Ponds are a good way of attracting animals into a garden. A pond is an example of an aquatic ecosystem (Figure 1).

**How are ecosystems organised?**

An *ecosystem* is made up of all the living organisms and physical conditions in an area. The organisms within the ecosystem are called the *community* and the area in which they live is the *habitat*. For example, in the pond ecosystem, the habitat is the pond. This includes the stones, soil and water. The community includes frogs, fish, insects, and the plants and algae living in the pond. The total number of organisms of each species is known as a *population*.

You can divide the organisms in a community into three groups:

- **Producers** – organisms that make their own food by photosynthesis. They include all plants, and algae.
- **Consumers** – organisms that cannot make their own food. They have to eat other organisms to gain energy. All animals are consumers.
- **Decomposers** are a special group of consumers. They gain their energy by feeding on dead or decaying material.

**How is energy transferred between organisms?**

Energy from the Sun is transferred by light to the chlorophyll in the cells of a producer. Here, carbon dioxide and water react to produce glucose, which stores energy within its chemical bonds. Glucose can then be converted into carbohydrates, fats, and proteins, which are used as energy stores, and for growth and repair. As an organism grows it increases its *biomass*. This is the mass of living material present.

Consumers then eat producers. When the organism respires, the energy stored in its food is transferred in the production of ATP. The organism grows and its biomass increases.

**A** State the ultimate source of energy for all living organisms.

**What is a food chain?**

A food chain displays what an organism eats. The arrows in a food chain show the transfer of biomass (and therefore energy transfer) from one organism to the next. Each step in the food chain is a *trophic level*. An example of a simple food chain is shown in Figure 2:

- **Grass** → **rabbit** → **fox**

Food chains always begin with a producer. A rabbit is a prey organism – it is eaten by another animal. A fox is a predator organism – it eats other animals.
Consumers are further classified by their position in a food chain (Figure 4).

**What is a food web?**

Food chains only show organisms eating one food source. In most communities, animals eat more than one type of organism. For example, a sparrow eats slugs, snails, and worms. To illustrate this, scientists draw food webs. These contain a series of interlinked food chains.

**B** Hedgehogs also eat slugs. State which trophic level they belong to.

**C** Using the food web shown in Figure 5, state the source of food for a beetle and an owl.

**Describing food webs**

Choose five organisms from the food web in Figure 5. For each choose the appropriate words from the list below to describe its role in the ecosystem. Can you add a sentence to explain why? Which trophic level would it belong to?

- producer
- prey
- carnivore
- consumer (primary, secondary or tertiary)
- herbivore
- predator
- omnivore

**Figure 4** Only a few food chains have more than four trophic levels in them.

**Figure 5** Woodland food web.

1. Herons are large birds. Construct a suitable food chain using these organisms: fish, heron, pond snail, pondweed. (2 marks)

2. Using your food chain:
   - a state which organism is the producer (1 mark)
   - b state which organism is the secondary consumer (1 mark)
   - c state which organism occupies trophic level 3. (1 mark)

3. Referring to the woodland food web, suggest and explain how the removal of slugs could affect other species in the food web. (6 marks)
**B4.1.2 Abiotic and biotic factors**

**Learning outcomes**
After studying this lesson you should be able to:

- state the difference between a biotic and an abiotic factor
- explain how biotic and abiotic factors can affect communities.

*Specification reference: B4.1f*

Orangutans (like those in Figure 1) are an endangered species. The main reason for this is habitat loss. Even without human interference, ecosystems are constantly changing.

Figure 1 Many conservation steps have been taken to prevent these organisms becoming extinct.

**What factors affect an ecosystem?**
The factors that affect an ecosystem can be divided into two groups:

- **Biotic factors** – the living factors. For example, in a woodland ecosystem, the presence of beech trees, squirrels, and hedgehogs are biotic factors. The numbers of these organisms are also biotic factors.

- **Abiotic factors** – the non-living (or physical) factors. Within the woodland ecosystem, abiotic factors would include the amount of rainfall received and the temperature of the ecosystem.

