

Ecosystems and material cycles revision notes

This topic looks at how living things fit together in ecosystems and how to measure what lives where. It also covers the effect humans have on biodiversity, and how carbon, water and nitrogen are cycled between living things and their surroundings.

For Edexcel GCSE Combined Science 1SC0. **Higher tier** is only on the Higher paper.

1 Communities and interdependence Spec 9.1-9.4

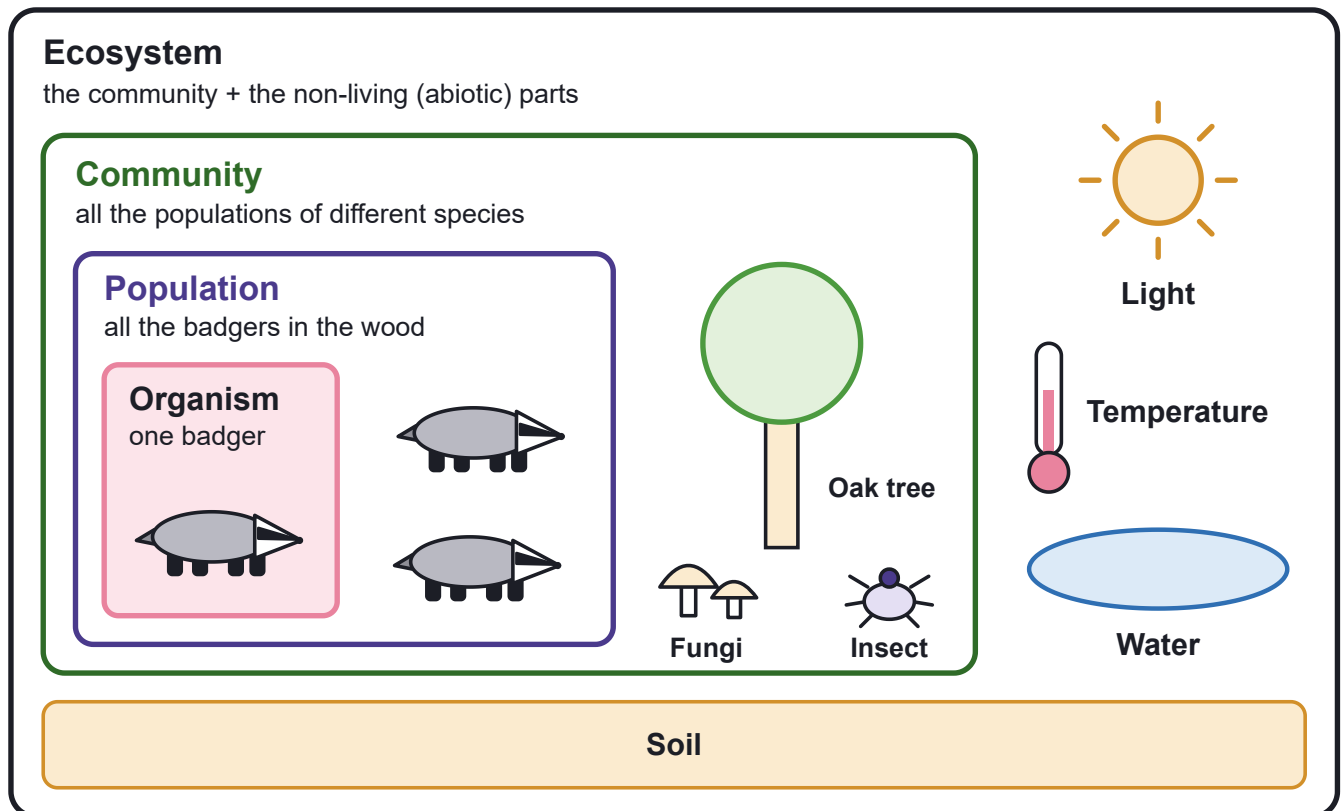
Levels of organisation Spec 9.1

Living things can be described at different levels of organisation, from a single organism up to a whole ecosystem. Each level contains the one before it.

Levels of organisation in ecology		
Level	What it means	Example
Organism	A single living thing	One badger
Population	All the organisms of one species living in the same area	All the badgers in a wood
Community	All the populations of different species living in the same area	The badgers, foxes, oak trees, insects and fungi in the wood
Ecosystem	A community together with the non-living (abiotic) parts of its environment	The wood, including its soil, water, light and temperature

An **ecosystem** is made of living (biotic) and non-living (abiotic) parts that interact with each other. Energy and materials move between them.

Common mistake: A population is one species only. If an answer mentions different species living together, it is describing a community.



[\(opens full size in a new tab\)](#)

Each level contains the one before it: **organism**, **population**, **community**, then **ecosystem** (the community plus its abiotic parts).

