هيكل امتحان نهاية الفصل - انسباير



تم تحميل هذا الملف من موقع المناهج الإماراتية
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إعداد: عبدالرحمن عصام عيد

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المزيد من الملفات بحسب الصف التاسع العام والمادة علوم في الفصل الأول	
1	هيكل امتحان نهاية الفصل - انسباير
2	هيكل امتحان نهاية الفصل مع الحل - بريدج (محلول)
3	مذكرة هيكل امتحان نهاية الفصل بريدج
4	تجميع هيكل انسباير 2027 مع حل
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Grade 9 General Inspire

Principles of Ecology

Biodiversity and Conservation • The Nature of Science

End of Term One Exam

EOT Booklet

- Biodiversity and Conservation
- Ecosystems and Ecology
- The Nature of Science

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Q1 · Multiple-Choice Question (Electronic) · 3 marks

Interactions Among Organisms

Learning outcome: Describe the interactions among organisms (competition, predation and symbiotic relationships).

Student Book: Check Your Progress – Ex 2, 4 · p. 14

Explanation

Organisms in a **biological community** constantly interact. These interactions decide which species **survive**, how many individuals live in an area and how energy moves through the **ecosystem**.

Interaction	What happens	Effect on the two species	Example
Competition	Two organisms use the **same limited resource** (food, water, space, light) at the same time and place.	(−) / (−)	Two lions fighting over a zebra; trees competing for sunlight
Predation	One organism (**predator**) hunts, kills and eats another (**prey**).	(+) / (−)	Coyote eating a jackrabbit
Mutualism	Both species **benefit** from living together.	(+) / (+)	Lichen: alga + fungus; bees and flowers
Commensalism	One species benefits; the other is **neither helped nor harmed**.	(+) / (0)	Lichens on a tree branch; clownfish and sea anemone
Parasitism	One species (**parasite**) benefits at the expense of the **host**, usually without killing it quickly.	(+) / (−)	Ticks on a dog; tapeworms; brood parasitism by cowbirds

Key ideas

- **Symbiosis** is a close relationship in which two or more species live together: mutualism, commensalism and parasitism.
- A parasite usually does **not kill** its host, because the death of the host would also mean the death of the parasite.
- Organisms have a **range of tolerance** for each limiting factor; **temperature** is a limiting factor for polar bears – they need ice and cold water to hunt seals.

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Key Ideas from the Student Book

- **Levels of organization** (simplest → most complex): organism → population → biological community → ecosystem → biome → biosphere. The higher the level, the more organisms and the more interactions.
- **Population:** individuals of the **same species** in the same place at the same time (a school of fish). Members **compete** for the same resources; the population grows when resources are enough and **declines** when it exceeds them.
- **Biological community:** populations of **different species** that interact in the same area. **Ecosystem:** the community **+ abiotic factors** (temperature, water, light); it can be small (a pond) or large (a forest) and its boundaries can overlap.
- **Biome:** a large group of ecosystems with the **same climate** and similar communities. **Biosphere:** the highest level – all the biomes on Earth.
- **Habitat** = the area where an organism lives (its "address"). **Niche** = its role and position in the environment, including food, temperature, moisture and breeding conditions (its "job").
- Several bird species can share **one tree** because they use resources **in different ways** (insects on leaves, insects under bark, twigs for nests) – this **reduces competition**.
- **Competition** happens when more than one organism uses the **same resource at the same time**; it becomes intense when resources are **scarce** (animals at a water hole in a drought).
- **Predation:** a predator eats its prey. Farmers use beneficial predators (ladybugs, praying mantises) instead of pesticides; carnivorous plants such as the Venus flytrap trap insects.
- **Parasites** may be external (ticks, fleas) or internal (bacteria, tapeworms, heartworms). A parasite usually does **not** kill its host. **Brood parasitism:** the cowbird lays its eggs in another bird's nest.

Relationship	Organism 1	Organism 2	Example
Mutualism	**benefits (+)**	**benefits (+)**	Algae and fungi in lichens
Commensalism	**benefits (+)**	not affected (0)	Clownfish and sea anemone
Parasitism	**benefits (+)**	**harmed (−)**	Heartworms in a dog

Remember

- Population = **one species**; community = **different species**; ecosystem = community + **abiotic factors**.
- Habitat = address; niche = job.
- Mutualism (+ +), commensalism (+ 0), parasitism (+ −); competition increases when resources are few.

