

Ecology revision notes

Ecology is the study of how living things interact with each other and with their environment. It covers communities, food chains, the cycling of materials such as carbon and water, and how human activity affects biodiversity. Triple students also study decomposition, environmental change (Higher), trophic levels, biomass transfer and food production.

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.

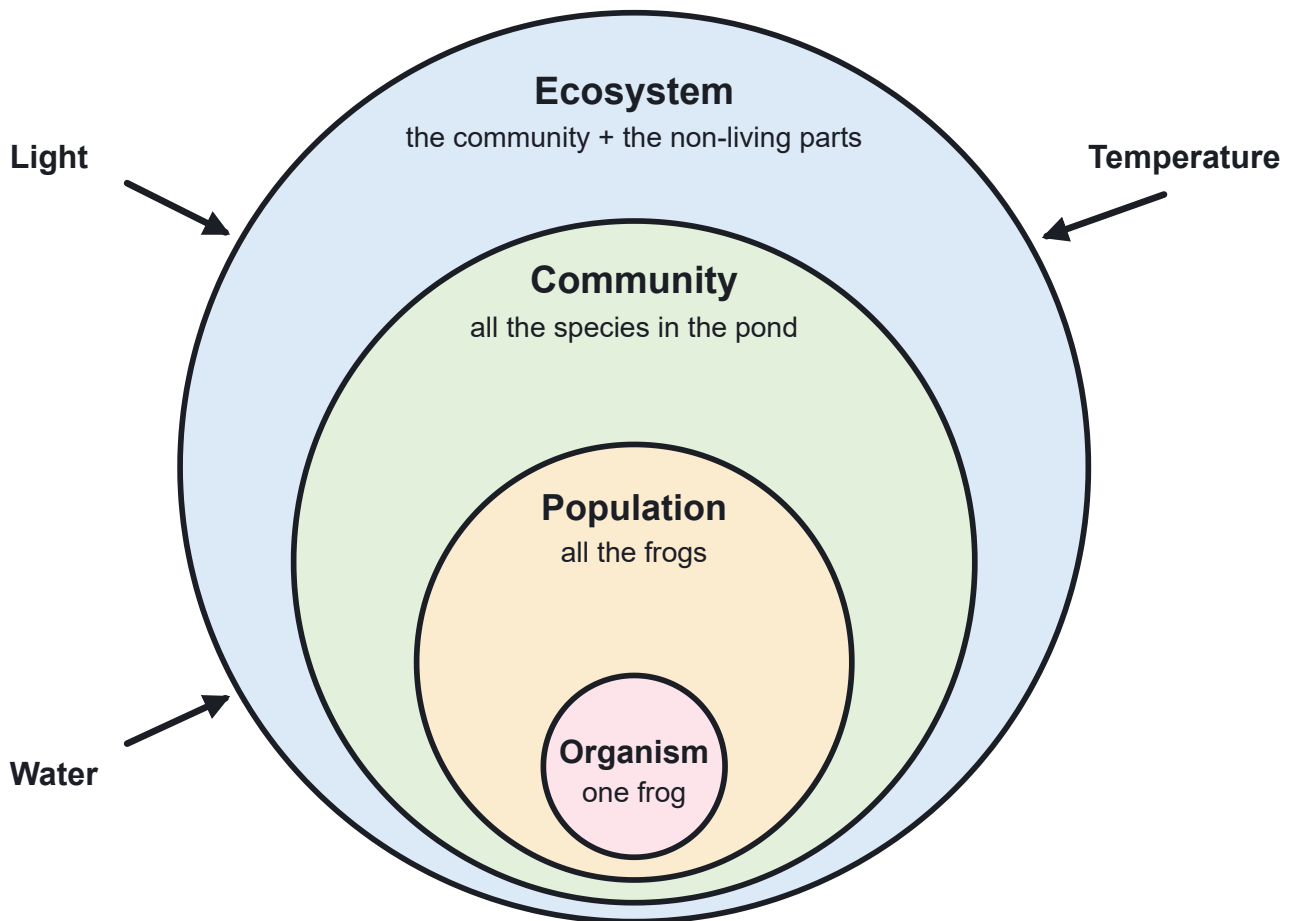
1 Adaptations, interdependence and competition Spec 4.7.1

Communities Spec 4.7.1.1

An **ecosystem** is the interaction of a community of living organisms (biotic) with the non-living (abiotic) parts of their environment.

Levels of organisation

From a single organism to the whole ecosystem, using a pond as the example		
Level	What it means	Pond example
Individual organism	One living thing	One frog
Population	All the organisms of one species living in the same area	All the frogs in the pond
Community	All the populations of the different species living in the same area	All the plants, animals and microorganisms in the pond
Ecosystem	The community together with the non-living parts of the environment	The pond community plus the water, light and temperature



Each level contains the one before it. The **ecosystem** is the community plus the abiotic factors (light, water, temperature).

To survive and reproduce, organisms need a supply of materials from their surroundings and from the other living organisms there.

Competition

Organisms in a community or habitat **compete** for the things they need when these are in short supply.

Organisms	They often compete for
Plants	Light, space, water and mineral ions from the soil
Animals	Food, mates and territory

Exam tip: You may be given a habitat and asked what organisms compete for. Match it to the table: trees in a wood compete for light, so a plant under them is short of light.

Interdependence and stable communities

Interdependence	Within a community each species depends on other species for food, shelter, pollination, seed dispersal and so on. If one species is removed it can affect the whole community.
Stable community	A community where all the species and environmental factors are in balance so that population sizes remain fairly constant.

For example, if a plant species that is pollinated by one type of insect is removed, that insect loses its food, and the animals that eat the insect lose theirs. One change spreads through the community.

