10 Organisms and Their Environment

Study Station ▸▸

A Energy and Nutrient Flow

Learning Outcome

- Describe the roles of producers, consumers and decomposers in ecosystems.

1. The living organisms in an ecosystem can be categorised as **producers**, **consumers** and **decomposers**, based on their mode of nutrition.
2. Energy and nutrients are transferred from producers to consumers to decomposers through feeding.
3. The table below describes the roles of producers, consumers and decomposers in an ecosystem.

	Producers	Consumers	Decomposers
Role in the food chain	• Make their own food through photosynthesis – Chlorophyll in producers converts light energy into chemical energy. – Glucose is synthesised from carbon dioxide and water. – Oxygen is released.	• Cannot make their own food • Obtain energy and nutrients by feeding on plants or other animals	• Obtain energy by breaking down dead organisms, faeces and excretory products • Return nutrients like mineral salts to the environment.
Examples	• Plants • Algae • Photosynthetic bacteria	• **Primary consumers** (feed on plants only) • **Secondary consumers** (feed on primary consumers) • **Tertiary consumers** (feed on secondary consumers)	• Bacteria • Fungi

4. A **habitat** is the place where an organism lives.
5. A **population** is a group of organisms of the same species that live together in the same habitat.
6. A **community** is made up of populations of different species living and interacting with one another in the same habitat.
7. Organisms within a community are affected by and dependent on others (**interdependent**).
8. An **ecosystem** is a community of organisms interacting with one another and its non-living environment.

Link Discover Biology (3rd Edition) Textbook — Section 10.1

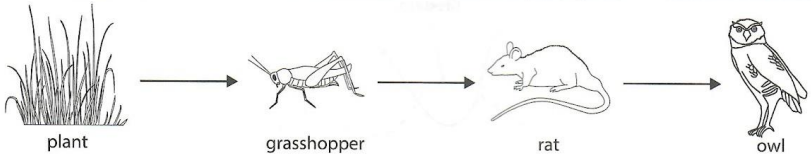
B Food Chains and Food Webs

Learning Outcome

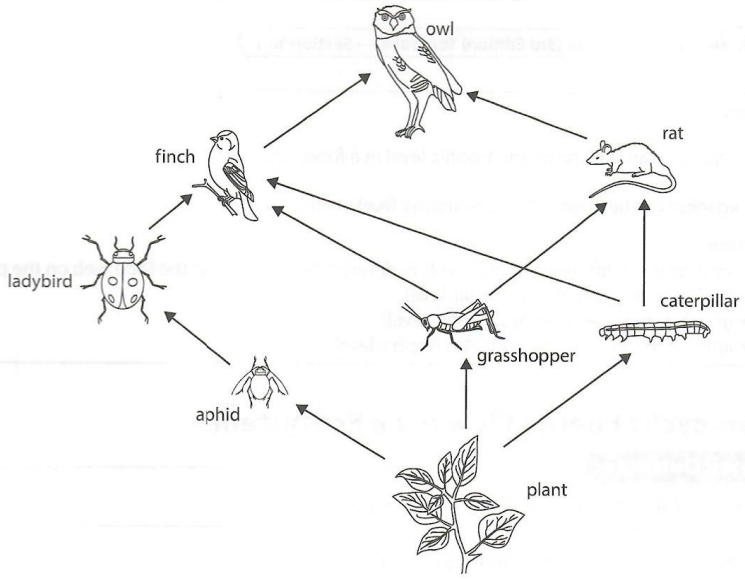
- Explain how energy is lost along food chains and discuss the efficiency of energy transfer between trophic levels.

1. A **food chain** is a series of organisms through which energy and nutrients are transferred. A food chain always begins with a producer.
2. Each stage in a food chain is called a **trophic level**.