Abiotic and biotic factors Spec 9.2

The organisms in a community are affected by **abiotic factors** (non-living) and **biotic factors** (living). Changes in either can change which species live in a community and how many there are.

Factors that affect communities		
Type	Factor	How it can affect a community
Abiotic	Temperature	Affects the rate of enzyme-controlled reactions, so growth and survival. Species survive only within a range of temperatures.
Abiotic	Light	Plants need light for photosynthesis. Less light means fewer plants, and so less food for the animals that depend on them.
Abiotic	Water	All organisms need water. In dry conditions only organisms adapted to save water survive, so numbers and variety fall.
Abiotic	Pollutants	Pollutants such as sulfur dioxide in air or sewage in water can kill sensitive species, reducing the variety of organisms.
Biotic	Competition	Organisms of the same or different species compete for the same limited resources, such as food, water, light and space.
Biotic	Predation	Predators eat prey, so predator and prey numbers affect each other.

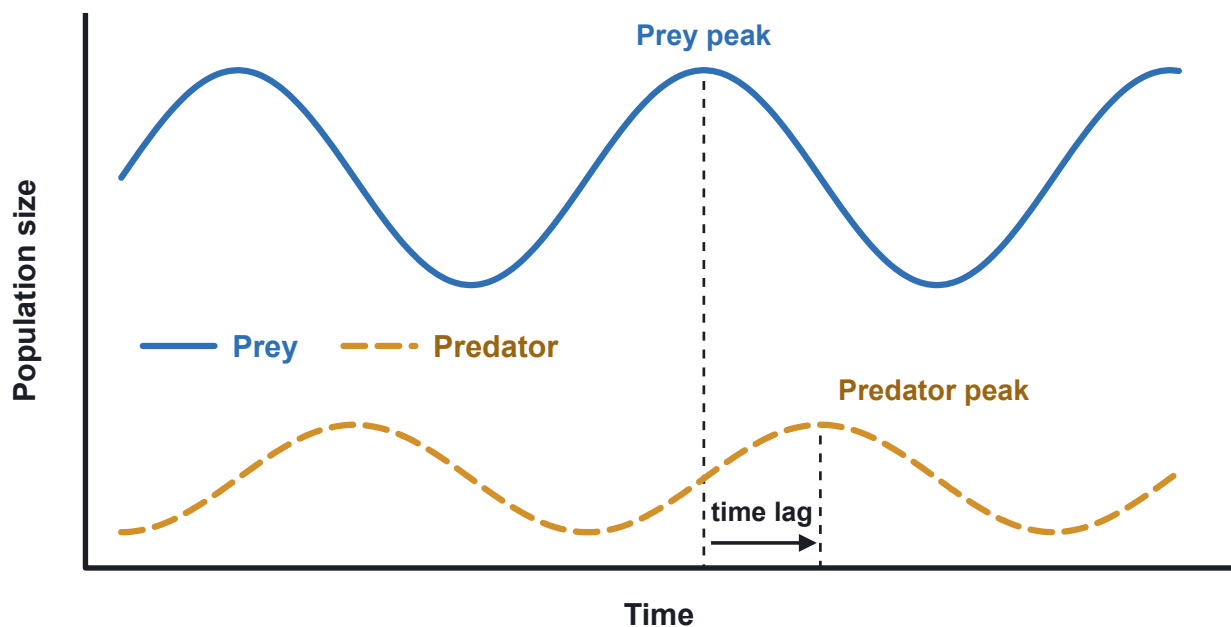
Competition

Competition happens when organisms need the same resource and there is not enough for all of them. Plants compete for light, water and mineral ions. Animals compete for food, water and territory. The better-adapted species gets more of the resource, so it survives and reproduces more, and the numbers of the other species may fall.

Predation

In a stable community, predator and prey numbers rise and fall in a repeating pattern. When prey numbers rise, predators have more food, so predator numbers rise. More predators eat more prey, so prey numbers fall. With less food, predator numbers then fall, and the prey can recover.

Exam tip: On a predator-prey graph, the predator peak comes after the prey peak, because predator numbers rise only once there is more food.



[\(opens full size in a new tab\)](#)

Predator and prey numbers cycle: the predator peak comes after the prey peak.

Interdependence Spec 9.3

In a community, species depend on one another. This is **interdependence**. Organisms depend on other species for food, shelter, pollination and seed dispersal.

- Animals depend on plants and other animals for food.
- Plants depend on insects and other animals for pollination and seed dispersal.
- Many species depend on trees for shelter and nesting sites.

Because of this, a change to one population can affect many others. If a species is removed or its numbers fall, species that feed on it may starve, while species it feeds on may increase in number. A community with many different species is more stable, because the loss of one species is less likely to cause the whole community to fail.