**A** State whether oxygen availability is an example of a biotic or abiotic factor.

Biotic factors normally refer to the interactions between living organisms, or those which have once lived. Many organisms compete for factors such as food, space, and breeding partners. Competition is therefore the most common biotic factor. For example, if a food supply is limited, this limits the number of organisms that can feed on it.

**How do abiotic factors affect communities?**

**Light intensity**
Light is required for photosynthesis. In general the greater the light availability, the greater the success of a plant.

Plants evolve to grow successfully in different light intensities. For example, in areas of low light, plants often have larger leaves.

**Temperature**
Temperature has its greatest effect on the enzymes that control metabolic reactions. Plants develop more rapidly in warmer temperatures as their metabolisms will be faster. This is also true for cold-blooded
animals (ectotherms) like lizards, which rely on the Sun to warm them up. Warm-blooded animals (endotherms) are less affected by their external environment.

B Suggest why plants that are adapted to survive in low light regions have larger leaves.

**Moisture level**

For most plant and animal species, a lack of water leads to death. For example, water is the main component of blood plasma. A lack of water causes most plants to wilt because water is required to keep their cells turgid, which keeps plants upright. Water is also required for photosynthesis.

**Soil pH**

The pH of soil affects the biological activity in soil, and the availability of certain minerals. Some plant species grow better in acidic soils (pH below 7). These include rhododendrons and ferns. Others grow better in alkaline soils (pH above 7), such as cucumbers and cauliflower.

C Explain why farmers may test the pH of their soil before planting.

### Measuring abiotic factors

Scientists use a range of measuring equipment to monitor the abiotic factors in an area, as shown in Table 1.

Copy and complete Table 1, using the following terms.
- °C
- lux
- %
- no units

<table>
<thead>
<tr>
<th>Abiotic factor</th>
<th>Sensor used</th>
<th>Example unit of measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>light intensity</td>
<td>light meter</td>
<td></td>
</tr>
<tr>
<td>availability of moisture</td>
<td>humidity sensor</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>pH probe (Figure 4)</td>
<td></td>
</tr>
<tr>
<td>temperature</td>
<td>thermometer</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Monitoring abiotic factors.

1 State two biotic and two abiotic factors in a pond ecosystem. (4 marks)

2 Describe how light level affects the species present in an ecosystem. (2 marks)

3 Explain why abiotic factors have a greater effect on plant species than they do on endothermic animal species. (4 marks)
B4.1.3 Competition and interdependence

Learning outcomes
After studying this lesson you should be able to:
- state the factors that plants and animals need to survive
- explain how predator and prey populations fluctuate in a predation relationship
- describe the difference between mutualism and parasitism.

Specification reference: B4.1g

The kangaroos in Figure 1 are boxing over a potential mate. This is an example of competition.

What is competition?
To survive, plants and animals need a number of different materials from their surroundings. If materials are limited, plants and animals have to compete for these resources. This may result in weaker competitors dying or leaving that area. Weaker plant species will often die.

What do plants need to survive?
- light
- water
- carbon dioxide
- minerals
- space

A Explain why a plant with a large amount of space has a higher chance of survival.

What do animals need to survive?
- food
- water
- breeding partners
- space (territory)
- shelter

The number of organisms of each species living in an area is known as a population. Competition has a direct effect on the size of a population. For example, if there is a large amount of food available, the population is likely to increase.

B Suggest and explain why animals require access to space to survive.

How do species interact within a community?
Scientists study how different organisms depend on each other within a community. This is known as interdependence. The interactions between organisms are known as ecological relationships. There are three main types: predation, mutualism and parasitism.

Predation
This is the name given to the relationship between a predator and a prey species. The size of the predator population directly affects the size of the prey population (see Figures 3 and 4).
Mutualism

In a mutualistic relationship, both organisms benefit from the relationship (Figure 5). For example, oxpeckers are small birds that live on buffalo. They are known as ‘cleaner species’ because they eat ticks and fleas living on the buffalo’s skin. They gain food, while the buffalo is free from irritation and potential disease.

Parasitism

In a parasitic relationship only one organism (the parasite) gains. The organism it lives off (the host) suffers. Examples include tapeworms in an animal’s digestive system, and fleas (Figure 6).