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Questions

Q1.1 A brown-headed cowbird lays its eggs in another bird's nest. The **host** bird feeds the cowbird chicks while its own chicks often die. Which relationship is this?

ⓐ Mutualism ⓑ Commensalism ⓒ Parasitism ⓓ Competition

Q1.2 An alga provides food for a fungus, and the fungus provides the alga with water and shelter. Which **symbiotic relationship** is shown?

ⓐ Mutualism ⓑ Parasitism ⓒ Predation ⓓ Commensalism

Q1.3 Lichens grow on the branches of a tree without harming or helping the tree. Which relationship describes the lichen and the tree?

ⓐ Parasitism ⓑ Commensalism ⓒ Mutualism ⓓ Predation

Q1.4 Two species of birds eat the same seeds in the same area during a dry season. What is the **most likely** result?

ⓐ Both populations increase
ⓑ Mutualism between the species
ⓒ Competition that limits both populations
ⓓ One species becomes a parasite

Q1.5 The coyote eats the jackrabbit. Which statement is correct?

ⓐ The coyote is the prey
ⓑ This is an example of commensalism
ⓒ Both organisms benefit
ⓓ The coyote is a predator and the jackrabbit is its prey

Q1.6 Why do **most** parasites **not** kill their **host** quickly?

ⓐ The host is always a producer
ⓑ The death of the host could also mean the death of the parasite
ⓒ Parasites do not need nutrients
ⓓ The host benefits from the parasite

Q1.7 Which factor is a **limiting factor** that **most** affects the distribution of **polar bears**?

ⓐ Low temperature and sea ice ⓑ Amount of desert sand
ⓒ Number of cacti ⓓ Height of trees

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Q1.8 A rabbit lives in a burrow in a grassland and eats grass at dawn and dusk. Which describes the rabbit's **niche** rather than its **habitat**?

ⓐ The grassland
ⓑ The burrow in the soil
ⓒ Eating grass at dawn and dusk
ⓓ The area where it lives

Q1.9 In the example shown, the tomato hornworm is infected with cocoons of a wasp. The pupating wasps will **most** likely kill their **host**. What is the type of **symbiotic relationship** in this example?

ⓐ Mutualism
ⓑ Parasitism
ⓒ Commensalism
ⓓ Predator–prey



Q1.10 In a given **biome**, a scientist studies the interactions between different populations of plants and animals. At which **level of organization** is the scientist working?

ⓐ Biological community
ⓑ Ecosystem
ⓒ Biome
ⓓ Biosphere

Q1.11 **Ecology** is the scientific discipline that studies all the interactions between:

ⓐ all the different regions of Earth
ⓑ different forms of matter on Earth
ⓒ humans and their polluting behaviors
ⓓ organisms and their environments

Q1.12 The suffix -ology comes from a word meaning to study. What is **ecology** the study of?

ⓐ organic molecules
ⓑ how organisms use sound to locate objects
ⓒ the interrelationships between organisms and their environment
ⓓ the interrelationships between single-cell organisms

Q1.13 Which of the following tasks would be completed by an **ecologist**?

ⓐ Explore the medicinal uses of nectar
ⓑ Test the effect of cyanide on algae
ⓒ Inoculate cattle against infection
ⓓ Survey and classify mollusk fossils

Q1.14 In which scientific study would an **ecologist** take part?

ⓐ observe how coral colonizes a sunken ship
ⓑ compare fossilized ant species in amber
ⓒ classify three new rain forest insect species
ⓓ assess the rabies risk of wild raccoons

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Q1.15 **Ecologists** often use modeling, instead of field studies, because it …….

ⓐ is less expensive than working in the field
ⓑ lets them study many organisms at once
ⓒ helps them collect more samples
ⓓ allows them to control all of the variables involved

Q1.16 The area between the **highest** mountain and the deepest ocean where there is life is called:

ⓐ Habitat ⓑ Biosphere ⓒ Biome ⓓ Ecosystem

Q1.17 What is the **biosphere**?

ⓐ the relatively thin layer of Earth and its atmosphere that supports life
ⓑ biological community and all the nonliving factors that affect it
ⓒ physical area where an organism lives
ⓓ all the interacting populations of different species in the same place

Q1.18 Based on your study of the concept of **ecology**, what does the picture below represent?