Maths skill: You may need to extract and interpret information from charts, graphs and tables about how organisms in a community affect each other. Describe the pattern first, then explain it using food, competition or predation.

Abiotic factors Spec 4.7.1.2

Abiotic (non-living) factors can affect a community. If one of them changes, the organisms that depend on it are affected, and so are the species that feed on or depend on those organisms.

Abiotic factors and how a change might affect organisms	
Abiotic factor	How a change could affect organisms
Light intensity	Less light means plants photosynthesise more slowly and grow less, so there is less food for the animals that eat them
Temperature	Changes the rate of enzyme-controlled reactions, so growth and reproduction speed up or slow down. Too hot or too cold and organisms may die or move away
Moisture levels	Plants and animals need water to survive. In drier conditions, fewer organisms can live there
Soil pH and mineral content	Plants only grow well in a suitable pH and need mineral ions for healthy growth. Poor soil means fewer plants
Wind intensity and direction	Strong wind can damage plants and increases water loss from them. It also affects how easily animals move and feed
Carbon dioxide levels for plants	Carbon dioxide is needed for photosynthesis. Lower levels slow the growth of plants
Oxygen levels for aquatic animals	Aquatic animals need oxygen for respiration. If levels fall, fewer animals can survive in the water

To **explain** the effect of a change, link three steps: what changed, how it affects the organism, and what happens to the community.

Exam tip: Always finish the chain. Saying 'less light' is not enough. Say that there is less photosynthesis, so plants grow less and fewer herbivores can be supported.

Maths skill: Questions often give a table or graph of an abiotic factor against the number of organisms. State where the number is highest or lowest, and quote values from the data.

Biotic factors Spec 4.7.1.3

Biotic (living) factors can also change a community. The four you need to know are:

Biotic factor	How a change could affect a community
Availability of food	Less food means more competition, so animal numbers fall. More food means numbers can rise
New predators arriving	Prey are eaten, so the prey population falls. Anything the prey ate may then increase
New pathogens	Disease can kill or weaken many organisms of a species, so the population falls
One species outcompeting another	The weaker competitor gets less of the food, light or space it needs. Its numbers may become no longer sufficient to breed, so the species can die out in that area

A change in one population affects others. If a new predator reduces the number of prey, the predator's other food sources and the prey's food source are all affected.

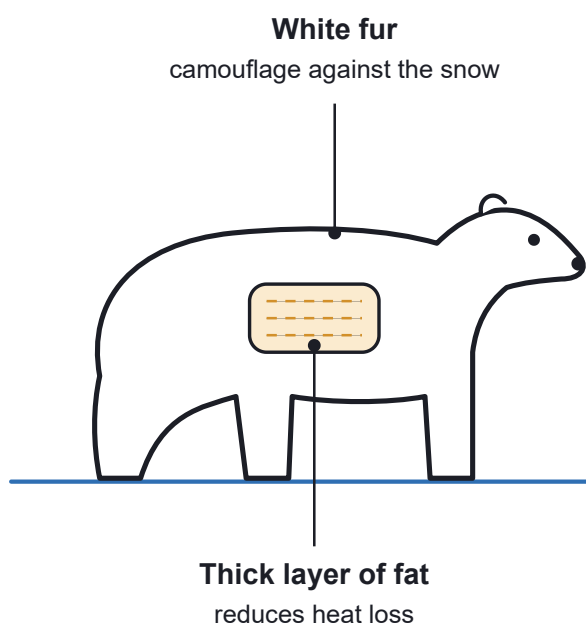
Common mistake: Do not say that a population 'adapts' to a new predator or pathogen in the short term. Describe what happens to numbers: they rise or fall, and why.

Maths skill: You may be asked to interpret a graph of two populations over time. Describe how each changes, then link the changes, for example prey falling when predators rise.

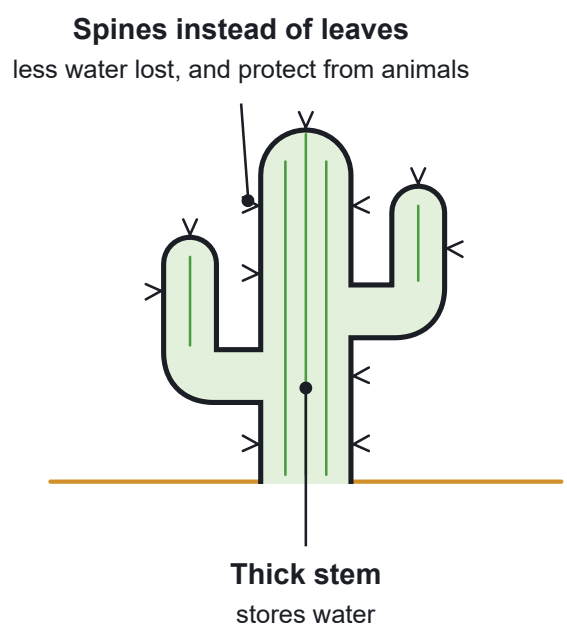
Adaptations Spec 4.71.4

Organisms have features called **adaptations** that enable them to survive in the conditions in which they normally live. Adaptations may be structural, behavioural or functional.

Type	What it is	Examples
Structural	A feature of the body's structure	A thick layer of fat and a white coat on a polar bear. Spines and a thick, water-storing stem on a cactus
Behavioural	The way an organism acts	Migrating to a warmer place for winter. Hunting at night to avoid the heat of the day
Functional	How a body process works	A camel producing very little, concentrated urine to save water



Polar bear: cold Arctic



Cactus: hot, dry desert

Structural adaptations match the conditions: the polar bear is adapted to the **cold**, the cactus to the **hot, dry** desert.