1st trophic level	2nd trophic level	3rd trophic level	4th trophic level
Producer (green plant) →	Primary consumer (herbivore) →	Secondary consumer (carnivore) →	Tertiary consumer (carnivore)

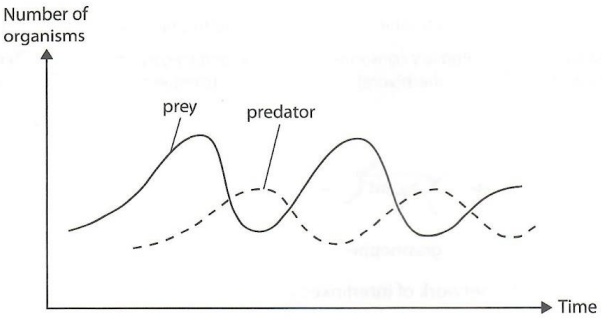


3. A **food web** consists of a network of interlinked food chains.



4. In a food web, an organism can be at more than one trophic level.
5. A **predator** is an animal that feeds on another animal. An animal that is eaten by another is called the **prey**.

6. The fluctuations of the populations of the predator and the prey can be seen in the graph below:
   - An increase in the number of prey means more food for the predators, leading to an increase in the number of predators.
   - This increase in the number of predators leads to a decrease in the number of prey as more prey are being consumed.
   - With fewer prey, there is less food for the predators leading to a decrease in the number of predators.
   - Note that the average size of the population of prey is always more than that of the predator.



Link Discover Biology (3rd Edition) Textbook — Section 10.1

Common Error

✗ An organism can only be in one trophic level in a food web.

✓ An organism can be in more than one trophic level in a food web.

Explanation
An organism may be in different trophic levels in different food chains. In the food web on the previous page, the finch is at more than one trophic level.
plant ⟶ grasshopper ⟶ finch (3rd trophic level)
plant ⟶ aphid ⟶ ladybird ⟶ finch (4th trophic level)

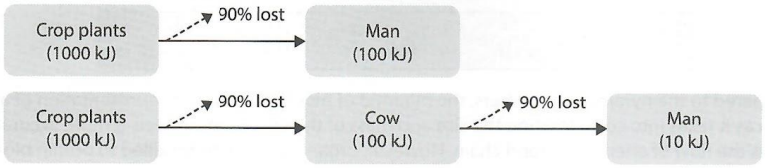
C Non-cyclic Energy Flow in an Ecosystem

Learning Outcome

- Describe the non-cyclical nature of energy flow.

1. In an ecosystem, energy flow is **non-cyclic** (linear).
2. The sun provides energy in the form of light. It is the source of energy for all ecosystems.
3. Energy from the sun is absorbed by chlorophyll in producers and transferred to chemical stores of energy in glucose during photosynthesis.
4. Energy in the producers is passed from one trophic level to another by feeding. Only some energy gets passed on to the next trophic level due to the following reasons:
   - Some energy is transferred to the environment as heat, through respiration.
   - Some energy is transferred to uneaten body parts, faeces and excretory products.

5. The chemical energy trapped in egested and excreted material and dead organisms is released through the activity of decomposers. Decomposers use some of this energy for their needs. The rest is transferred to the environment as heat.
6. The heat that is transferred to the environment cannot be recycled. Hence, the flow of energy through the ecosystem is non-cyclical.
7. Short food chains are more efficient than long food chains.
   - Since a large amount of energy does not get passed from one trophic level to the next, there will be less and less energy available as we move along the food chain.
   - A short food chain means that less energy is lost to the environment and more energy is available to the final consumer.
   - In the example below, assume that the producer received 1000 kJ of energy.
   - More energy is available to a man if he eats crop plants directly, rather than eating cows that feed on the same crop plants.



8. Food chains usually have less than five trophic levels.
   - About 90% of energy is lost from one trophic level to the next.
   - Hence, there is insufficient energy to support a long food chain.

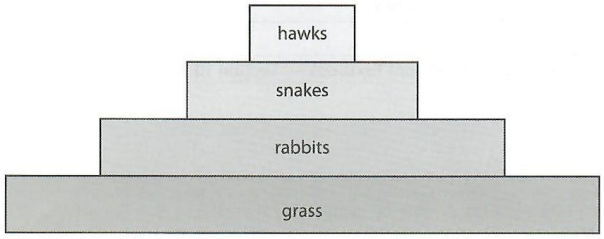
Link Discover Biology (3rd Edition) Textbook — Section 10.1

D Ecological Pyramids

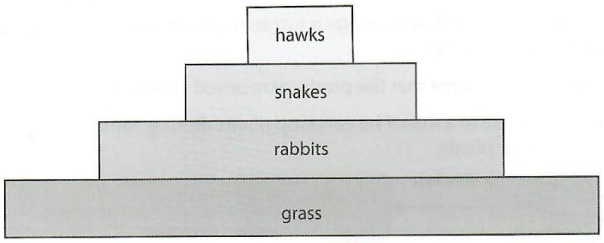
Learning Outcome

- Interpret pyramids of numbers and biomass.

