the percentage increase in the fish stock from 2005 to 2020. Give your answer to the nearest whole number. **[2]**

(c) Explain how the fish stock can be conserved. **[4]**

(a) A resource that is produced as quickly as it is removed from the environment **B1**, so that it does not run out **B1**.

(b) $\frac{150 - 84}{84} \times 100 = 78.57 \dots$ **M1 = 79% A1**

(c) Any four, each with how it helps: quotas limit the mass of fish each boat may catch, so no more are removed than are replaced **B1**; a minimum mesh size lets young fish escape, so they can grow up and breed **B1**; closed seasons stop fishing during the breeding season **B1**; protected areas give fish safe places to breed **B1**; monitoring the stock lets the quotas be changed if numbers fall; education persuades people to buy fish from sustainable stocks.

Example 4

A species of parrot lives on only one island. The wild population fell to 22 birds, all closely related. A conservation programme now keeps some of the parrots in captivity.

(a) Explain the risks to the parrot species of having such a small population. **[3]**

(b) Describe how artificial insemination could be used in the captive breeding programme. **[3]**

(c) Describe the reasons for setting up conservation programmes like this one. **[3]**

(a) Any three: there is little genetic variation **B1**; the birds are related, so there is inbreeding **B1**, and more chicks are homozygous for harmful recessive alleles, so inherited disease is more likely **B1**; with little variation the population may not be able to adapt to a change in the environment or a new disease; a single disaster could make it extinct.

(b) Any three: sperm is collected from a male **B1**; it can be frozen and stored, or sent from a male in another zoo, so less related birds can breed **B1**; when the female is ready to ovulate, the sperm is inserted into her reproductive tract **B1**; fertilisation then happens inside her body.

(c) Any three: to prevent the species becoming extinct **B1**; to maintain biodiversity **B1**; to keep the food webs and nutrient cycling of the island's ecosystem working, for example the parrots spread seeds **B1**; to protect a vulnerable ecosystem; to keep possible future resources such as genes.

Common mistakes

- **Blaming the wrong thing for the lost oxygen.** In eutrophication the oxygen falls because **decomposer bacteria respire aerobically** as they break down dead producers. Examiner reports say many answers blame less photosynthesis, or the fish, or manure covering the water.
- **Leaving out links in the chain.** "Bacteria use up oxygen" misses the marks for **more decomposition and aerobic respiration**, and "the fish die" needs "because there is less dissolved oxygen".
- **"Greenhouse effect" on its own.** The natural greenhouse effect keeps Earth warm; pollution causes an **enhanced** greenhouse effect. Mark schemes give no credit for the unqualified term where "enhanced" is needed.
- **Wrong greenhouse gases.** Nitrogen and oxygen are not greenhouse gases; the ones to know are carbon dioxide and methane.
- **Muddling "sustainable" with "renewable" or "recyclable".** A sustainable resource is produced as fast as it is removed. "It can be reused or recycled" earns nothing.
- **Mixing up AI and IVF.** In AI only sperm is collected and put into the female; in IVF eggs are removed and fertilised outside the body. Examiners see AI answers that turn into IVF halfway through. And it is the **embryo** that is implanted, after the zygote has divided.
- **Captive breeding versus selective breeding.** Captive breeding increases numbers of an endangered species; selective breeding chooses parents for useful features.
- **Answering a different question.** Asked for the **risks** of a small population, many explain **why** it became small. Asked why seeds are collected from **many** populations, many explain what seed banks are for.
- **Ignoring "other than".** If the question says "other than disease" or "other than climate change", giving it anyway scores nothing.
- **Seed banks for animals.** Seed banks store plant seeds only.
- **Data without units, or the wrong conversion.** Every data quote needs its units; to change centimetres to millimetres multiply by 10, so 0.8 cm is 8 mm (not 80 or 8000).
- **Lists of single words.** "Plastics, sewage, oil" is not a discussion. Name each threat and say how it harms the ecosystem.

How to get the marks

- **"State" or "name"**: a short answer with the exact term: eutrophication, methane, enhanced greenhouse effect, quota, captive breeding, seed bank.
- **"Describe"**: one mark per different point, so give at least as many points as there are marks. For data, give the trend, the key change and a quote with units.
- **"Explain"**: join cause and effect with "so" or "because": "decomposers respire aerobically, so the dissolved oxygen falls".
- **Long eutrophication answers** (Paper 4, up to 6 marks): one link of the chain per sentence, in order, using the words **nitrate ions**, **producers**, **decomposition**, **aerobic respiration**, **dissolved oxygen**.
- **Conservation methods**: say how each method helps ("closed seasons, so fish can breed"), especially for "explain".
- **"Suggest"**: apply what you know to the new species or place, such as a wild horse, a parrot or a lake next to a chicken farm.
- **"Discuss"** (Paper 4): several separate points, each developed.
- **Calculations**: write the values you read, then the working, then the answer rounded as asked. The mark schemes give a mark for the readings, one for the working and one for rounding, and later marks can still be earned from a wrong reading.
- **Multiple choice**: decide each column or statement on its own, then find the row that matches.

Quick check

1. Describe what is meant by a sustainable resource.
2. Put these stages of eutrophication in the correct order: P, less dissolved oxygen; Q, more nitrate ions in the water; R, producers die; S, more aerobic respiration by decomposers; T, fish die; U, faster growth of algae.
3. Use the river graph in "Understand it". At what distance along the river is the dissolved oxygen lowest? Calculate the percentage decrease in dissolved oxygen from above the outlet to this point, to the nearest whole number.
4. After a captive breeding and release programme, the number of breeding pairs of an eagle rose from 36 to 90. Calculate the percentage increase.
5. State two ways plastics harm animals in the sea, and one way to reduce plastic pollution.

Answers

1. A resource that is produced as quickly as it is removed from the environment, so that it does not run out.
2. $Q \rightarrow U \rightarrow R \rightarrow S \rightarrow P \rightarrow T$: more nitrate ions in the water, faster growth of algae, producers die, more aerobic respiration by decomposers, less dissolved oxygen, fish die.
3. At 4 km, where it is 2 mg per dm^3 . $\frac{9-2}{9} \times 100 = 77.8$, so a decrease of 78% to the nearest whole number.
4. $\frac{90-36}{36} \times 100 = 150\%$.
5. Any two harms: animals mistake it for food, so the gut is blocked and they starve; they get tangled and cannot swim or feed, or they suffocate; microplastics pass along food chains and build up. One way to reduce it: recycle, reuse, use less plastic, use biodegradable materials, or dispose of plastic properly.

Past questions to try

- [0610/41/M/J/24 Q7](#): completing a flowchart of the stages of eutrophication.
- [0610/41/O/N/23 Q5](#): a fish-stock graph, the risks of a falling population, and conserving fish stocks.
- [0610/31/O/N/21 Q2](#): indicator species along a river below a sewage outlet, with a percentage change.
- [0610/32/F/M/24 Q6](#): plastic waste data, sustainable resources, carbon dioxide and harm from plastics.