Exam tip: When asked about a change in a food web, follow the effect through at least two steps: what happens to the species that eats it, and what happens to the species it eats.

Parasitism and mutualism Spec 9.4

The survival of some organisms depends on a close relationship with another species. Two important types are parasitism and mutualism.

Parasitism and mutualism compared

	Parasitism	Mutualism
Meaning	One organism (the parasite) lives on or in another organism (the host) and takes food from it	Two organisms of different species live closely together and both benefit
Who benefits	The parasite benefits and the host is harmed	Both benefit
Examples	A tapeworm in the human gut. A flea on a dog.	Nitrogen-fixing bacteria in the root nodules of legume plants. Cleaner fish that eat parasites off larger fish.

In mutualism, nitrogen-fixing bacteria in root nodules get sugars from the legume plant, and the plant gets nitrogen compounds from the bacteria. Neither can do as well alone.

Common mistake: Say that the host is harmed in parasitism. Do not just say that the parasite lives on the host.

Quick check

1. Put in order from smallest to largest: ecosystem, population, organism, community.
2. Name two abiotic factors that affect communities.
3. What is meant by competition?
4. What is the difference between parasitism and mutualism?

2 Fieldwork and sampling Spec 9.5–9.6

Core practical: quadrats and belt transects Spec 9.5

Field-work techniques let you investigate the relationship between organisms and their environment, for example how the number of a plant species changes with light intensity.

Quadrat	A square frame used to sample the organisms in a small, known area.
Belt transect	A line (a tape measure) laid across a habitat, with quadrats placed along it at regular intervals, to show how organisms change along an environmental gradient.

Random sampling with quadrats

1. Mark out the study area with two tape measures laid at right angles along two sides.
2. Use a random number generator to pick two coordinates, one along each tape measure.
3. Place the quadrat at that point and count the number of the chosen species inside it, or estimate the percentage cover.
4. Repeat for many quadrats and calculate the mean.

Belt transect

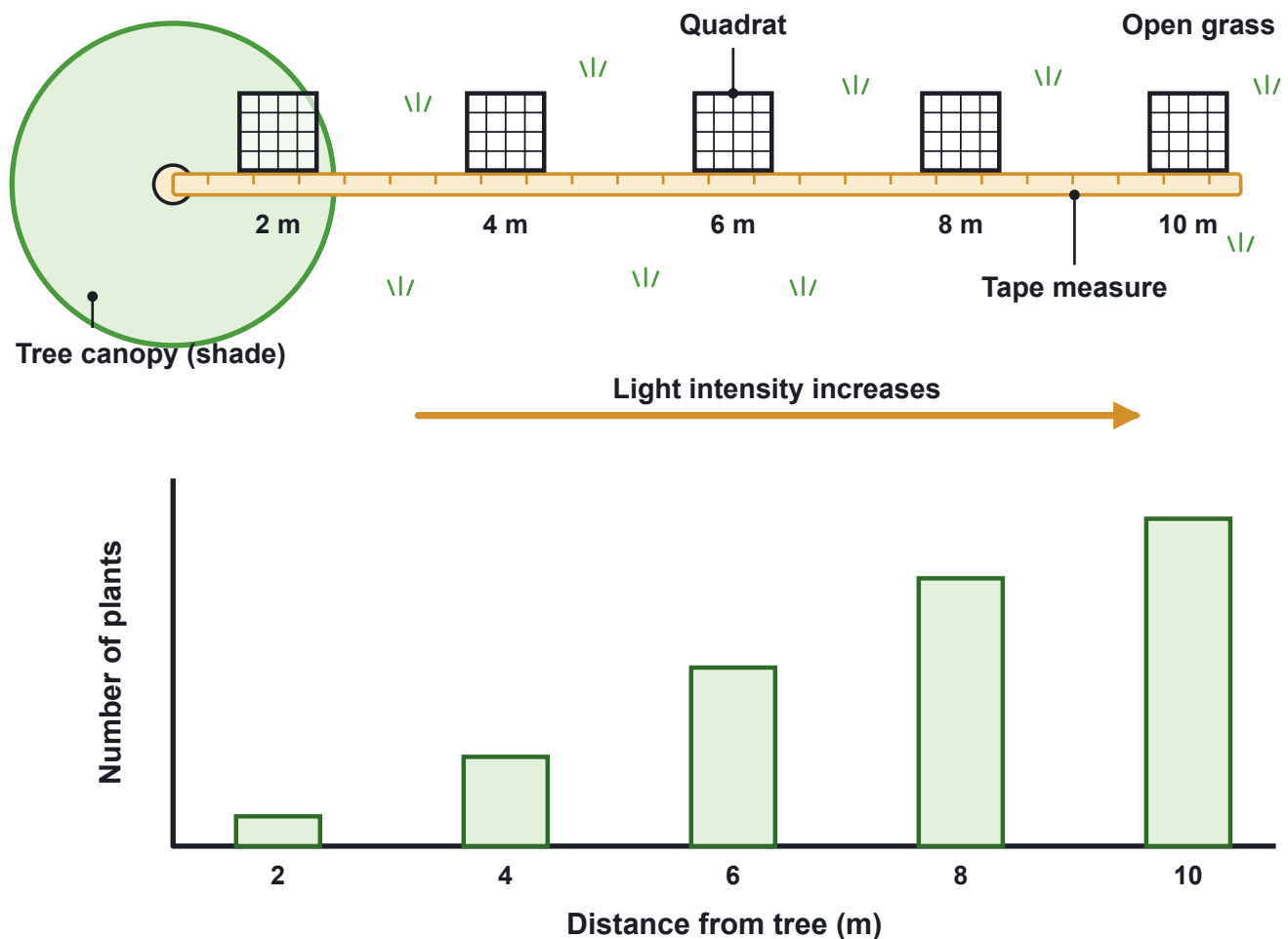
1. Lay a tape measure in a straight line across the habitat, for example from under a tree out into open grass.
2. Place a quadrat at regular intervals along the tape, such as every 2 m.
3. At each position count the organisms in the quadrat and measure the environmental factor, for example light intensity with a light meter or soil moisture with a moisture meter.
4. Record both in a table and plot a graph to look for a pattern.