C State which is the host and which is the parasite in the relationship between a mosquito and a human.

1 Explain why plants need light to survive but animals do not. (1 mark)

2 For the following pairs of species, state what type of relationship is seen:
   a bees and flowers  
   b blackbirds and worms  
   c headlice and humans.  
   (3 marks)

3 A scientist wanted to study the predator–prey relationship between ladybirds (predator) and aphids (prey) in the laboratory. A suitable aphid population was established, and then ladybirds were added. Sketch and annotate a graph to predict how the populations of these organisms would vary over time.  
   (6 marks)

Figure 4  This famous predator–prey study was carried out in Canada using data from fur trappers who caught lynx.

Figure 3 Canadian lynx (predator) and snowshoe hare (prey).

Figure 5 These are nodules on the roots of a pea plant. They are full of nitrogen-fixing bacteria. They convert nitrogen from the air into nitrates, which plants use for growth. The bacteria also benefit because they gain sugars from the plant.

Figure 6 This cat flea (parasite) sucks blood from its host.

Go further

In the 1870s the grey squirrel was introduced into the UK from North America. Its population quickly increased, resulting in the native red squirrel disappearing from many areas. Find out why the grey squirrel is the more successful competitor.
**Learning outcomes**

After studying this lesson you should be able to:

- explain what pyramids of biomass show
- describe how biomass data is collected
- construct a pyramid of biomass.

*Specification reference: B4.1h, B4.1i*

---

The giant sequoia (Figure 1) is among the tallest (over 80 m), widest (over 10 m) and longest living (over 2000 years) organisms on Earth. It has huge biomass.

**What is a pyramid of biomass?**

Food chains show the flow of biomass through a community. However, they do not show the number of organisms involved, or the size of biomass transferred.

Pyramids of numbers show the population at each trophic level. The producer in the food chain is placed at the base, with the next trophic levels placed above. The bar width represents the number of organisms present.

The diagram is usually pyramid shaped, as one organism normally eats several organisms from the trophic level below. For example, a blue tit eats many caterpillars to survive (see Figure 2). As you move from one trophic level to the next, the size of organisms generally increases, but the number of organisms decreases.

However, not all pyramids of numbers are pyramid shaped. This is because these diagrams do not take into account the size of the organisms present. For example, one tree can support a large number of living organisms (Figure 3).

---

**Pyramids of biomass** are not usually inverted. By plotting the amount of biomass at each trophic level, you take into account both the number and size of the organisms present. Figure 4 shows the oak tree pyramid of numbers from Figure 3, as a pyramid of biomass.

---

**A** Suggest another example of a food chain that would produce an inverted pyramid of numbers.

---

**B** State which type of organism is always found at tropic level 1 of a pyramid of biomass.
How do you calculate biomass?
Scientists take samples of organisms from each trophic level. They measure the average mass of each of these organisms and multiply it by the number of organisms present to calculate the total biomass at each trophic level.

Scientists normally calculate the dry mass of an organism, as water content can vary between individuals. This requires the organisms to be killed, and dried in a kiln.

C State one disadvantage of collecting biomass data.

Drawing a pyramid of biomass
Pyramids of biomass are scale diagrams. The width of a bar represents the biomass of organisms in the trophic level.

Draw a pyramid of biomass for this data:
young oak tree 100 kg caterpillar 10 kg blue tit 1 kg sparrowhawk 0.2 kg

Step 1: Decide on a sensible scale to use to represent the biomass of each species.
1 cm = 10 kg, written as 10 kg/cm.

Step 2: Calculate the width of each bar by dividing each biomass by the scale factor.
young oak tree \( \frac{100 \text{ kg}}{10 \text{ kg/cm}} = 10 \text{ cm} \)
caterpillar \( \frac{10 \text{ kg}}{10 \text{ kg/cm}} = 1 \text{ cm} \)
blue tit \( \frac{1 \text{ kg}}{10 \text{ kg/cm}} = 0.1 \text{ cm} \)
sparrowhawk \( \frac{0.2 \text{ kg}}{10 \text{ kg/cm}} = 0.02 \text{ cm} \)

Step 3: Use these measurements to draw each bar in the pyramid. Keep the height of each bar the same.