ⓐ Ecosystem ⓑ Biosphere
ⓒ A biome ⓓ Population



Q1.19 Based on your study of the concept of **ecology**, what do the **biotic factors** in the picture below represent?

ⓐ Biosphere ⓑ A biome
ⓒ Population ⓓ Community



Q1.20 "It includes living and non-living components in a region" is a definition of:

ⓐ The biological population ⓑ The biosphere
ⓒ The ecosystem ⓓ The biological community

Q1.21 Which of the following is the **least** complex?

ⓐ biological community ⓑ population
ⓒ biome ⓓ ecosystem

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Q1.22 Which term describes all individuals of one species that occupy a certain area?

ⓐ population ⓑ population explosion
ⓒ carrying capacity ⓓ biological community

Q1.23 Which level of organization includes all the other levels listed?

ⓐ biological community ⓑ population
ⓒ individual ⓓ ecosystem

Q1.24 Which of the following would be considered an **ecosystem**?

ⓐ bacteria living in a deep-ocean vent
ⓑ the biotic factors in a forest
ⓒ the living and nonliving things in a pond
ⓓ populations of zebras and lions

Q1.25 What is a **population**?

ⓐ a role, or position, of an organism in its environment
ⓑ group of organisms of the same species that occupy the same area at the same time
ⓒ physical area where an organism lives
ⓓ biological community and all the nonliving factors that affect it

Q1.26 What is a **biological community**?

ⓐ all the interacting populations of different species in the same place at the same time
ⓑ group of organisms of the same species in the same area
ⓒ physical area where an organism lives
ⓓ a role, or position, of an organism in its environment

Q1.27 The tree in the figure below represents the area where an organism lives and spends its life on. What is this tree called?

ⓐ Habitat ⓑ Biome
ⓒ Ecosystem ⓓ Niche



Q1.28 The area where an organism lives is called:

ⓐ community ⓑ ecosystem ⓒ house ⓓ Habitat

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Q1.29 The region of land — approximately 4 km² — a gazelle must roam to collect food would be an example of a(n):

ⓐ population ⓑ ecosystem ⓒ habitat ⓓ biome

Q1.30 What term **best** describes the bee's role of gathering pollen?



ⓐ Parasite ⓑ Niche ⓒ Predator ⓓ Habitat

Q1.31 Two leaf-eating species of animals live in a **habitat** with a severe drought, and many plants die. Which term describes the relationship the two species will probably have?

ⓐ predator-prey ⓑ competitive ⓒ abiotic ⓓ symbiotic

Q1.32 Which of the following is an example of **predation**?

ⓐ Mallard eating aquatic invertebrates
ⓑ Tick lodging in the skin of a wolf
ⓒ Clownfish protecting its anemone
ⓓ Two male rams fighting for females

Q1.33 What is **predation**?

ⓐ process in which fixed nitrogen compounds are converted back into nitrogen gas
ⓑ exchange of matter through the biosphere
ⓒ process through which nitrogen gas is converted into a form plants can use
ⓓ act of one organism feeding on another organism

Q1.34 In the figure below, which shows lichens, the algae provide food for the fungi, and the fungi provide a **habitat** for the algae.



Which term **best** describes the relationship between the two species?

ⓐ Commensalism ⓑ Mutualism
ⓒ Competition ⓓ Predation

Q1.35 The insect in the photo below is gathering pollen and nectar for food, but at the same time is aiding in the plant's reproduction.



What does this relationship demonstrate?

ⓐ Mutualism ⓑ Commensalism
ⓒ Predation ⓓ Parasitism

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Q1.36 Which of the following is an example of **mutualism**?

ⓐ Crayfish and minnows resting under the same rock
ⓑ Two snake species with similar markings advertising their toxic venom
ⓒ A peacock courting and mating with a peahen
ⓓ A fish protecting a shrimp, who builds a burrow for the pair to share

Q1.37 Clownfish swim among the stinging tentacles of sea anemones without harm. The sea anemones protect the fish from predators while the clownfish eat bits of food missed by the anemones.

Which of the following describes this relationship?

ⓐ Brood parasitism ⓑ Competition ⓒ Mutualism ⓓ Commensalism

Q1.38 The relationship between two living things in which one gains benefits at the expense of the other is called:

ⓐ commensalism ⓑ parasitism ⓒ predation ⓓ mutualism

Q1.39 A close association between two or more species that live together is called a …… relationship. It can be mutualistic, parasitic, or commensalistic.