Extremophiles

Extremophile	An organism that lives in an environment that is very extreme, such as at high temperature, pressure or salt concentration. Bacteria living in deep sea vents are extremophiles.
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When you explain an adaptation, you are given information about the environment. Name the feature, then say how it helps survival.

Exam tip: Use the pattern 'feature, then how it helps, then in that environment'. For example: thick fat (feature) reduces heat loss (how it helps) in the cold Arctic (environment).

Quick check

1. Put in order, smallest to largest: community, organism, ecosystem, population.
2. What do plants often compete for?
3. What do animals often compete for?
4. What is a stable community?
5. What is an extremophile?

2 Organisation of an ecosystem Spec 4.7.2

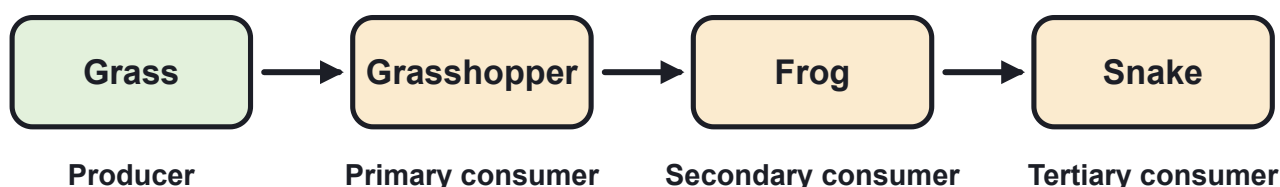
Producers, consumers and food chains Spec 4.7.2.1

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**.



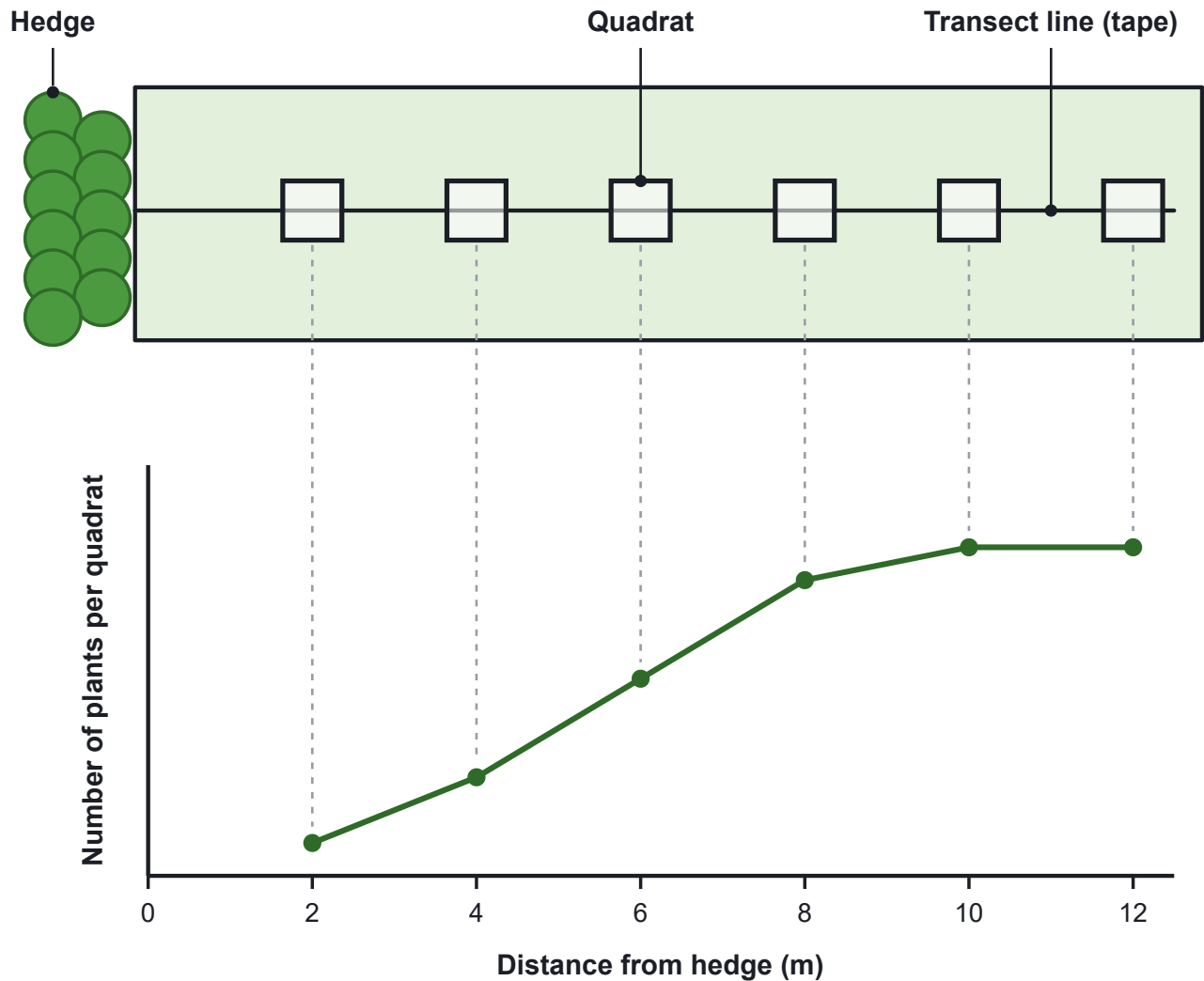
The arrows show the direction the food (biomass) goes: **from the food to the animal that eats it**.