Variables and safety

- **Independent variable:** the position along the transect, or the environmental factor such as light intensity.
- **Dependent variable:** the number or percentage cover of the species.
- **Control variables:** the quadrat size, the species being counted and the person counting.
- **Safety:** wear suitable footwear, wash hands after handling soil or plants, and do not touch plants you cannot identify.

Core practical: Say that random placement avoids bias, and that a belt transect is used when you want to see how a species changes along a gradient.

Typical result: along a transect from shade into open ground, plants that need lots of light increase in number as light intensity increases. A scatter diagram of number against light intensity can show a **correlation**, but a correlation alone does not prove that one factor causes the other.



[\(opens full size in a new tab\)](#)

A belt transect: quadrats at regular intervals along a tape measure, with the count from each quadrat plotted against distance.

Estimating the number of organisms Spec 9.6

You cannot count every organism in a large area, so you take samples and use them to estimate the total. A larger number of quadrats, placed randomly, gives a more reliable estimate.

estimated population = mean number per quadrat × (total area ÷ area of one quadrat)

Estimating a population

A student counted daisies in five 0.25 m² quadrats placed randomly in a field of area 100 m². The counts were 3, 5, 4, 6 and 2. Estimate the number of daisies in the field.

1. Mean per quadrat = $(3 + 5 + 4 + 6 + 2) \div 5 = 20 \div 5 = 4$
2. Number of quadrat areas in the field = $100 \div 0.25 = 400$
3. Estimated population = $4 \times 400 = 1600$

Answer: 1600 daisies

Plants that are difficult to count individually, such as grass, can be measured by **percentage cover**: the percentage of the quadrat covered by the species.

Other points to understand about sampling:

- Take as many quadrats as possible, because a bigger sample is more representative and reduces the effect of anomalies.

- Place quadrats randomly, to avoid bias.
- Calculate a **mean** from the raw data. A bar chart or frequency table is useful for presenting the results.

Maths skill: Check the units. If the quadrat is 0.5 m by 0.5 m its area is 0.25 m², not 0.5 m². This is the most common slip in estimate questions.

Quick check

1. How do you stop bias when placing quadrats?
2. What does a belt transect show?
3. Write the equation for estimating a population from quadrat data.
4. Why use many quadrats?

3 Human impacts, biodiversity and food security Spec 9.9–9.11B

Fish farming Spec 9.9

Human interactions with ecosystems can have both positive and negative impacts on **biodiversity**, which is the variety of living organisms in an ecosystem. Fish farming is one example.

Fish farming: positive and negative effects	
Positive	Negative
Provides a reliable supply of food for a growing population	Waste and uneaten food pollute water and can cause eutrophication
Reduces overfishing, which protects wild fish stocks and biodiversity	Disease and parasites can spread from farmed fish to wild fish
Conditions can be controlled, so fish grow quickly	Escaped farmed fish may compete or interbreed with wild fish, reducing their genetic variety
	Fish may be fed on wild fish, and chemicals used to control disease can harm other organisms

Exam tip: For an evaluation, give at least one positive and one negative, and then say which you think outweighs the other and why.

Non-indigenous species Spec 9.9

A **non-indigenous species** (also called an introduced or invasive species) is one that has been brought, deliberately or accidentally, into an area where it does not naturally live.