ⓐ biosphere ⓑ food web ⓒ food chain ⓓ symbiotic

Q1.40 What is **mutualism**?

ⓐ symbiotic relationship in which one organism benefits and the other is neither helped nor harmed
ⓑ symbiotic relationship in which one organism benefits at the expense of another
ⓒ symbiotic relationship in which both organisms benefit

Q1.41 What is **commensalism**?

ⓐ symbiotic relationship in which both organisms benefit
ⓑ symbiotic relationship in which one organism benefits at the expense of another
ⓒ symbiotic relationship in which one organism benefits and the other is neither helped nor harmed

Q1.42 What is **parasitism**?

ⓐ symbiotic relationship in which one organism benefits and the other is neither helped nor harmed
ⓑ symbiotic relationship in which both organisms benefit
ⓒ symbiotic relationship in which one organism benefits at the expense of another

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Q1.43 Which level of ecological organization is the **simplest** and represents one individual (such as one fish)?

ⓐ Population ⓑ Biological community
ⓒ Organism ⓓ Ecosystem

Q1.44 What do we call a group of fish of the **same species** that live in the same place at the same time and compete for resources?

ⓐ Population ⓑ Biological community
ⓒ Biome ⓓ Biosphere

Q1.45 Which level of organization is the **highest** and includes all the biomes on Earth?

ⓐ Ecosystem ⓑ Biological community
ⓒ Biome ⓓ Biosphere

Q1.46 What term represents the "address" of an organism – the area where it lives (such as trees in a forest for birds)?

ⓐ Niche ⓑ Habitat ⓒ Biome ⓓ Commensalism

Q1.47 Zebras and gazelles gather around the same water hole to drink at the same time. What type of interaction happens between them?

ⓐ Predation ⓑ Parasitism ⓒ Competition ⓓ Mutualism

Q1.48 Lichens are a classic example of **mutualism**. Which two organisms form a lichen?

ⓐ Bacteria and worms ⓑ Fungi and algae
ⓒ Ticks and fleas ⓓ Plants and insects

Q1.49 In the **mutualism** inside a lichen, what do the **algae** provide for the fungi?

ⓐ A habitat and water ⓑ Protection from predators
ⓒ Food made by photosynthesis ⓓ Attachment to rocks

Q1.50 Which **symbiotic relationship** (+/−) benefits one organism (the **parasite**) while the other (the **host**) is harmed, as with heartworms or ticks?

ⓐ Mutualism ⓑ Commensalism ⓒ Parasitism ⓓ Competition

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Q1.51 The cowbird lays its eggs in the nests of other birds, which raise its chicks.
What type of **parasitism** is this?

ⓐ Brood parasitism
ⓑ Commensalism
ⓒ External parasitism
ⓓ Internal parasitism

Q1.52 What usually happens during a drought when water becomes scarce for many organisms?

ⓐ Organisms stop competing completely
ⓑ The weak usually die and the strong survive, or some organisms move to a place with water
ⓒ All organisms become autotrophs
ⓓ The numbers of all organisms increase

Q1.53 The Venus flytrap lives in soil that lacks one element, so it traps and digests insects. Which element is it?

ⓐ Oxygen ⓑ Carbon ⓒ Nitrogen ⓓ Hydrogen

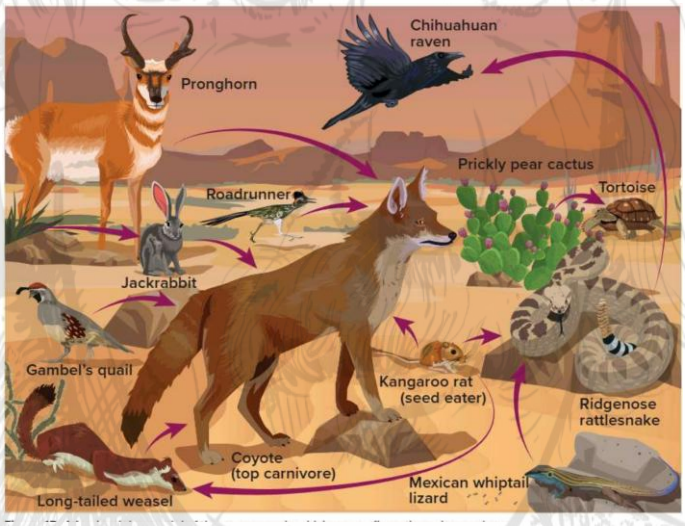


Figure 15 – *A desert food web: predation links predators (coyote, rattlesnake) with their prey.*

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Q2 · Multiple-Choice Question (Electronic) · 3 marks

Photosynthesis and Cellular Respiration

Learning outcome: Explain that cellular respiration and photosynthesis are complementary processes.