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

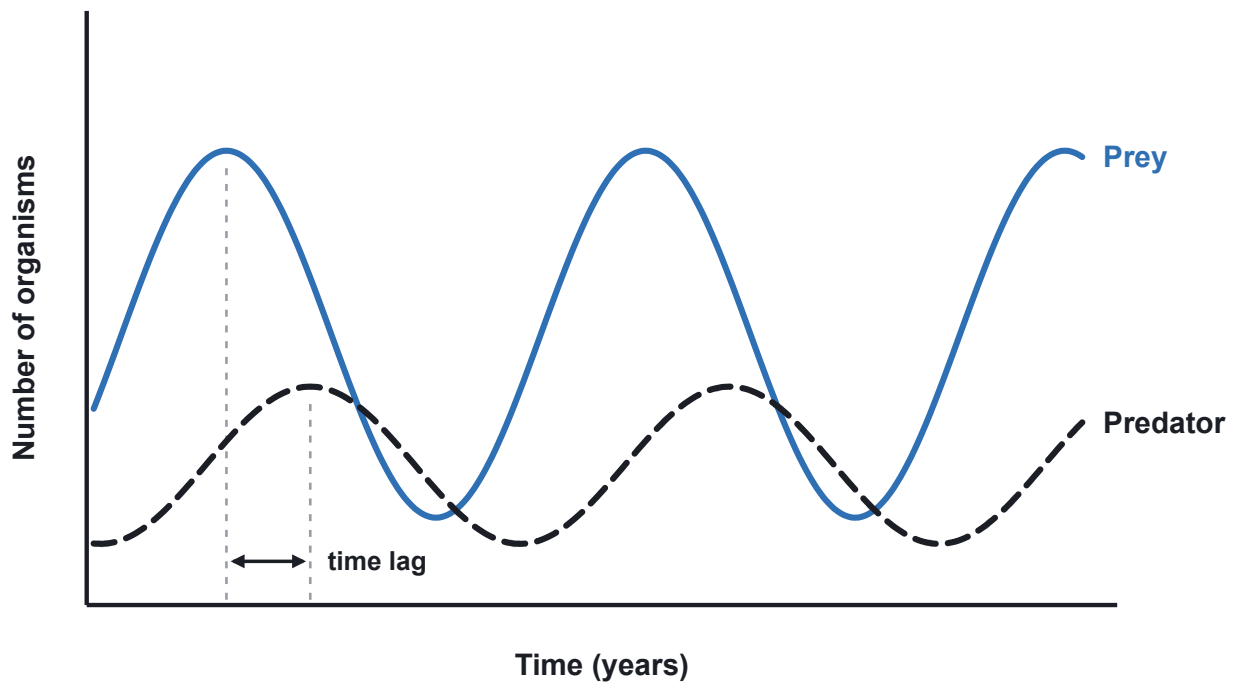
Choose a bar chart for categories such as different species, and a line graph for continuous data such as distance along a transect. Put the independent variable on the x-axis. Choose a scale that uses more than half of the grid, goes up in equal steps, and label each axis with its quantity and unit.

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.