- It may have no natural predators in the new area, so its population can grow quickly.
- It can compete with native species for food and space, so native species decline.
- It may eat native species or carry diseases that native species cannot resist.
- The result is that biodiversity falls, as native species decline or die out.

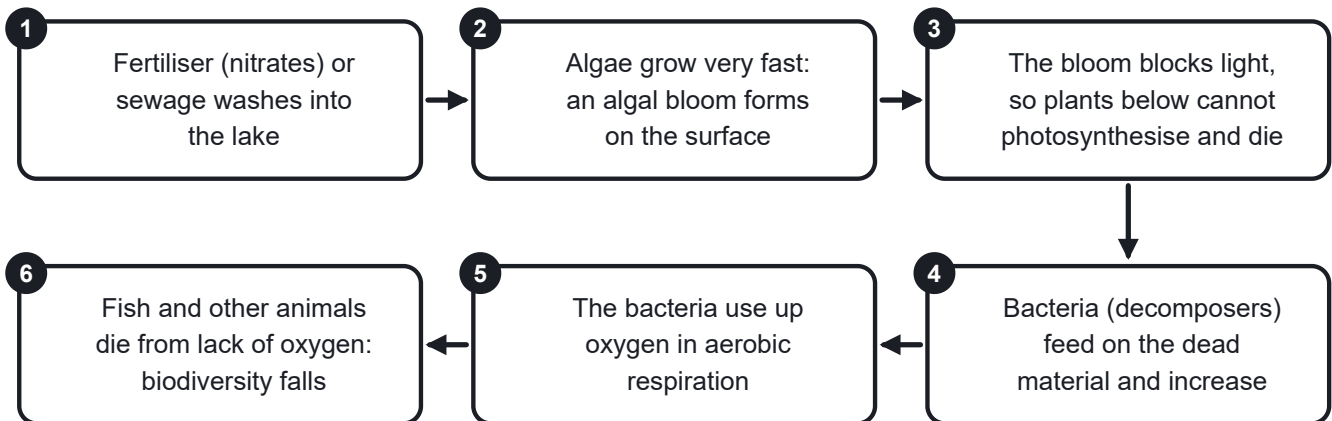
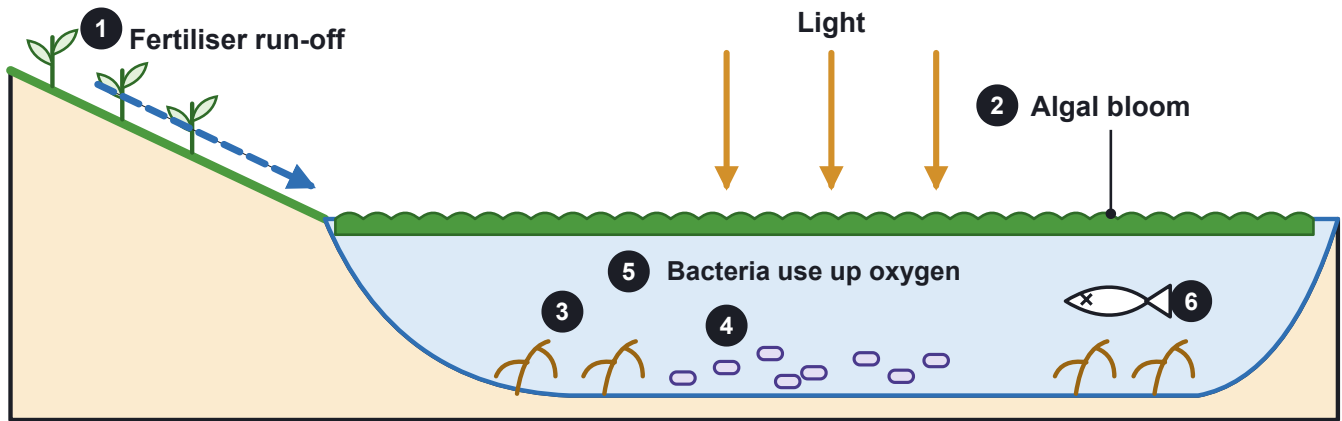
Positive effects are possible. Some non-indigenous species are introduced to provide food or other products, or to control pests. But the risk to native species means that introductions need careful control.

Eutrophication Spec 9.9

Eutrophication happens when too many nutrients, such as nitrates from fertilisers or sewage, run off into lakes and rivers.

1. Nitrates from fertilisers or sewage are washed into the water.
2. Algae in the water grow very quickly because of the extra nutrients, forming a layer on the surface (an algal bloom).
3. The layer blocks light, so plants and algae lower down cannot photosynthesise and die.
4. Bacteria (decomposers) feed on the dead material and their numbers increase.
5. The bacteria use up oxygen in the water for aerobic respiration.
6. Fish and other aquatic animals die from lack of oxygen, so biodiversity falls.