Student Book: Check Your Progress – Ex 2 · p. 18

Explanation

Photosynthesis and **cellular respiration** are **complementary** (opposite) processes: the **products** of one process are the **reactants** of the other. Together they cycle carbon and oxygen and supply energy to every step of a food chain.

∑ Formula

$$\text{Photosynthesis: } 6CO_2 + 6H_2O \xrightarrow{\text{light energy}} C_6H_{12}O_6 + 6O_2$$

∑ Formula

$$\text{Cellular respiration: } C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy (ATP)}$$

Feature	Photosynthesis	Cellular respiration
Organisms	Producers (plants, algae, some bacteria)	All living organisms (producers and consumers)
Location	Chloroplasts	Mitochondria
Reactants	Carbon dioxide + water + light energy	Glucose + oxygen
Products	Glucose + oxygen	Carbon dioxide + water + energy
Energy	**Stores** energy in glucose (chemical energy)	**Releases** energy stored in glucose
Effect on atmospheric CO_2	**Removes** CO_2	**Adds** CO_2

Energy in a food chain (Ex 2 p. 18)

- Producers use **photosynthesis** to convert light energy into chemical energy in glucose. Every organism in the chain then uses **cellular respiration** to release that energy for its life processes; some energy is **lost** as **heat** at each step.

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Key Ideas from the Student Book

- Organisms are classified by how they obtain **energy**: **autotrophs** (producers) and **heterotrophs** (consumers).
- **Autotroph:** collects energy from sunlight or from inorganic substances to make its own food (plants, algae). Autotrophs are the **foundation** of every ecosystem.
- **Photosynthesis** (in words): carbon dioxide + water → sugar (glucose) + oxygen, using light absorbed by chlorophyll.
- **Chemosynthetic bacteria** live in dark places and use hydrogen sulfide and carbon dioxide to build organic molecules.
- **Heterotroph:** gets energy by eating other organisms – **herbivores** (cow, rabbit, grasshopper), **carnivores** (wolf, lion, lynx), **omnivores** (bear, human, mockingbird).
- **Detritivores** feed on dead matter (worms, some aquatic insects). **Decomposers** (fungi, bacteria) break down dead organisms with digestive enzymes and **return nutrients** to soil, air and water.
- **Trophic level:** each step in a food chain or food web; producers form the **first** level.

	Autotroph (producer)	Heterotroph (consumer)
Energy source	Sunlight or inorganic substances	Eating other organisms
Examples	Plants, algae, some bacteria	Herbivores, carnivores, omnivores, decomposers

Remember

- Producers make their own food by **photosynthesis**; consumers eat other organisms.
- Photosynthesis changes CO_2 and water into sugar and oxygen; **cellular respiration** returns them – the two processes are **complementary**.

Questions

Q2.1 Which statement **best** explains why **photosynthesis** and **cellular respiration** are **complementary**?

ⓐ Both processes occur only in animals
ⓑ The products of one process are the reactants of the other
ⓒ Both processes release oxygen
ⓓ Both processes need light

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Q2.2 Which pair of substances are the **reactants** of **cellular respiration**?

ⓐ Glucose and oxygen
ⓑ Carbon dioxide and water
ⓒ Oxygen and water
ⓓ Glucose and carbon dioxide

Q2.3 Which organelle is the site of **photosynthesis**?

ⓐ Mitochondrion ⓑ Nucleus ⓒ Chloroplast ⓓ Ribosome

Q2.4 Which organisms carry out **cellular respiration**?

ⓐ Only animals
ⓑ Only plants
ⓒ Only decomposers
ⓓ Both producers and consumers

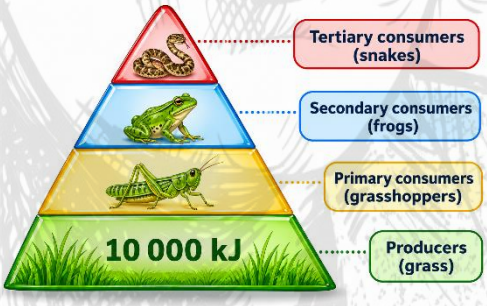
Q2.5 How does **energy** move through each step of a **food chain**?

