

Organisation of an ecosystem

Revision notes • Food chains, sampling with quadrats and transects, predator-prey cycles, the carbon and water cycles, decay and the effect of environmental change.

For AQA GCSE Biology 8461 and Combined Science: Trilogy 8464. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

Organisation of an ecosystem Spec 4.7.2

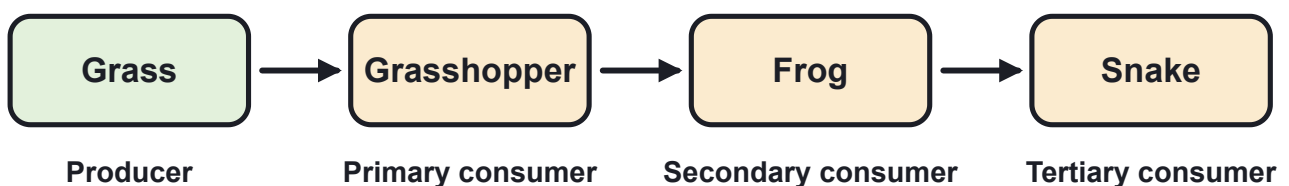
Producers, consumers and food chains Spec 4.7.2.1

Photosynthetic organisms are the producers of biomass for life on Earth. Feeding relationships within a community can be represented by **food chains**.

All food chains begin with a **producer** which synthesises molecules. This is usually a green plant or alga which makes glucose by photosynthesis.

Feeding levels in a food chain		
Name	What it does	Example
Producer	Makes glucose by photosynthesis	Grass
Primary consumer	Eats the producer	Grasshopper
Secondary consumer	Eats the primary consumer	Frog
Tertiary consumer	Eats the secondary consumer	Snake

Consumers that kill and eat other animals are **predators**, and those eaten are **prey**.



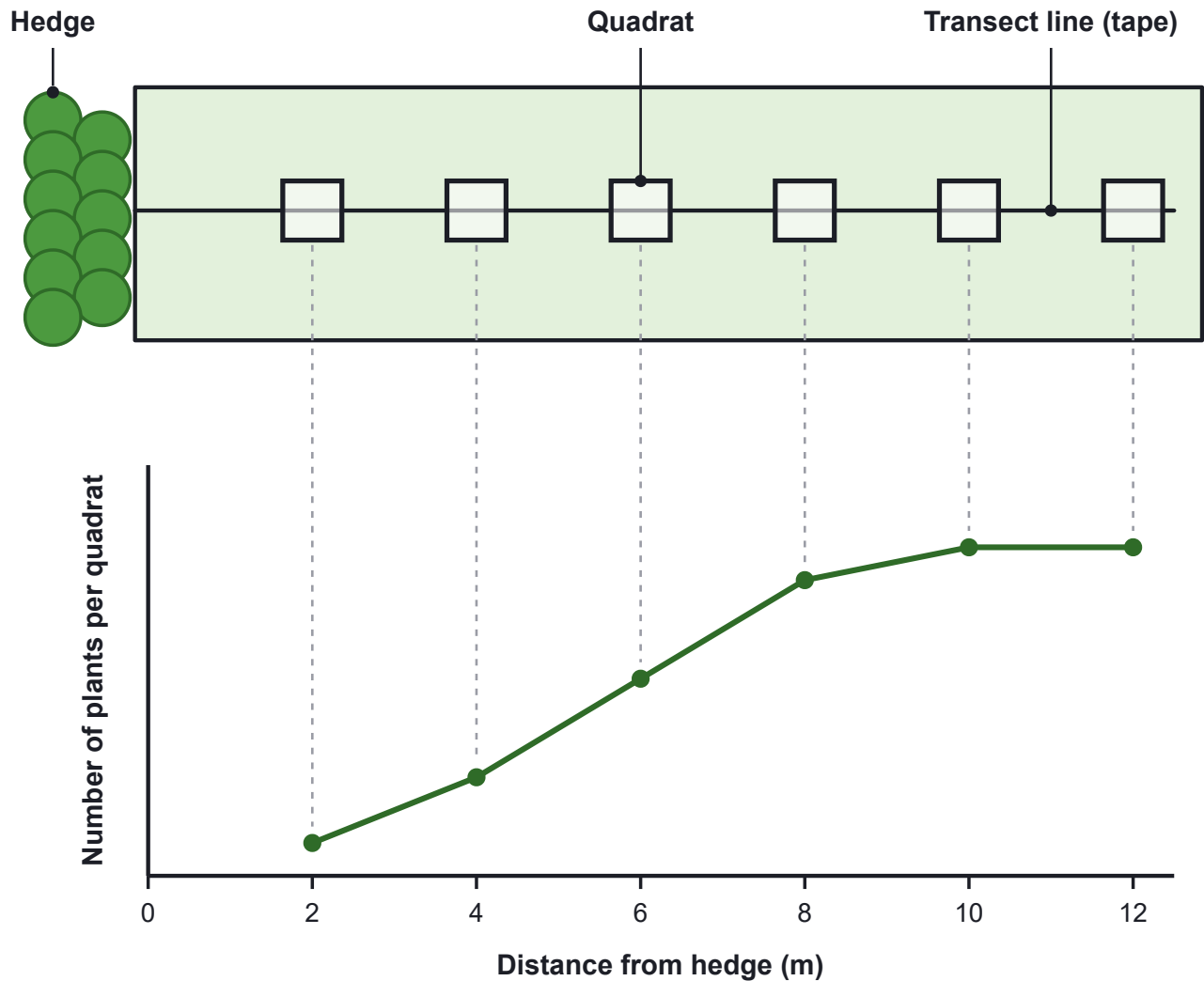
The arrows show the direction the food (biomass) goes: **from the food to the animal that eats it**.