Figure 5 Pyramid of biomass for organisms living on a young oak tree.

1 State one piece of information that can be gained from a pyramid of biomass, but not from a pyramid of numbers. (1 mark)

2 / Describe how scientists measure the biomass of a species. (3 marks)

3 A scientist collected the data in Table 1 on a food chain: Aphids are primary consumers.
   a Write the food chain for this feeding relationship. (1 mark)
   b Explain why a pyramid of numbers may be misleading for this food chain. (1 mark)
   c Complete the table and draw a pyramid of biomass, to scale, for this data. (3 marks)

Table 1 Data collected on a food chain.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Number present</th>
<th>Mass of one organism (kg)</th>
<th>Total biomass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>rose bush</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>ladybird</td>
<td>5</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>aphid</td>
<td>200</td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>
Efficiency of biomass transfer

Animals remove food they cannot digest from their bodies as faeces (e.g., the horse dung in Figure 1). This reduces the biomass available for organisms further up the food chain.

Why does biomass decrease at each trophic level?
Energy is transferred to producers by sunlight. The producers only transfer around 1% of this energy into chemical stores. Most of the light is reflected from the leaf. The proportion of the remaining energy that is transferred to chemical stores, via photosynthesis, is limited by factors such as temperature or water availability.

Up to half of the energy transferred by photosynthesis is transferred in respiration. The remaining energy is transferred in order to increase the plant’s biomass.

A State the main reason why not all energy from the Sun is transferred to chemical energy in the plant.

Consumers at each trophic level convert around 10% of the chemical energy in their food to new body tissue (see Figure 2). This is because biomass is lost when:

- Not all of an organism is eaten. For example, plant roots or animal bones may not be consumed.
- Some of the biomass is used in respiration. Respiration produces ATP; muscles then use ATP to produce movement. Respiration also causes thermal energy to transfer to the environment.

Figure 1  Horses produce large amounts of dung, which contains undigested biomass.

Figure 2  Only around 10% of the biomass eaten by this horse will get turned into new biomass.
• Some parts of an organism cannot be digested, such as hair and teeth. These are removed from the body in faeces. This is known as egestion.
• Waste products produced by the body are lost through excretion. For example, urea is lost in urine.

Not all of the organisms at the previous trophic level are eaten. Therefore their biomass is not transferred.

B State the difference between egestion and excretion.

At each stage of a food chain the amount of energy transferred becomes less. A large plant biomass can only support a small herbivore biomass. In turn, an even smaller carnivore biomass can be supported. Very few food chains have more than four trophic levels as not enough energy can be transferred to sustain life processes.

**Calculate the efficiency of biomass transfer**

Use this formula to calculate the efficiency of the biomass transfer between each trophic level of a food chain:

\[
\text{efficiency of biomass transfer} = \frac{\text{biomass available after the transfer (g or kg)}}{\text{biomass available before the transfer (g or kg)}} \times 100\%
\]

A lamb gains 12 kg in mass after consuming 150 kg of grass. Calculate the efficiency of biomass transfer.

**Step 1:** Write down the formula.

\[
\text{efficiency of biomass transfer} = \frac{\text{biomass available after the transfer (kg)}}{\text{biomass available before the transfer (kg)}} \times 100\%
\]

**Step 2:** Fill in the values and calculate the answer. Remember to include the per cent symbol.

\[
\text{efficiency of biomass transfer} = \frac{12\ kg}{150\ kg} \times 100\% = 8\%
\]

1 Explain why biomass decreases at each level in a food chain. (4 marks)

2 Sheep ticks are parasites that live on sheep. Calculate the efficiency of biomass transfer between sheep of biomass 15,000 g, and sheep ticks of biomass 90 g. (3 marks)

3 Intensively farmed pigs are kept in a warm environment, and the pigs’ movements are restricted. Explain why this maximises the rate of growth of the pigs reared. (5 marks)
B4.1.6 Nutrient cycling

Learning outcomes
After studying this lesson you should be able to:
● describe what is meant by nutrient cycling
● describe how nitrogen is cycled through the ecosystem
● describe how water is cycled through the ecosystem.