ⓐ Photosynthesis stores light energy in glucose, and cellular respiration releases it for each organism
ⓑ Cellular respiration produces light energy for the next level
ⓒ Energy is recycled back to the Sun
ⓓ Consumers carry out photosynthesis

Q2.6 A plant is placed in a sealed jar in bright light. Which change is expected in the jar's air after several hours?

ⓐ CO_2 increases and O_2 decreases
ⓑ O_2 increases and CO_2 decreases
ⓒ Both gases stay the same
ⓓ Both gases decrease

Q2.7 The **energy pyramid** shows the **energy** available to the **producers**. How much energy is available to the **primary consumers** (?)



ⓐ 10 000 kJ ⓑ 1000 kJ ⓒ 100 kJ ⓓ 10 kJ

Q2.8 Using the same pyramid, how much **energy** reaches the **tertiary consumers (snakes)**?

ⓐ 1000 kJ ⓑ 100 kJ ⓒ 10 kJ ⓓ 1 kJ

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Q2.9 What is the category of the **grasshopper** in the **food chain**: plant → grasshopper → mouse → snake?

ⓐ Carnivore ⓑ Omnivore ⓒ Detritivore ⓓ Herbivore

Q2.10 Studying the **energy** flow of an **ecosystem**, if **autotrophs** are removed from an ecosystem, what is the likely impact on **heterotrophs**?

ⓐ Heterotrophs may face a shortage of food and energy, leading to population declines
ⓑ Heterotrophs would find alternative sources of energy and remain unaffected
ⓒ Heterotrophs would increase in number due to the lack of competition
ⓓ There would be no impact on heterotrophs since they produce their own food

Q2.11 Which of the following is an **autotroph**?

ⓐ Sparrow ⓑ Wolf ⓒ Alga ⓓ Mushroom

Q2.12 Which of the following is an **autotroph**?

ⓐ falcon ⓑ mosses ⓒ fox ⓓ cat

Q2.13 Which of the following is a product of the **photosynthesis** process?

ⓐ Carbon dioxide ⓑ Nitrogen ⓒ Water vapor ⓓ Oxygen

Q2.14 Which of the following is a product of **photosynthesis**?

ⓐ chlorophyll ⓑ water vapor ⓒ sugar ⓓ carbon dioxide

Q2.15 In the figure below, the lynx is about to consume a deer. Which type of **heterotrophs** is the lynx?



ⓐ Carnivore ⓑ Herbivore
ⓒ Omnivore ⓓ Detritivore

Q2.16 In the figure below, which of the following are considered as **heterotrophs biotic factors**?



ⓐ B and C ⓑ C and D ⓒ A and D ⓓ A and C

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Q2.17 Which of the following is an example of **omnivores**?

ⓐ Worms ⓑ Lions ⓒ Mockingbirds ⓓ Wolves

Q2.18 Which of the following is an example of **omnivores**?

ⓐ snakes ⓑ bears ⓒ eagles ⓓ wolves

Q2.19 To which group of **heterotrophs** does the mouse belong?

ⓐ omnivore ⓑ carnivore
ⓒ detritivore (scavenger) ⓓ herbivore

Q2.20 Which of the following is a **decomposer**?

ⓐ Frogs ⓑ Plants ⓒ Mice ⓓ Fungus

Q2.21 Which of the following is a **detritivore** (scavenger)?

ⓐ cat ⓑ mouse ⓒ shrimp ⓓ sunflower

Q2.22 How can **detritivores** be beneficial to the environment?

ⓐ rid waste and dead matter ⓑ provide food for autotrophs
ⓒ facilitate photosynthesis in plants ⓓ allow predation to occur

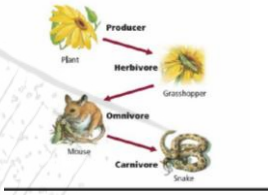
Q2.23 A doctorfish grazing on ocean algae is an example of a **heterotroph** that is an **herbivore**.