Common mistake: The fish do not die because the algae poison them. The main cause is the decomposers feeding on the dead plants and algae, which use up the oxygen.



[\(opens full size in a new tab\)](#)

Eutrophication: extra nitrates cause an algal bloom, plants die, **decomposers use up the oxygen** and fish die.

Benefits of maintaining biodiversity Spec 9.10

It is important to maintain biodiversity both locally and globally.

- Ecosystems with high biodiversity are more stable, because species depend on each other (interdependence) and the loss of one is less likely to cause others to fail.
- Biodiversity gives humans food, materials and medicines, and may supply useful resources not yet discovered.
- Species help to maintain the conditions we depend on, such as pollination of crops and cycling of materials.
- Local biodiversity benefits the local people and wildlife. Global biodiversity protects species from extinction.

Conservation of animal species

Endangered animal species can be protected by conservation programmes, such as protecting their habitats, captive breeding programmes, and laws to prevent hunting. This helps to maintain biodiversity.

Reforestation

Reforestation means replanting trees in areas where forest has been cut down. It has benefits for biodiversity and the environment:

- It restores habitats, so the variety of species can increase.
- Trees absorb carbon dioxide by photosynthesis, which helps to reduce the amount of carbon dioxide in the atmosphere.
- Tree roots help to hold soil, which reduces soil erosion and flooding.

Reforestation takes a long time, and the land may be needed for farming, so there can be conflict between the needs of people and the needs of wildlife.

Quick check

1. Name the three human interactions you must be able to explain for this topic.
2. Why do fish die in eutrophication?
3. Give two benefits of reforestation.
4. What is meant by a non-indigenous species?

4 Material cycles Spec 9.12–9.15

Cycling of materials Spec 9.12

Materials such as carbon, nitrogen and water are **cycled** through an ecosystem, moving between the abiotic components (air, water and soil) and the biotic components (living organisms).

Plants take up materials from the air, water and soil and build them into their own biomass. The materials pass to animals when they feed. Materials return to the soil and air when organisms excrete waste, and when dead organisms and their waste are broken down by decomposers. The materials can then be used again by new organisms. Cycling is needed because the supply of each material is limited.

The carbon cycle Spec 9.13

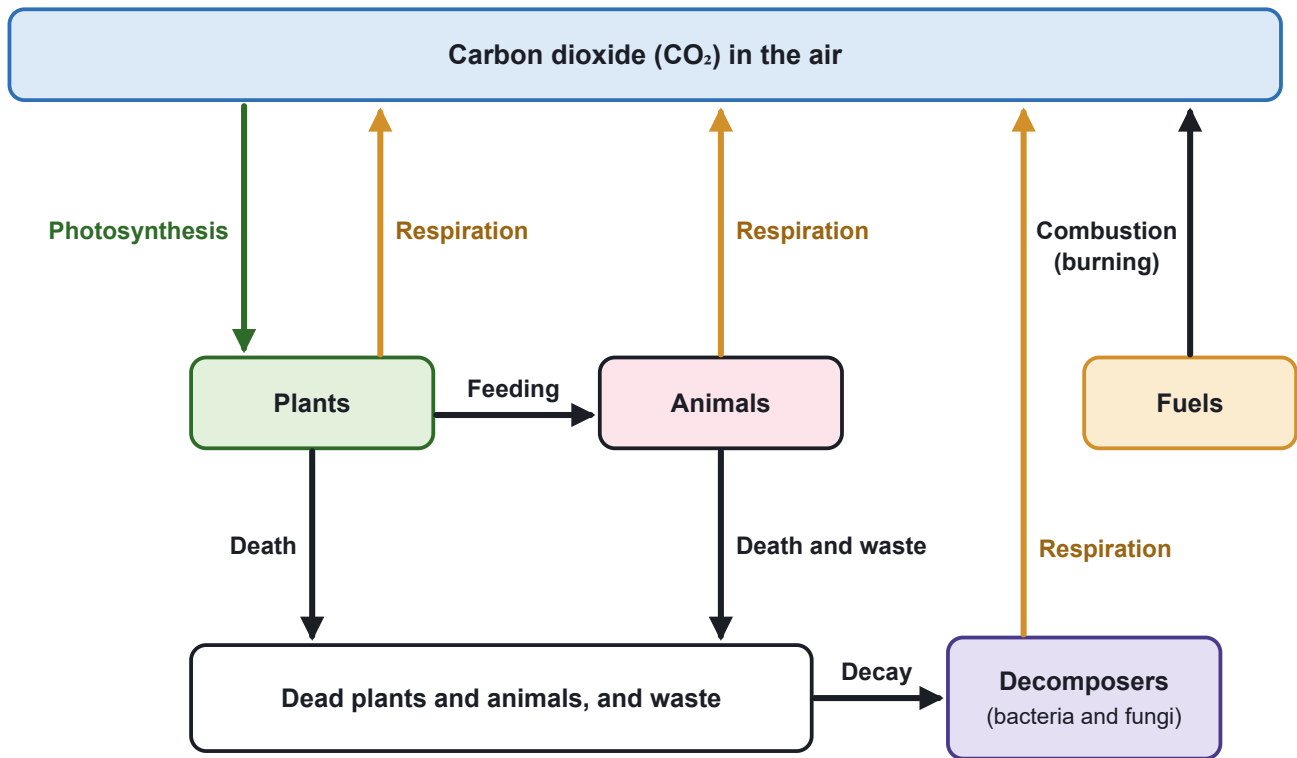
All living things are made of carbon compounds. The **carbon cycle** is important because it returns carbon to the atmosphere as carbon dioxide, so that it is available for plants to use in photosynthesis again.