Specification reference: B4.1ia, B4.1b, B4.1c

When plants and animals die, decomposers break down their bodies (Figure 1). This releases the nutrients that they contain back into the environment where they can be used again.

What is nutrient cycling?
Plants obtain the nutrients they need for growth from the soil. These are passed onto animals when the plant is eaten. When plants lose material such as leaves, and organisms die, decomposers release the trapped nutrients. Many of the nutrients are released back into the soil, where they are absorbed by plants. Some are released into the atmosphere.

In this process materials are passed between the biotic and abiotic components of an ecosystem. This is known as nutrient cycling. It is summarised in Figure 2:

What materials are cycled?
Carbon
Carbon is one of the most common elements in organisms. It is used to make carbohydrates, fats, proteins, and DNA. It cycles between the atmosphere, living organisms, and fossil fuels. It can also become trapped in the oceans and in rocks.

A State one biotic and one abiotic component of an ecosystem that contains carbon.

![Image of decomposed animal]
Nitrogen

Nitrogen makes up nearly 80% of the atmosphere. Organisms use nitrogen to make DNA and proteins. Most organisms can only use nitrogen when it is part of a compound, such as a nitrate. Nitrogen exists in the soil as nitrates dissolved in water. The water (containing the dissolved nitrates) is taken up by the roots and the nitrates are used to make proteins. When the plant is eaten, the nitrogen compounds are passed on to an animal. When the plants and animals die, these compounds are broken down and released back into the soil as ammonia. Animals also put nitrogen back into the soil in faeces and urea (in urine).

Some plants such as peas and beans (legumes) form mutualistic relationships with nitrogen-fixing bacteria. These bacteria live in their roots and combine nitrogen from the air with oxygen to form nitrates. These are then used by the plant. This nitrogen cycle is shown in Figure 3.

**B** State one biotic and one abiotic component of an ecosystem that contains nitrogen.

Water

Water is an essential component of any ecosystem. All living organisms need to drink or absorb water to survive.

Water also determines the physical characteristics of many habitats necessary for particular organisms to survive. For example, polar bears rely on ocean ice to hunt and capture seals. Amphibians such as frogs require water to reproduce. Other organisms, such as sharks and eels, can only survive when submerged in water.

The water cycle moves water and nutrients through the atmosphere, soil, rivers, lakes, and oceans. In doing so, it brings fresh water to people, animals, and plants all around the world. As water moves through the cycle it also transports nutrients. This helps to replenish those that have been used within a habitat. The water cycle is shown in Figure 4.

**C** Explain how clouds are formed.

1. Explain why nutrient cycling is essential to maintain life. (2 marks)
2. Using named examples, state and explain three different ways that organisms use water to survive. (3 marks)
3. Pea plants and wheat are planted together in a nitrogen-poor soil. State and explain which of the plants gains the greatest proportion of biomass. (6 marks)

**Water cycle adventure**

Describe the journey of a water molecule from a river high in the mountains, through the atmosphere and eventually back to the starting point.
**B4.1.7 The carbon cycle**

**Learning outcomes**
After studying this lesson you should be able to:
- describe how carbon is removed from the atmosphere
- describe how carbon is added to the atmosphere
- explain why atmospheric carbon dioxide levels are increasing.

*Specification reference: B4.1c*

---

**What is the carbon cycle?**
The carbon cycle is the process by which carbon is cycled through the atmosphere, the Earth, plants, and animals. It is summarised in Figure 2.

---

**Figure 1** The white cliffs of Dover are made of chalk. They formed from the remains of plankton many millions of years ago. The carbon from the plankton is locked into the rock in a compound, calcium carbonate.

**Figure 2** The carbon cycle.

A Name one human activity that has altered the natural carbon cycle.

**How is carbon removed from the atmosphere?**
Carbon dioxide (CO₂) is removed from the environment during photosynthesis. This process occurs in green plants, algae, and phytoplankton (Figure 3). It converts carbon dioxide and water into glucose and oxygen.