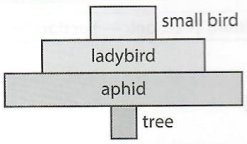
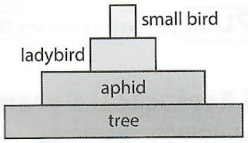
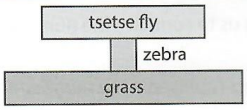
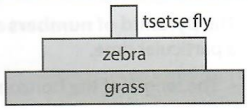
1. The food and energy relationships in food chains can be represented in the form of horizontal bars forming an ecological pyramid.
2. The **pyramid of numbers** allows us to compare the number of organisms in each trophic level at a particular time.
   - The length of the horizontal bars represents the number of organisms present.
   - Consider the food chain and corresponding pyramid of numbers:
     grass → rabbit → snake → hawk



3. The pyramid of numbers has limitations — it does not consider the size, mass or whether the organism is an adult or juvenile.
4. The **pyramid of biomass** allows us to compare the mass of organisms in each trophic level at a particular time.
   - It is constructed based on the dry mass of the organisms at any one time, that is, the mass of the organisms when all their water has been removed.
   - Consider the food chain and corresponding pyramid of numbers:
     grass → rabbit → snake → hawk



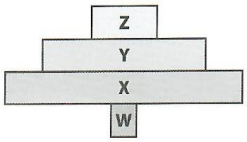
5. Compared to the pyramid of numbers, the pyramid of biomass is a better representation of a food chain as it takes into consideration the size and mass of the organisms. Hence, it more accurately shows the flow of energy in a food chain. However, organisms have to be killed to obtain biomass and the pyramid needs to be constructed at a particular point in time.
6. Most ecological pyramids are wide at the bottom and narrow at the top. Some variations are shown in the table below.

Food Chain	Pyramid of Numbers	Pyramid of Biomass
tree → aphid → ladybird → small bird	 • When many organisms of one trophic level feed on a large organism of another trophic level, the pyramid is inverted.	 • As one tree has a comparatively large biomass to support other populations, the pyramid is still broad at the bottom and narrow at the top.
grass → zebra → tsetse fly	 • The tsetse flies are parasites that suck on the blood of the zebra.	

Link — Discover Biology (3rd Edition) Textbook — Section 10.2

Worked Example 10.1

Study the pyramid of numbers shown below.



Which of the following statements about the pyramid of numbers is **not** true?

A Organism **X** is a herbivore.
B Organism **W** is likely to be a tree.
C Organism **Z** has the greatest biomass.
D Energy flows from organism **Y** to organism **Z**.

Solution

Option **C** is the correct answer.

Explanation

- The pyramid of numbers does not consider the mass of organisms.
- Organism **X** is a primary consumer and thus, a herbivore.
- The pyramid of numbers is inverted, showing that many of organism **X** feed on organism **W**. Thus, organism **W** is likely to be a tree.
- Energy flows in this way: **W → X → Y → Z**

Checkpoint 10.1

1. In the food chain below, which is the population with the highest biomass?

   grass → grasshopper → mole → weasel

   A grasshopper
   B grass
   C mole
   D weasel

Tip

Questions requiring students to understand the pyramid of biomass have appeared in the examinations. One example can be found in GCE 'O' Level Science (Biology) Oct/Nov 2017 Paper 1 Q39.

2. Refer to the food chain below:

   tree → caterpillar → sparrow → snake

   (a) Draw the pyramid of numbers and the pyramid of biomass for the food chain.