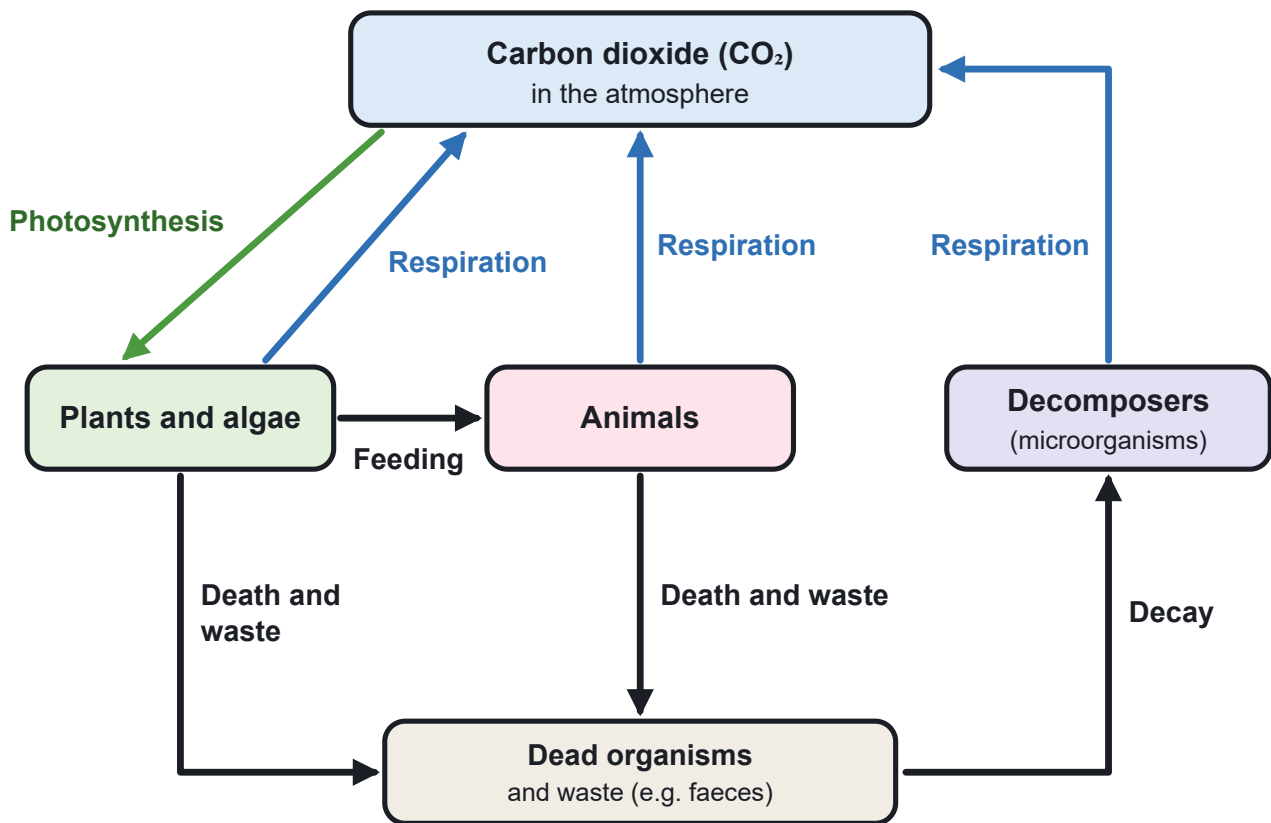
How materials are cycled Spec 4.7.2.2

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?

3 Biodiversity and the effect of human interaction on ecosystems

Spec 4.7.3

Biodiversity Spec 4.7.3.1

Biodiversity

The variety of all the different species of organisms on Earth, or within an ecosystem.

A great biodiversity ensures the **stability** of ecosystems by reducing the dependence of one species on another for food, shelter and the maintenance of the physical environment.

The future of the human species on Earth relies on us maintaining a good level of **biodiversity**. Many human activities are reducing biodiversity, and only recently have measures been taken to try to stop this reduction.

The next sections explain how waste, land use, deforestation and global warming each have an impact on biodiversity.

Exam tip: Biodiversity is about the number of different species, not the number of individuals. A field with a million of one species has low biodiversity.

Waste management Spec 4.7.3.2

Rapid growth in the human population and an increase in the standard of living mean that increasingly more resources are used and more **waste** is produced. Unless waste and chemical materials are properly handled, more **pollution** will be caused.

Where pollution can occur	
Where	Causes
In water	Sewage, fertiliser or toxic chemicals
In air	Smoke and acidic gases
On land	Landfill and toxic chemicals

Pollution kills plants and animals, which can reduce biodiversity.

Exam tip: Link the cause to the effect in two steps: pollution kills organisms, and so the number of species falls, which reduces biodiversity.

Land use Spec 4.7.3.3

Humans reduce the amount of land available for other animals and plants by **building**, **quarrying**, **farming** and **dumping waste**.

Peat bogs

The destruction of peat bogs and other areas of peat to produce garden compost reduces the area of this habitat. This reduces the variety of different plant, animal and microorganism species that live there (biodiversity).

The decay or burning of the peat releases **carbon dioxide** into the atmosphere, which contributes to global warming.

There is a conflict. People want cheap, available compost to increase food production, but peat bogs and peatlands need to be conserved as habitats for biodiversity and to reduce carbon dioxide emissions.

Exam tip: In a conflict question give both sides, then reach a conclusion, for example that using peat-free compost protects the habitat but may cost more.

Deforestation Spec 4.7.3.4

Large-scale **deforestation** in tropical areas has occurred to:

- provide land for cattle and rice fields
- grow crops for biofuels.

Environmental implications of deforestation	
Implication	Why
Loss of biodiversity	The habitat is destroyed, so many species lose their food and shelter and die out
More carbon dioxide in the atmosphere	Fewer trees means less photosynthesis, so less carbon dioxide is removed. Decay and burning of the trees release carbon dioxide
Contribution to global warming	Higher carbon dioxide levels contribute to global warming

Cleared land can provide food and fuel crops, so there is a conflict between the economic needs of people and protecting the environment.

Exam tip: To evaluate, state a benefit (land for cattle, rice or biofuel crops), then the environmental costs (less biodiversity, more carbon dioxide), then give a judgement.

Global warming Spec 4.7.3.5

Levels of **carbon dioxide** and **methane** in the atmosphere are increasing, and contribute to 'global warming'.

Some biological consequences

- Loss of habitats, for example as ice melts or as sea levels rise and flood low-lying areas.
- Changes in the distribution of species, as organisms move to cooler areas or cannot survive where they were.
- Changes in the migration patterns of animals.
- Some species may not be able to adapt or move, and may die out, which reduces biodiversity.

The evidence

The scientific consensus about global warming and climate change is based on systematic reviews of thousands of peer reviewed publications.

In a complex context the evidence can be uncertain or incomplete. The climate depends on many factors, and predictions use models, so scientists may not agree on exactly how much the temperature will change.

Exam tip: Be specific when you describe a biological consequence. 'Habitat loss' or 'species move to different areas' will score; 'bad for animals' will not.

Maintaining biodiversity Spec 4.7.3.6

Human interactions in an ecosystem can be **negative** or **positive**. You need to describe both and explain their impact on biodiversity.

Negative interactions	Positive interactions
Building, quarrying, farming and dumping waste reduce the land available	Breeding programmes for endangered species
Pollution of water, air and land	Protection and regeneration of rare habitats
Destroying peat bogs and clearing forest	Reintroduction of field margins and hedgerows in agricultural areas where farmers grow only one type of crop
Releasing more carbon dioxide and methane	Reduction of deforestation and carbon dioxide emissions by some governments
Dumping waste in landfill	Recycling resources rather than dumping waste in landfill

Scientists and concerned citizens have put in place programmes to reduce the negative effects of humans on ecosystems and biodiversity.