Glucose is a simple sugar. It can be used to make complex carbohydrates such as starch, fats, and proteins. This enables plants to grow and develop. The carbon is part of their extra biomass.

When animals eat plants, carbon in the plant is transferred to the animal. Some of this carbon is used to produce fats and proteins in the animal’s body.

**B Explain how atmospheric carbon is used for plants’ growth.**

---

**Figure 3** Scanning electron micrograph (SEM) image of phytoplankton. These organisms float near to the surface of the ocean where sunlight can penetrate. They trap atmospheric carbon through photosynthesis.
How is carbon released back into the atmosphere?
Carbon is released back into the atmosphere through:

- Respiration – all living organisms respire to transfer energy from chemical stores in food. As a result, carbon dioxide is produced and released.
- Decomposition – when plants, algae and animals die decomposers break down their remains, releasing carbon dioxide as they respire.
- Burning fossil fuels – fossil fuels are a store of carbon. When they burn this trapped carbon is released (Figure 4). Fossil fuels include coal, oil, and natural gas.

Why does the level of atmospheric carbon dioxide vary?
Carbon dioxide levels vary throughout the day:

- photosynthesis only takes place in the light, so carbon dioxide is only removed from the atmosphere in the daytime
- respiration is carried out by all living organisms throughout the day and night, releasing carbon dioxide at a relatively consistent rate.

Over the past 200 years, the average atmospheric carbon dioxide concentration has increased significantly (Figure 5). This is mainly due to human activities – the combustion of fossil fuels and deforestation. These increased levels of carbon dioxide are contributing to global warming.

State one way in which bacteria take part in the carbon cycle. (3 marks)

Some fuels made from plants are 'carbon neutral', as they remove as much carbon dioxide during growth as they release once burnt.

Find out more about the use of plant-based oils as fuels, and produce a poster explaining their benefits over fossil fuels, as well as their disadvantages.
Dung beetles (Figure 1) are **detritivores**. They help to break down organic waste into small pieces. This speeds up the process of decomposition.

**What is the difference between a decomposer and a detritivore?**

Decomposers are microorganisms. These bacteria and microscopic fungi break down, or decay, dead organic material at a microscopic level. They also break down animal waste, including faeces and urine. Through decomposition nutrients are released which can then be recycled. Organisms that feed on dead material in this way are called saprophytes.

Detritivores are small animals. They speed up decomposition by shredding organic material into very small pieces. This creates a larger surface area for decomposers to work on. Table 1 shows some examples of detritivores.

**What is the difference between a decomposer and a detritivore?**

A fungus releases enzymes on to the dead remains

The enzymes digest the dead matter and make it soluble

The soluble products are absorbed by the fungus

**How do decomposers release nutrients?**

Bacteria and fungi release enzymes, which break down substances in the organic matter. They can then absorb the soluble nutrients into their bodies, and use them for growth and as an energy store (See Figure 2). Many of the bacteria and fungi may be eaten by other organisms, resulting in the nutrients being passed on. Some of the nutrients are released directly into the soil or the environment.

**Table 1** Detritivores shred a variety of organic materials.

<table>
<thead>
<tr>
<th>Detritivore</th>
<th>Material it breaks down</th>
</tr>
</thead>
<tbody>
<tr>
<td>earthworm</td>
<td>leaves</td>
</tr>
<tr>
<td>woodlouse</td>
<td>wood</td>
</tr>
<tr>
<td>maggot</td>
<td>animal material</td>
</tr>
</tbody>
</table>

**A** State the difference between a decomposer and a detritivore.

**B** Explain how microorganisms cause materials to decompose.
What factors affect the rate of decomposition?

Microorganisms decompose materials most efficiently in:

**Warm temperatures**
At high temperatures, the enzymes used by microorganisms are denatured. This prevents decomposition, and often results in the death of the microorganism.
At low temperatures, the rate of decomposition is slow as the rates of enzyme-controlled reactions are reduced. The rate of microorganism replication is also slow.

**Moist environments**
If not enough water is available, reactions within the microorganisms will slow down or be prevented. This reduces or stops the process of decomposition.

**Aerobic conditions**
Oxygen is needed for the microorganisms to respire. Anaerobic conditions will prevent most forms of decomposition as the microorganisms cannot survive in this environment.