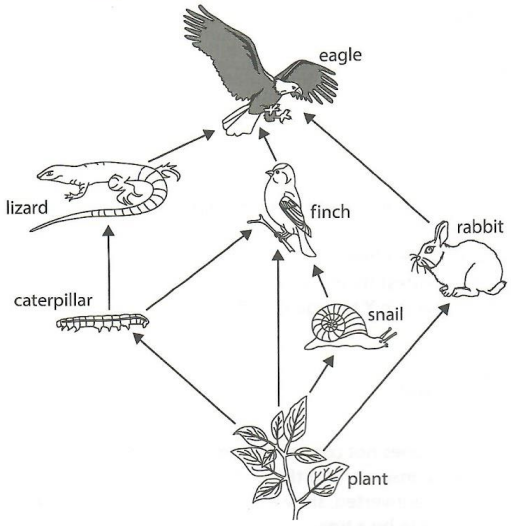
   (b) State the role of the tree in the food chain and its source of energy.

   (c) Name the primary and secondary consumers.

Tip

Questions requiring students to sketch or deduce the pyramid of numbers and biomass based on a food chain have appeared in examinations. One example can be found in GCE 'O' Level Science (Biology) Oct/Nov 2021 Paper 4 Q1.

3. Study the food web shown below.



(a) Fill in the table below using the names of the organisms in the food web.

Producer	Primary Consumer	Secondary Consumer	Tertiary Consumer

(b) Suggest what would happen to the lizard population if the caterpillar population was affected by a disease.

Tip

Questions on the roles of organisms in a food web and the effects of predator or prey fluctuations have appeared in the examinations. One example can be found in GCE 'O' Level Science (Biology) Oct/Nov 2014 Paper 4 Q5.

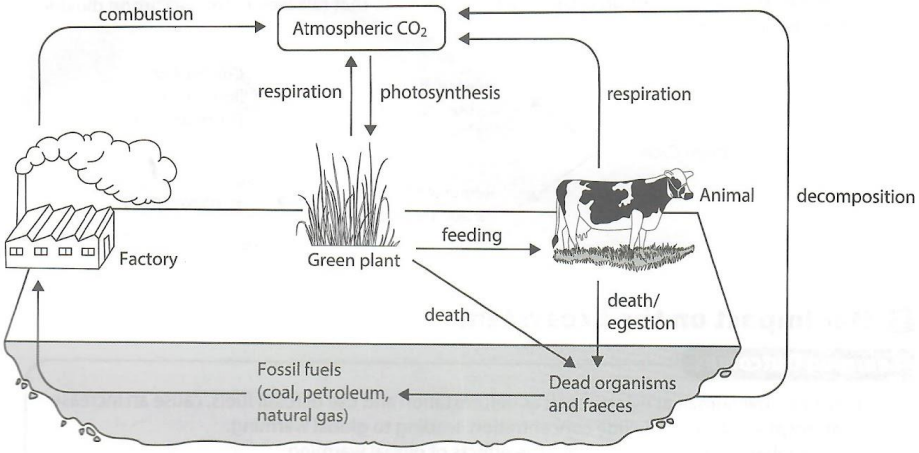
E The Carbon Cycle and Carbon Sinks

Learning Outcomes

- Describe the carbon cycle.
- Outline the role of forests and oceans as carbon sinks.

1. The **carbon cycle** is a series of processes by which carbon, in the form of carbon dioxide, is removed from and released into the environment.
2. Carbon is **removed from the environment** in the form of carbon dioxide through photosynthesis in plants.
   - Plants use carbon dioxide to synthesise carbohydrates and other carbon compounds.
   - Animals obtain carbon compounds when they feed on plants or other animals.

3. Carbon is **returned to the environment** in the form of carbon dioxide in the following ways:
   - Respiration: When plants and animals respire, they release carbon dioxide.
   - Decomposition: Decomposers release carbon dioxide when they break down dead organic matter.
   - Formation of fossil fuels and combustion: When the remains of dead plants and animals are buried in the ground, the high temperature and pressure convert them into fossil fuels. The combustion of these fossil fuels releases carbon dioxide.