Common mistake: Arrows in a food chain point from the food to the animal that eats it. Grass → rabbit means the rabbit eats the grass.

Sampling: distribution and abundance Spec 4.7.2.1

Ecologists use experimental methods with **quadrats** and **transects** to find the **distribution** (where a species is found) and **abundance** (how many there are) of species in an ecosystem.

- A quadrat is a square frame placed on the ground. You count the organisms inside it.
- A transect is a line (such as a tape measure) laid across the ground. You place quadrats along it at regular intervals to see how the species changes along the line.



Quadrats placed at regular intervals along a transect. Here the plant becomes more common further from the shady hedge.

Required practical: Required practical 9 (numbered 7 in Combined Science): *measure the population size of a common species in a habitat. Use sampling techniques to investigate the effect of a factor on the distribution of this species. The method is below.*

Method: population size

1. Choose the habitat and the species to count, for example a plant such as daisies on a field.
2. Place the quadrat at random positions. Use a random number generator to pick coordinates on a grid laid out with two tape measures. Random placement avoids bias.
3. Count the organisms of the chosen species inside the quadrat each time.
4. Repeat many times, for example 10 or more quadrats, so that the sample is representative.
5. Calculate the mean number per quadrat.
6. Estimate the population size. If the quadrat is not 1 m², first find the mean per m² (mean per quadrat ÷ area of the quadrat). Then: population = mean number per m² × total area of the habitat in m².

Method: effect of a factor on distribution

1. Lay a transect line across the habitat where the factor changes, for example from an area of shade into an open area.
2. Place a quadrat at regular intervals along the line, for example every 2 metres.
3. At each position count the organisms of the species, and measure the factor (for example light intensity with a light meter, or soil moisture).

- Record the results in a table and plot a graph of number of organisms against distance or against the value of the factor.

Control variables include the size of the quadrat, the species being counted, the time of day, and the person doing the counting. Take care outdoors: wear gloves if needed, avoid harmful plants, take care near water and wash your hands afterwards.

A typical result is that the number of organisms of a species changes along the transect as the factor changes. For example, the number of a plant species may be lower under trees where there is less light, and higher in the open.

Mean, mode and median

Mean	The total of all the values divided by the number of values.
Mode	The value that occurs most often.
Median	The middle value when the values are in order. With an even number of values, it is halfway between the two middle values.

Mean, mode and median of quadrat counts

A student counted daisies in 8 quadrats and got: 2, 4, 4, 5, 6, 7, 4, 8. Calculate the mean, mode and median. Then estimate the population in a field of 300 m², using quadrats of area 0.25 m².

- Mean: add the values: $2 + 4 + 4 + 5 + 6 + 7 + 4 + 8 = 40$. Divide by 8 quadrats: $40 \div 8 = 5$.
- Mode: the most common value is 4 (it appears three times).
- Median: put the values in order: 2, 4, 4, 4, 5, 6, 7, 8. The middle two values are 4 and 5, so the median is 4.5.
- Population estimate: mean per quadrat is 5 in 0.25 m², so per m² is $5 \div 0.25 = 20$. Over 300 m²: $20 \times 300 = 6000$.

Answer: Mean = 5, mode = 4, median = 4.5. Estimated population = 6000 daisies.