**State three ways you could slow the rate of decomposition.**

**Calculating the rate of decay of biological material**
The proportion of a material that decays in a given period of time can be calculated from the following equation.

\[
\text{rate of decay (g/day)} = \frac{\text{change in mass (g)}}{\text{time (day)}}
\]

You can calculate how the rate of decay changes by comparing results taken at different times.

A group of students investigated the decay of bread in the laboratory. They took the data recorded in Table 2.

Compare the rate of decay of bread between the first five days, and the last five days.

**Step 1:** Write down the formula.

\[
\text{rate of decay (g/day)} = \frac{\text{change in mass (g)}}{\text{time (day)}}
\]

**Step 2:** Fill in the values for the first five days.

\[
\text{rate of decay (g/day)} = \frac{2 \text{ g}}{5 \text{ days}}
\]

**Step 3:** Calculate the rate over the first five days.

\[
\text{rate of decay (g/day)} = 0.4 \text{ g/day}
\]

**Step 4:** Repeat the calculation for the final five days.

\[
\text{rate of decay (g/day)} = 2 \text{ g/day}
\]

**Step 5:** Compare the two rates.

The rate for the last five days was five times faster than for the first five days.
Community-level systems

B4.1 Ecosystems

Summary questions

1. Match the ecological term to its definition.
   - habitat: organisms that make their own food through the process of photosynthesis
   - producer: organisms that eat other organisms to gain energy
   - consumer: the number of organisms of one species present in an area
   - population: the living organisms and physical conditions present in an area
   - ecosystem: the area in which an organism lives

2. This is a pyramid of biomass from a woodland:
   - sparrowhawk 0.2 kg
   - blue tits 1 kg
   - caterpillars 10 kg
   - young oak tree 100 kg
   a. Identify:
      i. the producer
      ii. the secondary consumer.
   b. Draw a food chain for this feeding relationship.

3. Using appropriate labels, complete the carbon cycle:

4. a. Sort the following factors into biotic and abiotic factors:
    - temperature
    - number of predators
    - light intensity
    - range of food sources
    - pH of soil
    - competition for resources
   b. Explain how the temperature of a habitat affects the organisms that inhabit the area.
   c. Sketch and annotate a typical predator–prey population graph.

5. Decomposers play an important role in the cycling of nutrients.
   a. State what is meant by a decomposer.
   b. Explain three factors that affect the rate of decomposition.
   c. Explain the role of bacteria in the nitrogen cycle.

6. This table shows some biomass data collected by students, showing the plants and animals present in a school field.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Estimated number</th>
<th>Biomass of one organism (g)</th>
<th>Total biomass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>oak tree</td>
<td>1</td>
<td>500 000</td>
<td></td>
</tr>
<tr>
<td>aphid</td>
<td>10 000</td>
<td>1 000</td>
<td></td>
</tr>
<tr>
<td>ladybird</td>
<td>200</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

   a. Suggest how the students collected the ladybird biomass data.
   b. Calculate the biomass of one organism at each trophic level and complete the data table.
   c. Calculate the efficiency of biomass transfer between aphids and ladybirds.

   Efficiency of biomass transfer (%):
   \[
   \text{Efficiency} = \frac{\text{biomass available after the transfer}}{\text{biomass available before the transfer}} \times 100\%
   \]
   d. Explain why there are rarely more than four trophic levels in a food chain.
Revision questions

1. Red squirrels and grey squirrels eat the same types of food. What name is given to this relationship?
   A competition  
   B mutualism  
   C parasitism  
   D predation  
   (1 mark)

2. Which of the following is a biotic factor?
   A food availability  
   B light intensity  
   C soil pH  
   D temperature  
   (1 mark)

3. The diagram shows a food chain.
   \[ \text{plants} \rightarrow \text{insects} \rightarrow \text{small birds} \rightarrow \text{hawk} \]
   Biomass: 40,000 g 4,000 g 800 g 80 g
   a Calculate the efficiency of biomass transfer from the plants to the hawk.
   You should show your working.  
   (2 marks)
   b Explain why there are not more trophic levels after the hawk.  
   (1 mark)
   c Not all the biomass from the plants is transferred to the hawk.
   Describe the ways biomass is lost from food chains.  
   (3 marks)

4. A student is investigating decay in bread.
   He puts four identical pieces of bread in plastic petri dishes labelled A, B, C, and D.
   He adds different amounts of water to each dish and puts lids on them. The lids are not air-tight.
   He then weighs the dishes. He leaves them in a warm place for two weeks.