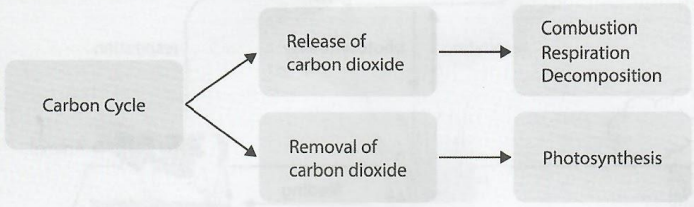
4. The carbon cycle plays an important role in the following ways.
   - Ensuring a continuous supply of carbon dioxide for photosynthesis
   - Regulating the amount of carbon dioxide in the atmosphere
   - Allowing energy to flow from one organism to the next via carbon compounds
5. A **carbon sink** is an area that stores carbon from the atmosphere for a long period of time.
   - It removes carbon dioxide from the atmosphere.
   - It stores more carbon than it releases.
6. Forests and oceans are important carbon sinks.
7. **Oceans** are the largest carbon sinks on Earth.
   - Oceans absorb one-third of the carbon dioxide released by human activities.
   - Carbon dioxide that dissolves in the ocean's water is absorbed and used by aquatic plants for photosynthesis.
   - A portion of carbon compounds is buried in the seabed in the form of fossil fuels (natural gas or oil).

8. **Forests** have a large number of plants which absorb carbon dioxide during photosynthesis.
   - Carbon compounds made during photosynthesis are stored in plants.
   - When the plants die, their remains are buried deep in the ground and form coal after millions of years.

Link Discover Biology (3rd Edition) Textbook — Sections 10.3 and 10.4

Tip

For questions on the carbon cycle, recall the processes that release or remove carbon dioxide from the environment.

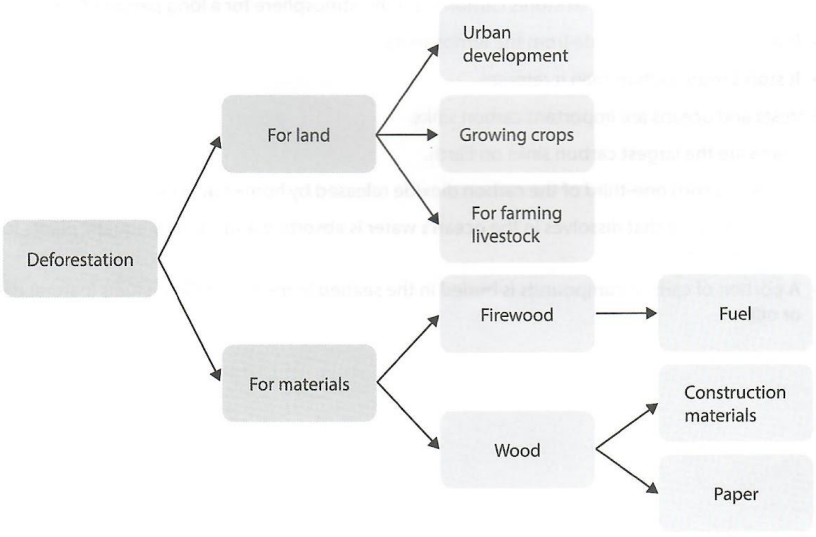


F Our Impact on the Ecosystem

Learning Outcomes

- Describe how human activities, such as deforestation and use of fossil fuels, cause an increase in atmospheric carbon dioxide concentration, leading to global warming.
- Discuss what can be done to reduce the effects of global warming.

1. Human activities such as agriculture and industry make use of Earth's natural resources. When these activities are not carefully carried out, habitat destruction through **deforestation** and **pollution** may occur.
2. **Deforestation** is the clearing of forests.
3. Forests are cleared for land and materials such as wood.