Plotting graphs

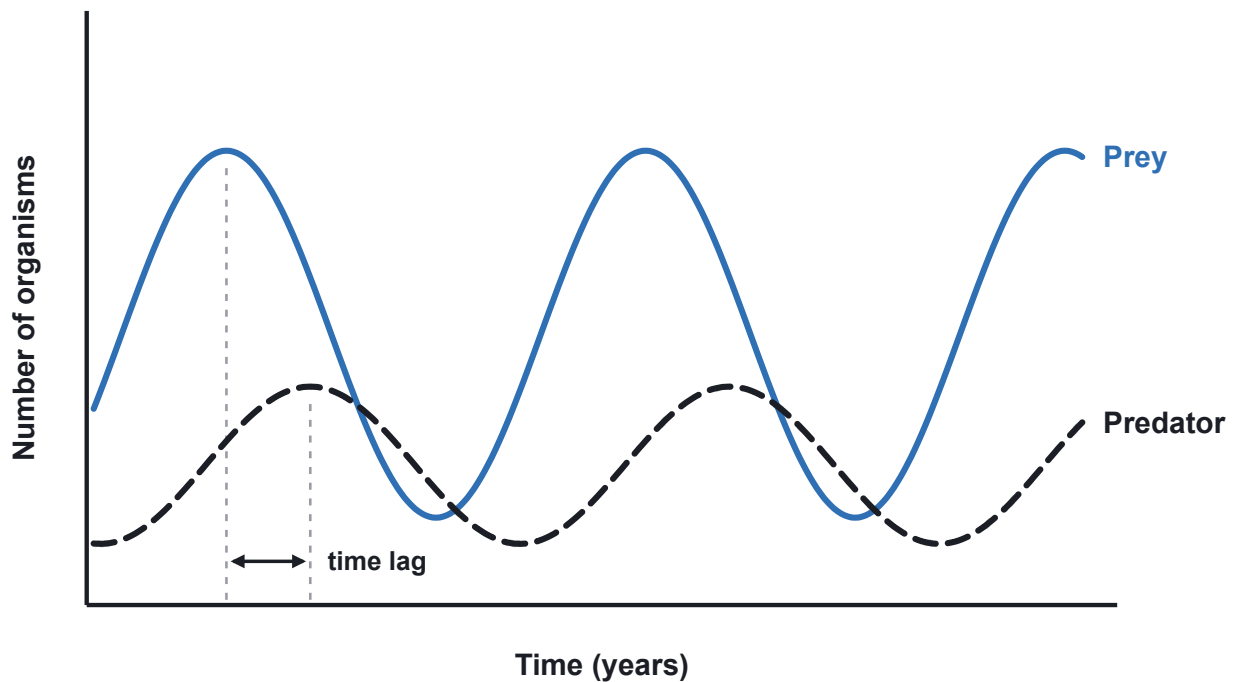
Choose a bar chart for categories such as different species, and a line graph for continuous data such as distance along a transect. Put the independent variable on the x-axis. Choose a scale that uses more than half of the grid, goes up in equal steps, and label each axis with its quantity and unit.

Exam tip: If asked why many quadrats are used, say that it makes the results more representative and reduces the effect of anomalies. If asked why placement is random, say it avoids bias.

Predator-prey cycles Spec 4.7.2.1

In a stable community the numbers of **predators and prey** rise and fall in **cycles**.

- Prey numbers are high, so there is plenty of food for the predators.
- Predator numbers rise as they eat more prey and breed.
- Prey numbers fall as more of them are eaten.
- With less food, predator numbers fall.
- Fewer predators means fewer prey are eaten, so prey numbers rise again.



Predator and prey numbers cycle. The **prey peak comes first** and the predator peak follows after a time lag.

Exam tip: On a graph, the prey peak comes first and the predator peak follows a short time later. The line that peaks first is the prey. Say that the predator numbers depend on the food supply.

Maths skill: Interpret graphs used to model these cycles. Quote values from the graph, describe the pattern of both populations, and explain the link between them.