5. Describe how plants are involved in the carbon cycle.  
   (4 marks)

<table>
<thead>
<tr>
<th>dish</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>mass at start (g)</td>
<td>80</td>
<td>81</td>
<td>82</td>
<td>83</td>
</tr>
<tr>
<td>mass after two weeks (g)</td>
<td>79</td>
<td>77</td>
<td>76</td>
<td>74</td>
</tr>
</tbody>
</table>

After two weeks some of the pieces of bread have mould (fungus) growing on them. The student weighs the dishes again. The table shows his results.

Which dish is most likely to have had the most mould growing on it?
Explain your answer.
Use information in the question as well as your own knowledge to help you answer.  
(6 marks)
B4.1 Ecosystems

- Describe the levels of organisation within an ecosystem.
- Describe the differences between a producer and a consumer.
- Explain how organisms are organised into food chains.
- State the difference between a biotic and an abiotic factor.
- Explain how biotic and abiotic factors can affect communities.
- State the factors that plants and animals need to survive.
- Explain how predator and prey populations fluctuate in a predation relationship.
- Describe the difference between mutualism and parasitism.

- Describe how biomass data is collected.
- Construct and analyse a pyramid of biomass.
- Explain why biomass is lost between trophic levels.
- Calculate the efficiency of biomass transfer between trophic levels.
- Explain why the number of trophic levels is limited in a food chain.

- Describe how nitrogen is cycled through the ecosystem.
- Describe how water is cycled through the ecosystem.
- Describe how carbon is added and removed from the atmosphere.
- Explain why atmospheric carbon dioxide levels are increasing.
- State some examples of decomposers.
- State what is meant by decomposition.

- Explain how environmental factors affect the rate of decomposition.
**Community-level systems**

### Pyramids of biomass

- **tertiary consumer** (carnivore)
- **secondary consumer** (carnivore)
- **primary consumer** (herbivore)
- **plants** (producers)

- Takes into account number and size of organisms in a community
- Moving up the trophic levels number of organisms generally ↑ but size ↓
- Not normally inverted like some pyramids of numbers (e.g., oak tree)

### Calculate biomass
1. Take sample of organisms at each trophic level.
2. Measure dry mass (organisms killed).
3. Multiply dry mass by number of organisms.

**Biomass decreases at each trophic level**

### Efficiency of biomass transfer
- Not all energy in sunlight → biomass in producer
- Only 10% of biomass eaten → new biomass in consumer:
  1. Not all organism eaten (e.g., bones)
  2. Biomass used in respiration → ATP → movement
  3. Some organism **egested** (e.g., teeth, hair)
  4. Waste lost via **excretion**

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**Nutrient cycling**

- **Carbon**
  - Used to make carbohydrates, fats, proteins, and DNA
  - Carbon cycle:
    - To atmosphere:
      - Respiration
      - Decomposition
      - Burning fossil fuels
    - From atmosphere:
      - Photosynthesis

- **Nitrogen**
  - Used to make DNA and proteins
  - Makes up 80% of atmosphere
  - Most organisms can only use it as nitrates:
    - Nitrate → plant (protein)
    - Animal
    - Nitrogen compounds excreted and broken down in decay

- **Water**
  - Essential to all organisms
  - Water cycle moves nutrients through ecosystems

**Decomposers**
- Microorganisms (bacteria, fungi)
- Release enzymes → break down organic matter
- Absorb nutrients
- Decomposers then eaten or nutrients released into soil

Rate of decomposition ↑ by:
1. ↑ Temperature (→ ↑ enzyme action)
2. ↑ Moisture
3. ↑ Oxygen for respiration (aerobic conditions)

**Detritivores**