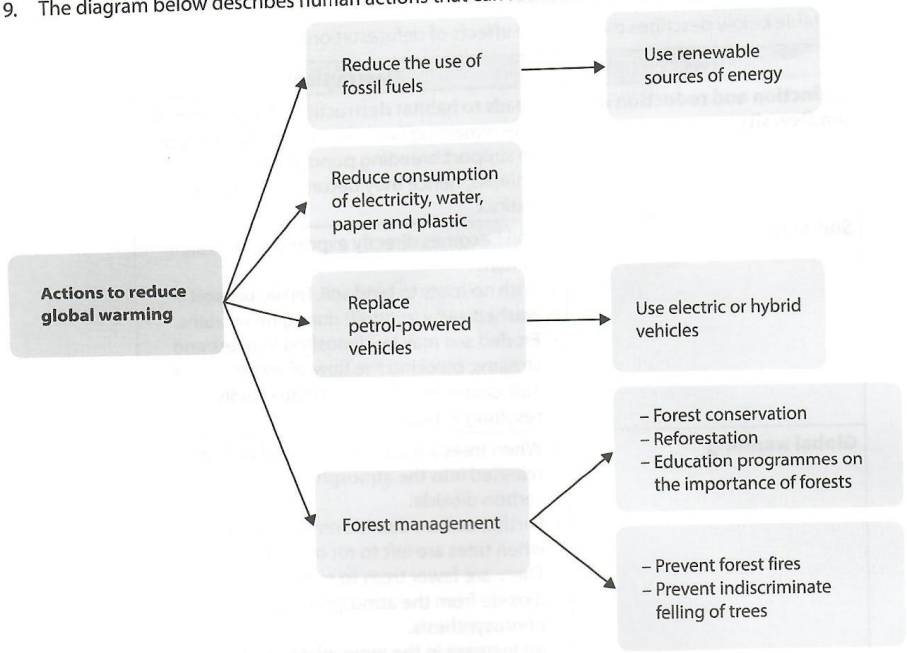


4. With the help of modern technology, forests are cleared faster than they can be replaced.
5. The table below describes the negative effects of deforestation.

Effect	Description
Extinction and reduction of biodiversity	• Leads to habitat destruction of many animals • The remaining land may not be big enough to support breeding populations of the animals, hence they become endangered or extinct.
Soil erosion	• Soil becomes directly exposed to the force of rain. • With no roots to bind soil, fertile **topsoil** is washed away (eroded) during heavy rains. • Eroded soil may be deposited in rivers and streams, blocking the flow of water. • This causes water levels to rise rapidly, resulting in floods.
Global warming	• When trees are cut down, stored carbon is released into the atmosphere as carbon dioxide. • Further carbon dioxide emissions result when trees are left to rot or are burnt. • There are fewer trees to remove carbon dioxide from the atmosphere through photosynthesis. • An increase in the atmospheric carbon dioxide concentration results in global warming.
Desertification	• Soil is directly exposed to sunlight. • Water evaporates rapidly from the soil, causing the soil to harden. • Eventually, the land becomes **barren** — plants cannot grow and thus, consumers cannot survive.

6. **Greenhouse gases** in the atmosphere such as carbon dioxide trap heat from the sun. This is the **greenhouse effect**. An increased carbon dioxide concentration in the atmosphere enhances the greenhouse effect, leading to global warming.
7. **Global warming** is a rise in global temperature. Human activities that contribute to global warming include deforestation, combustion of fossil fuels and plastic waste, and emissions from motor vehicles.
8. An enhanced greenhouse effect may result in **climate change** which refers to changes in weather patterns over a long period of time. The effects of climate change include the following:
   - Melting of ice sheets in Greenland and Antarctica leading to rising sea levels
   - Shifts in plant growth cycles, flowering and blooming times
   - Unpredictable weather changes
   - More frequent and intense hurricanes and winter storms in some areas

9. The diagram below describes human actions that can reduce the effects of global warming.



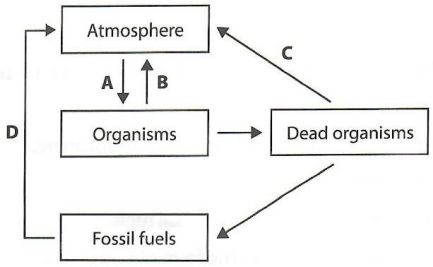
Link Discover Biology (3rd Edition) Textbook — Section 10.5

Checkpoint 10.2

1. Which of the following describes activities that directly increase and decrease the area of carbon sinks in an ecosystem?

	Activity That Increases the Area of Carbon Sinks	Activity That Decreases the Area of Carbon Sinks
A	Draining of rivers	Increasing human population
B	Increasing in human population	Planting more trees in forests
C	Clearing of land for new buildings	Increasing meat consumption
D	Planting more trees in forests	Clearing of land for new buildings

2. The diagram below shows part of the carbon cycle.



(a) Name process **A**.

(b) State the group of organisms vital for process **C**.

(c) Explain how plants and animals contribute to the removal of carbon from the environment.