Programmes and how they help	
Programme	How it helps biodiversity
Breeding programmes for endangered species	Increase the numbers of a species so it does not die out
Protection and regeneration of rare habitats	Keeps the habitat and the species that depend on it
Reintroducing field margins and hedgerows	Gives shelter and food for wildlife in fields where only one crop grows, so more species can live there
Reducing deforestation and carbon dioxide emissions	Protects forest habitats and slows global warming
Recycling instead of landfill	Uses less land for dumping waste and reduces pollution

Conflicting pressures

Maintaining biodiversity is not always easy. There are **conflicting pressures**. Farmers want land for crops and animals, people need food, fuel and homes, and conservation costs money. Reducing emissions or protecting habitats may reduce profits or jobs.

Exam tip: When asked to evaluate a method, give a benefit and a drawback, using the information in the question, and then give a conclusion.

Quick check

1. Define biodiversity.
2. Name three ways humans reduce the land available for other organisms.
3. Why does destroying peat bogs add to global warming?
4. Which two gases are increasing in the atmosphere and contributing to global warming?
5. Give two programmes that help maintain biodiversity.

4 Trophic levels in an ecosystem Spec 4.7.4 Triple only

Trophic levels Spec 4.7.4.1

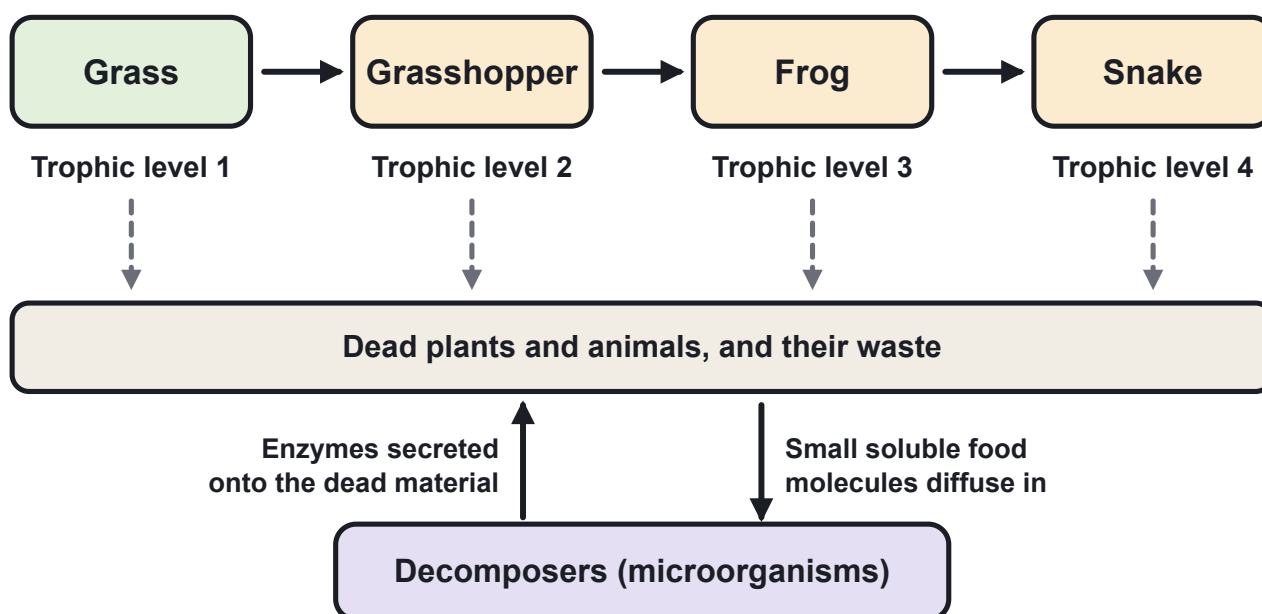
Trophic levels can be represented by numbers, starting at level 1 with plants and algae. Further trophic levels are numbered subsequently according to how far the organism is along the food chain.

Trophic level	Organisms	Name
Level 1	Plants and algae make their own food	Producers
Level 2	Herbivores eat plants and algae	Primary consumers
Level 3	Carnivores that eat herbivores	Secondary consumers
Level 4	Carnivores that eat other carnivores	Tertiary consumers

Apex predators are carnivores with no predators.

Decomposers

Decomposers break down dead plant and animal matter by secreting enzymes into the environment. Small soluble food molecules then diffuse into the microorganism.



Every trophic level ends up as dead material or waste. Decomposers **secrete enzymes** onto it, then the small soluble molecules diffuse in.

Exam tip: Decomposers secrete enzymes outside their bodies, onto the dead material. Small soluble food molecules then diffuse in. Decomposers do not take in the dead material and then digest it.

Pyramids of biomass Spec 4.7.4.2

Pyramids of biomass can be constructed to represent the relative amount of biomass in each level of a food chain. Trophic level 1 is at the bottom of the pyramid.

Each bar is narrower than the one below it, because the **biomass** decreases at each higher trophic level. This gives the pyramid shape.

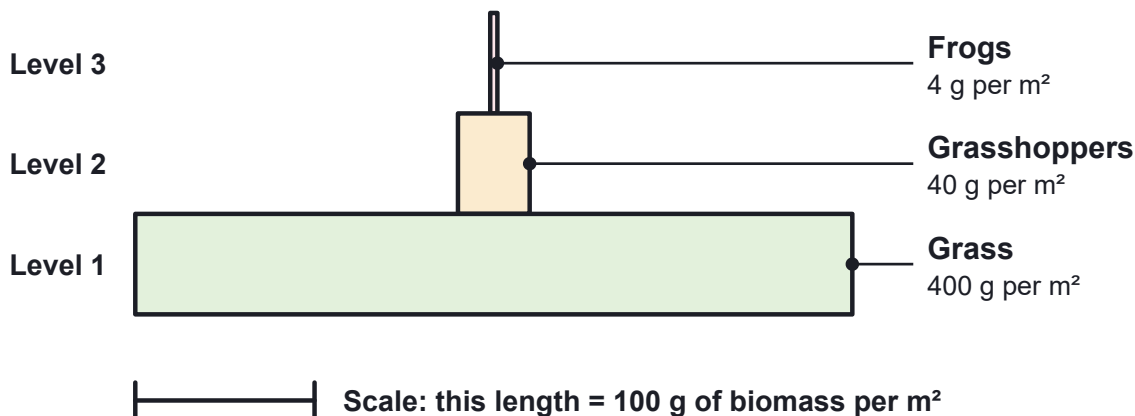
1. Draw horizontal bars, one for each trophic level, with trophic level 1 at the bottom.
2. Choose a scale so that the length of each bar is proportional to the biomass of that level.
3. Centre the bars on a vertical line and label each bar with the organism or level.