1. Plants and algae take carbon dioxide from the air and use it in **photosynthesis** to make carbon compounds such as glucose, starch and proteins.
2. The carbon compounds pass along the food chain when animals feed.
3. All organisms (plants, animals and decomposers) release carbon dioxide into the air by **respiration**.
4. When plants and animals die, their bodies and waste are broken down by decomposers, which release carbon dioxide into the air by respiration.
5. Burning of fuels (combustion) also releases carbon dioxide into the air.

The role of microorganisms as decomposers

Decomposers are microorganisms such as bacteria and fungi. They release enzymes to break down dead plants, dead animals and waste, and they respire, releasing carbon dioxide into the air. Without decomposers, dead material would pile up, carbon would be locked in it, and the supply of carbon dioxide for photosynthesis would run out. Decomposers also release mineral ions back into the soil.

Exam tip: Name the process at each arrow: photosynthesis takes carbon dioxide in, and respiration (including by decomposers) and combustion put it back.



[\(opens full size in a new tab\)](#)

The carbon cycle: **photosynthesis** takes carbon dioxide in; **respiration** and **combustion** put it back.

The water cycle and potable water Spec 9.14

All organisms need water to survive, and plants need it for photosynthesis. The **water cycle** is important because it keeps supplying fresh water to the land for plants, animals and humans. The main processes are:

- **Evaporation:** water from seas, lakes and soil changes to water vapour, using heat from the Sun.
- **Transpiration:** water vapour is lost from the leaves of plants.
- **Condensation:** water vapour cools and turns into liquid water droplets, forming clouds.
- **Precipitation:** water falls as rain, snow or hail, and then runs over the land or soaks into the soil and flows into rivers, lakes and the sea.

Potable water and desalination

Potable water is water that is safe to drink. In areas of drought there may not be enough fresh water. Sea water contains too much dissolved salt to drink, but **desalination** removes the salt to produce potable water.

- **Distillation:** sea water is evaporated, leaving the salt behind, and the water vapour is condensed back to pure water.
- **Reverse osmosis:** sea water is forced through a partially permeable membrane that lets water through but not salt.

Desalination needs large amounts of energy, so it is expensive.

The nitrogen cycle Spec 9.15

Plants need **nitrates** from the soil to make amino acids and proteins. Although 78% of air is nitrogen gas, plants cannot use it directly. Bacteria in the soil have key roles in making nitrates available.

Bacteria in the nitrogen cycle		
Process	Bacteria	What happens
Decay	Decomposers (bacteria and fungi)	Break down proteins and urea in dead material and waste into ammonia (ammonium ions)
Nitrification	Nitrifying bacteria	Convert ammonium ions in the soil into nitrates, which plants absorb
Nitrogen fixation	Nitrogen-fixing bacteria, in the soil or in root nodules of legumes	Convert nitrogen gas from the air into nitrogen compounds, which become nitrates
Denitrification	Denitrifying bacteria	Convert nitrates in the soil into nitrogen gas, which reduces soil fertility