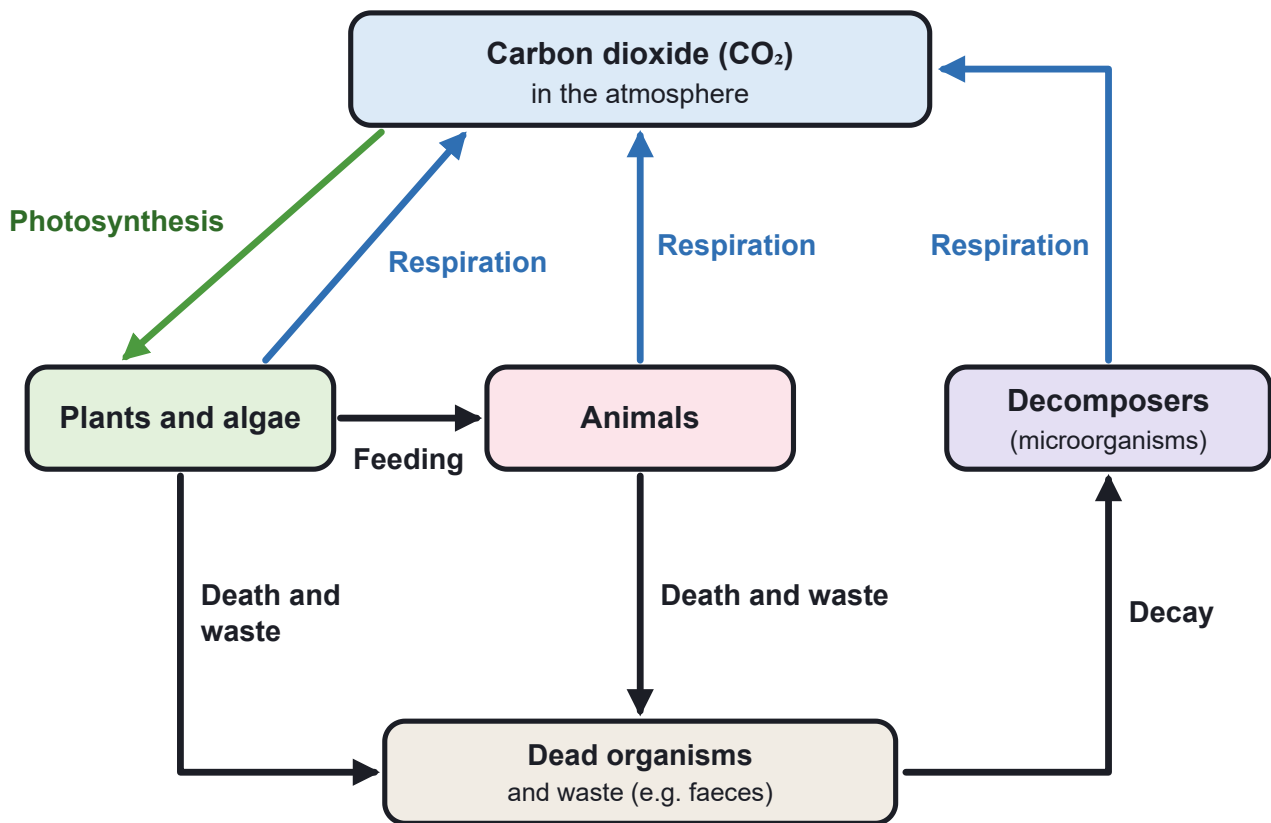
How materials are cycled Spec 4.7.2.2

Many different materials cycle through the abiotic and biotic components of an ecosystem. All materials in the living world are recycled to provide the building blocks for future organisms.

The carbon cycle

The **carbon cycle** returns carbon from organisms to the atmosphere as carbon dioxide to be used by plants in photosynthesis.

1. Plants and algae take in carbon dioxide from the atmosphere for photosynthesis, and make glucose and other molecules.
2. Carbon passes along food chains as animals eat the plants, and then other animals.
3. Plants, animals and decomposing microorganisms release carbon dioxide into the atmosphere by respiration.
4. When organisms die, microorganisms decompose them. They release carbon dioxide by respiration.



The carbon cycle. **Photosynthesis** removes carbon dioxide from the atmosphere; **respiration** by plants, animals and decomposers returns it.

Carbon is important to living organisms because the main molecules they are built from, such as carbohydrates, proteins and fats, contain carbon. The cycle makes sure that carbon is available for new organisms.

The water cycle

The **water cycle** provides fresh water for plants and animals on land before draining into the seas. Water is continuously evaporated and precipitated.

1. Water evaporates from the sea, from the land and from plants.
2. The water vapour rises and cools, and condenses to form clouds.
3. Water falls as precipitation, such as rain, hail and snow.
4. The fresh water on land is used by plants and animals before draining into rivers and then the seas.

Water is important to living organisms because it is needed in cells, plants need it for photosynthesis, and land plants and animals need a supply of fresh water.

The role of microorganisms

Microorganisms that decompose dead plants, dead animals and waste have an important role in cycling materials through an ecosystem. They return **carbon** to the atmosphere as carbon dioxide (by respiration) and return **mineral ions** to the soil, where plants take them up.

Exam tip: You are not expected to study the nitrogen cycle. Learn the carbon and water cycles. In diagrams, name each arrow with the correct process: photosynthesis, respiration, feeding, decay, evaporation, condensation or precipitation.