(d) Name process **D**, which returns carbon dioxide to the environment.

Tip

Questions on identifying carbon sinks and the processes that make up the carbon cycle have been asked in examination questions. One example can be found in GCE 'O' Level Science (Biology) Oct/Nov 2020 Paper 4 Q8.

3. Describe how deforestation can result in

(a) soil erosion; and

(b) global warming.

Test Station ▸▸

1. Which of the following statements about carbon sinks and sources are **true**?

   1 All forests are carbon sinks.

   2 Carbon sinks remove carbon permanently from the atmosphere.

   3 Carbon sinks can become carbon sources.

   4 Carbon sinks can store carbon in the form of fossil fuels.

   5 Carbon is returned to the atmosphere in the form of carbon dioxide.

   A 1, 2, 3, 4

   B 1, 2, 3, 5

   C 1, 3, 4, 5

   D 1, 2, 3, 4 and 5

2. Figure 10.1 shows a pyramid of numbers and its corresponding pyramid of biomass in an ecosystem on land.

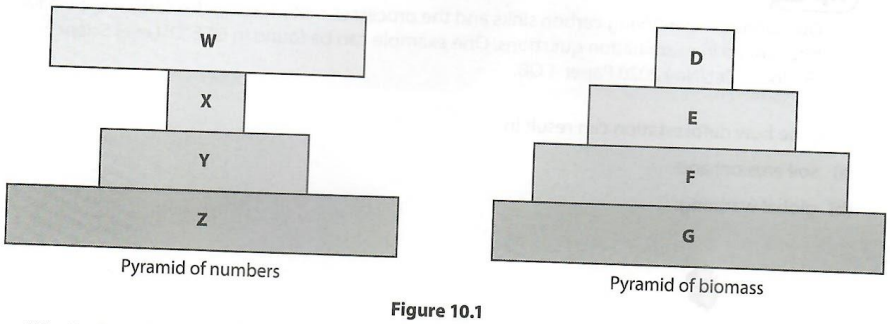


Figure 10.1

Which of the following statements are **true**?

	Pyramid of Numbers	Pyramid of Biomass
A	**Y** has the smallest body size.	**E** represents primary consumers.
B	**X** has the smallest body size.	**F** represents herbivores.
C	**W** has the smallest body size.	**G** obtains energy from the sun.
D	**X** has the largest body size.	The most energy is available at **D**.

3. Which of the following is **not** a result of deforestation?

   A Soil erosion

   B Flooding

   C Desertification

   D A decreased greenhouse effect

4. Figure 10.2 shows part of the carbon cycle.

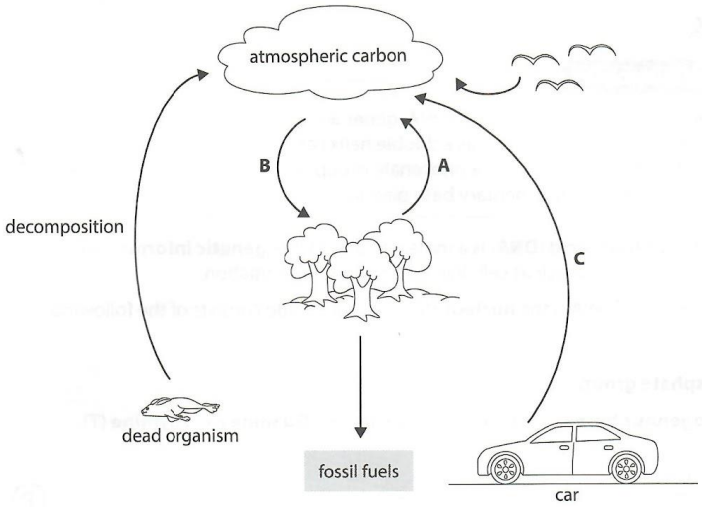


Figure 10.2

   (a) Name process **A**. [1]

   (b) Describe what happens in processes **B** and **C**. [4]

   (c) Describe the role of decomposers in the carbon cycle. [2]

5. (a) Explain why forests are carbon sinks. [2]

   (b) Explain how deforestation may lead to floods in some areas. [4]

   (c) Suggest **four** ways to manage forests and reduce deforestation. [4]