Constructing a pyramid

A food chain has biomass of 400 g per m² of grass, 40 g per m² of grasshoppers and 4 g per m² of frogs. Describe how to construct the pyramid using a scale of 1 mm = 4 g.

1. Grass: $400 \div 4 = 100$ mm long, at the bottom.
2. Grasshoppers: $40 \div 4 = 10$ mm long, above the grass.
3. Frogs: $4 \div 4 = 1$ mm long, at the top.

Answer: Three centred bars of 100 mm, 10 mm and 1 mm, with grass at the bottom and frogs at the top.



The pyramid from the worked example, drawn to scale. Each bar is about 10% of the one below it.

Transfer of biomass Spec 4.7.4.3

Producers are mostly plants and algae which transfer about 1% of the incident energy from light for photosynthesis.

Only approximately 10% of the biomass from each trophic level is transferred to the level above it.

How biomass is lost

- Not all the ingested material is absorbed. Some is egested as faeces.
- Some absorbed material is lost as waste, such as carbon dioxide and water in respiration, and water and urea in urine.
- Large amounts of glucose are used in respiration.

Efficiency of biomass transfer

efficiency (%) = biomass transferred to the next level ÷ biomass available at the previous level × 100

Efficiency of transfer

Caterpillars eat 250 g of leaves and their body mass increases by 20 g. Calculate the efficiency of biomass transfer.

1. Biomass transferred = 20 g.
2. Biomass available = 250 g.
3. Efficiency = $20 \div 250 \times 100 = 8\%$.

Answer: 8%

Maths skill: You can also be asked for efficiency as a fraction. $20 \div 250$ simplifies to $2/25$. Check which one the question asks for.

Effect on numbers of organisms

Because so much biomass is lost at each step, less biomass is available to each higher trophic level. This means fewer organisms can be supported at each higher trophic level, and food chains have only a few trophic levels.

Common mistake: Do not just say biomass is 'used up'. Name the losses: egested as faeces, lost as carbon dioxide and water in respiration, and as water and urea in urine.

Quick check

1. What is trophic level 1, and what are those organisms called?
2. What is an apex predator?
3. How do decomposers break down dead material?
4. Approximately what percentage of biomass passes to the next trophic level?
5. Give two ways biomass is lost between trophic levels.

5 Food production Spec 4.7.5 Triple only

Factors affecting food security Spec 4.7.5.1

Food security Having enough food to feed a population.

Biological factors which are threatening **food security** include:

- the increasing birth rate has threatened food security in some countries
- changing diets in developed countries means scarce food resources are transported around the world
- new pests and pathogens that affect farming
- environmental changes that affect food production, such as widespread famine occurring in some countries if rains fail
- the cost of agricultural inputs
- conflicts that have arisen in some parts of the world which affect the availability of water or food.

Sustainable methods must be found to feed all people on Earth.

Maths skill: You may be given population and food production statistics to evaluate food security. Compare how fast the population and the food supply are each increasing.

Farming techniques Spec 4.7.5.2

The efficiency of food production can be improved by **restricting energy transfer** from food animals to the environment. This can be done by:

- limiting their movement
- controlling the temperature of their surroundings.

Animals that move less and are kept warm transfer less energy to their surroundings, so more of the energy from their food is used for growth. Some animals are fed **high protein foods** to increase growth.

Modern intensive farming techniques	
Advantages	Disadvantages
More meat produced from the same amount of food, so food is cheaper	Some people have ethical objections: animals are kept in restricted, unnatural conditions
Less land is needed for the number of animals	Costs of heating, buildings and feed
Helps meet the demands of a growing population	Disease can spread quickly between animals kept close together

Exam tip: For 'evaluate', use both columns and then give a conclusion. Link ethical objections to animals' welfare, and benefits to the efficiency of energy transfer.

Sustainable fisheries Spec 4.7.5.3

Fish stocks in the oceans are declining. It is important to maintain fish stocks at a level where **breeding** continues or certain species may disappear altogether in some areas.

Method	How it helps
Control of net size	A larger mesh lets small, young fish escape. They survive, grow and breed
Fishing quotas	A limit on how much fish can be caught, so enough fish are left to breed and stocks recover

These techniques promote recovery of fish stocks and conserve them at a sustainable level.

Exam tip: Link both methods to breeding: they leave enough fish to reproduce, so the population is maintained.

Role of biotechnology Spec 4.7.5.4

Biotechnological and agricultural solutions, including genetic modification, can help meet the demands of the growing human population. Modern biotechnology techniques enable large quantities of microorganisms to be cultured for food.