Decomposition Spec 4.7.2.3 Triple only

Decay is the breakdown of dead biological material by microorganisms. The rate of decay depends on the conditions the decomposers are in.

Factors that affect the rate of decay

Factor	Effect on the rate of decay
Temperature	Warmer conditions speed up decay, because the enzymes and the respiration of the microorganisms work faster, until an optimum. If it is too hot, the enzymes denature and decay slows. In cold conditions, decay is slow
Water	Microorganisms need water to grow and be active. More water (moist conditions) means faster decay. Dry material decays slowly
Availability of oxygen	Most decomposers need oxygen for aerobic respiration, so more oxygen means faster decay. With little or no oxygen, decay is slower

Compost and biogas

Gardeners and farmers try to provide optimum conditions for rapid decay of waste biological material. The **compost** produced is used as a natural fertiliser for growing garden plants or crops.

Anaerobic decay (decay without oxygen) produces methane gas. Biogas generators can be used to produce methane gas as a fuel.

Calculating rate changes

$$\text{rate of decay} = \text{change in amount of material} \div \text{time}$$

Rate of decay

The mass of dead leaves in a compost heap falls from 80 g to 56 g in 12 days. Calculate the mean rate of decay.

1. Change in mass = $80 - 56 = 24$ g.
2. Rate = change in mass $\div$ time = $24 \text{ g} \div 12 \text{ days} = 2 \text{ g per day}$.

Answer: 2 g per day

You may also be asked to translate information between numerical and graphical form, and to plot a graph, for example mass of material or pH against time. Choose a scale that uses more than half the grid and label the axes with units.

Required practical: Required practical 10: investigate the effect of temperature on the rate of decay of fresh milk by measuring pH change. The method is below.

1. Put a set volume of milk into a test tube. Add a set volume of sodium carbonate solution, which makes it alkaline, and a few drops of phenolphthalein indicator, which is pink in alkaline conditions.
2. Put this tube, and a separate tube of lipase solution, into a water bath at the chosen temperature. Leave them until they reach that temperature.
3. Add a set volume of lipase to the milk, stir and start a stopwatch.
4. Stop the stopwatch when the pink colour disappears. Lipase breaks down the fat in milk into fatty acids, which lower the pH.
5. Repeat at a range of temperatures, for example 20, 30, 40 and 50 °C, and repeat each temperature.
6. Calculate the rate for each temperature as $1 \div \text{time taken}$.

Another version leaves fresh milk at different temperatures and measures its pH at regular intervals with a pH probe. As bacteria in the milk decay it, acid is produced and the pH falls.

The independent variable is the temperature. The dependent variable is the time taken for the colour to change (or the change in pH). Control variables: the volume of milk, the volume and concentration of lipase and sodium carbonate, and the number of drops of indicator.

A typical result is that the rate increases as the temperature rises, up to an optimum. Above the optimum the rate falls, because the enzymes denature.

Safety: wear eye protection, do not taste the milk, wash your hands afterwards and take care with hot water baths.

Impact of environmental change Spec 4.7.2.4 Triple only Higher tier

Environmental changes affect the **distribution** of species in an ecosystem. These changes include:

- temperature
- availability of water
- composition of atmospheric gases.

The changes may be **seasonal**, **geographic** or caused by **human interaction**.

Type of change	Example of how it could affect distribution
Seasonal	Temperature and rainfall change through the year, so some species are only found in the area in particular seasons, such as animals that migrate away for winter
Geographic	Temperature and the availability of water are different in different places, for example further from the equator or higher up a mountain. A species is only found where the conditions suit it
Human interaction	Burning fossil fuels changes the composition of atmospheric gases and contributes to rising temperatures. Farming or building can change the water available

To evaluate the impact, use the information given. Say which species are affected, how (more or fewer, moved to a different place), and whether the effect is likely to be large, small, short term or long term.

Exam tip: For 'evaluate' questions, make a judgement. Give the effect on the species, a reason, and a conclusion about how serious the impact is.

Quick check

1. What does a food chain always begin with?
2. Why do ecologists use a transect?
3. In a predator-prey graph, which peak comes first?
4. Which organisms return carbon dioxide and mineral ions to the environment when material decays?
5. What does the water cycle provide for plants and animals on land?

Quick check answers

Organisation of an ecosystem

1. A producer, usually a green plant or alga that makes glucose by photosynthesis.
2. To see how the distribution of a species changes along a line as a factor changes.
3. The prey peak, followed by the predator peak.
4. Microorganisms (decomposers).
5. Fresh water, before it drains into the seas.