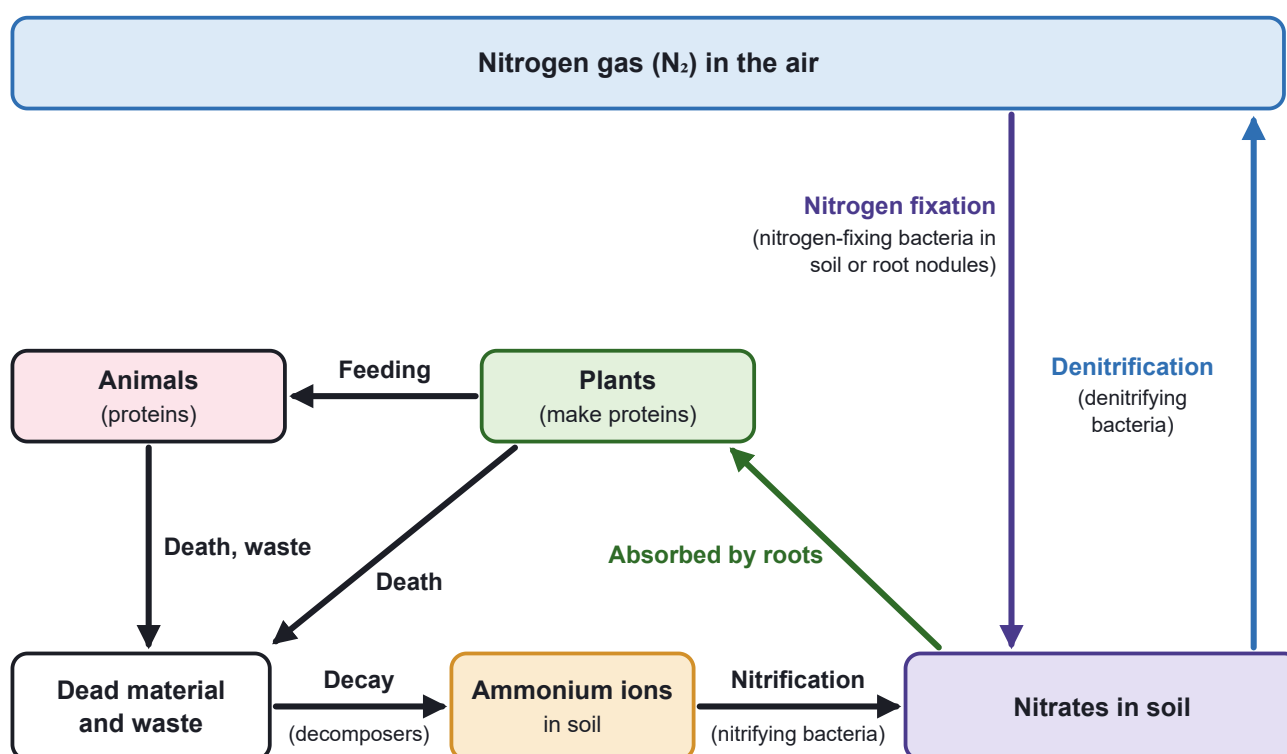
Plants take up nitrates and build them into proteins. Animals get the nitrogen by eating plants or other animals.

Fertilisers and crop rotation

Farmers remove crops, so nitrates are lost from the soil. They can replace them in two ways:

- **Fertilisers:** add nitrates (and other minerals) to the soil.
- **Crop rotation:** different crops are grown in a field in different years. In some years a legume crop such as clover or peas is grown. Its root nodules contain nitrogen-fixing bacteria, and when its remains are ploughed into the soil they add nitrates. It is then followed by a crop that needs a lot of nitrates.

Common mistake: Nitrogen-fixing bacteria are not the bacteria that make ammonia from dead material. That is decay. Fixing means turning nitrogen gas into compounds.



[\(opens full size in a new tab\)](#)

The nitrogen cycle: bacteria carry out **nitrogen fixation**, **nitrification** and **denitrification**; decomposers carry out **decay**.

Quick check

- 1 . Which process removes carbon dioxide from the air?
- 2 . What is potable water?
- 3 . Why do plants need nitrates?
- 4 . Which bacteria are found in the root nodules of legumes?
- 5 . Why are decomposers important in the carbon cycle?

Quick check answers

Communities and interdependence

1. Organism, population, community, ecosystem.
2. Any two of: temperature, light, water, pollutants.
3. Organisms needing the same limited resource, such as food, light or water.
4. In parasitism the parasite benefits and the host is harmed. In mutualism both organisms benefit.

Fieldwork and sampling

1. Use random numbers to choose the coordinates.
2. How the distribution of organisms changes along an environmental gradient.
3. $\text{Mean per quadrat} \times (\text{total area} \div \text{area of one quadrat})$.
4. To give a more representative and reliable sample, and reduce the effect of anomalies.

Human impacts, biodiversity and food security

1. Fish farming, introduction of non-indigenous species, eutrophication.
2. Bacteria feeding on dead plants and algae use up the oxygen in the water.
3. Any two of: restores habitats, absorbs carbon dioxide, reduces soil erosion.
4. A species introduced to an area where it does not naturally live.

Material cycles

1. Photosynthesis.
2. Water that is safe to drink.
3. To make amino acids and proteins.
4. Nitrogen-fixing bacteria.
5. They break down dead material and release carbon dioxide by respiration.