Mycoprotein

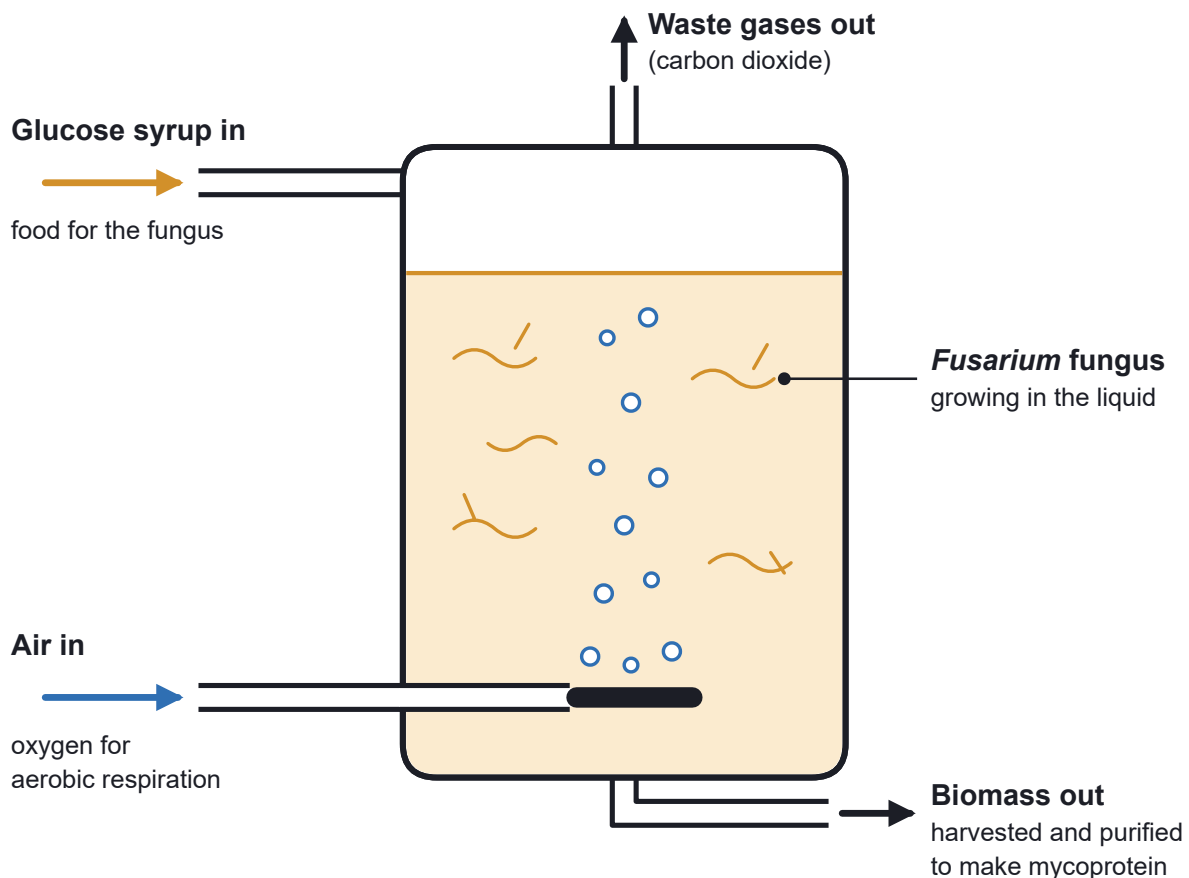
The fungus *Fusarium* is useful for producing **mycoprotein**, a protein-rich food suitable for vegetarians.

1. The fungus is grown on glucose syrup.
2. It is grown in aerobic conditions (with oxygen).
3. The biomass is harvested and purified.

Genetically modified organisms

A genetically modified bacterium produces **human insulin**. When harvested and purified this is used to treat people with diabetes.

GM crops could provide more food or food with an improved nutritional value, such as **golden rice**.



Fusarium is grown in a fermenter on **glucose syrup** in **aerobic conditions**, then the biomass is harvested and purified to make mycoprotein.

Exam tip: Link each product to its use: mycoprotein as a protein source for vegetarians, insulin to treat diabetes, and golden rice to improve nutrition.

Quick check

- 1 . Define food security.
- 2 . Why does limiting the movement of food animals increase efficiency of food production?
- 3 . Give two ways to keep fish stocks sustainable.
- 4 . What is mycoprotein and what is it grown on?
- 5 . What is produced by a genetically modified bacterium to treat diabetes?

Quick check answers

Adaptations, interdependence and competition

1. Organism, population, community, ecosystem.
2. Light, space, water and mineral ions from the soil.
3. Food, mates and territory.
4. One where all the species and environmental factors are in balance so population sizes remain fairly constant.
5. An organism that lives in very extreme conditions, such as high temperature, pressure or salt concentration.

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.

Biodiversity and the effect of human interaction on ecosystems

1. The variety of all the different species of organisms on Earth, or within an ecosystem.
2. Any three of: building, quarrying, farming, dumping waste.
3. The decay or burning of peat releases carbon dioxide into the atmosphere.
4. Carbon dioxide and methane.
5. Any two of: breeding programmes, protecting rare habitats, hedgerows and field margins, reducing deforestation and emissions, recycling.

Trophic levels in an ecosystem

1. Plants and algae, called producers.
2. A carnivore with no predators.
3. They secrete enzymes into the environment and small soluble food molecules diffuse in.
4. About 10%.
5. Egested as faeces; lost as carbon dioxide and water in respiration, and as water and urea in urine.

Food production

1. Having enough food to feed a population.
2. Less energy is transferred to the environment, so more goes into growth.
3. Control of net size and fishing quotas.
4. A protein-rich food made from the fungus *Fusarium*, grown on glucose syrup in aerobic conditions.
5. Human insulin.