ⓐ True ⓑ False

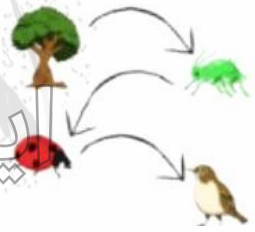
Q2.24 The figure below represents a **food chain**.

Which of the following represents the **second trophic level**?

ⓐ The grasshopper ⓑ The mouse
ⓒ The plants ⓓ The snake



Q2.25 The picture below refers to:



ⓐ only consumers ⓑ Trophic levels
ⓒ food web ⓓ food chain

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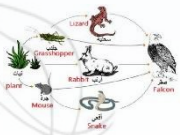
Q2.26 What is a **trophic level**?

ⓐ chemical substance organisms obtain from the environment
ⓑ model that shows many interconnected food chains
ⓒ each step in a food chain or food web
ⓓ simplified model that shows a single path for energy flow

Q2.27 In the **food chain**: phytoplankton → krill → penguin → seal, which organism is at the **third trophic level**?

ⓐ phytoplankton ⓑ penguin ⓒ krill ⓓ seal

Q2.28 How many food chains are there in the **food web** shown below?

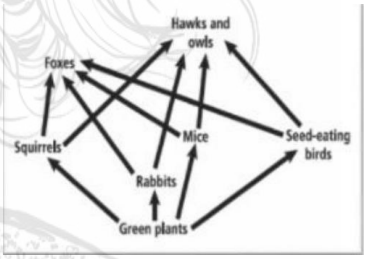


ⓐ 4 ⓑ 5 ⓒ 6 ⓓ 7

Q2.29 Which of the following is a weakness of traditional food webs when they are applied to complex ecological problems?

ⓐ Trophic levels are not taken into account when creating a food web
ⓑ Food webs do not account for non-native species in the environment
ⓒ The many food chains of a food web make it too complicated to use
ⓓ A food web does not represent all the links in an actual ecosystem

Q2.30 Use the illustration below to answer the following question:
What happens to the **energy** that the fox uses for maintaining its body **temperature**?



ⓐ It stays in the fox through the metabolism of food
ⓑ It is taken up by decomposers that consume the fox
ⓒ It moves into the surrounding environment
ⓓ It travels to the next trophic level when the fox is eaten

Q2.31 In the same **food web**, which organisms have the **greatest biomass**?

ⓐ green plants ⓑ foxes ⓒ hawks and owls ⓓ rabbits

Q2.32 Food chains, food webs and **ecological pyramids** are models used to show ……

ⓐ symbiotic relationships ⓑ the levels of organization
ⓒ how energy moves through ecosystems ⓓ types of ecosystems

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Q2.33 What does the below figure represent?



ⓐ Pyramid of Numbers ⓑ Pyramid of Biomass
ⓒ Pyramid of Energy ⓓ Biogeochemical cycle

Q2.34 Only ……% of **energy** gets passed on from one **trophic level** to the next:
ⓐ 10% ⓑ 20% ⓒ 50% ⓓ 5%

Q2.35 The models used to represent trophic levels in **ecosystems** are called:
ⓐ food chain ⓑ Relationship between organisms
ⓒ food web ⓓ Ecological pyramids

Q2.36 What is released at each level of a **pyramid of energy**?
ⓐ plants ⓑ decomposers ⓒ heat ⓓ animals

Q2.37 The total **mass** of living **matter** at each **trophic level** is called its …….
ⓐ abiotic factors ⓑ biomass ⓒ food chain ⓓ biotic factors

Q2.38 How does **energy first** enter a pond **ecosystem**?
ⓐ Through the growth of algae ⓑ Through sunlight
ⓒ Through decomposition of dead fish ⓓ Through runoff from fields

Q2.39 Which statement about **energy** in an **ecosystem** is **correct**?
ⓐ Energy levels increase toward the top of the food chain
ⓑ Energy flows from heterotrophs to autotrophs
ⓒ Energy is usually released as light from the ecosystem
ⓓ Energy in most ecosystems originates from the Sun

Q2.40 A snake feeds on mice, frogs and birds. Which type of **heterotroph best** describes the snake?
ⓐ Herbivore ⓑ Omnivore ⓒ Carnivore ⓓ Detritivore

Q2.41 In the absence of sunlight, which inorganic substance do some bacteria use to produce **energy** and food?
ⓐ Dead organic compounds ⓑ Pure oxygen
ⓒ Plant leaves ⓓ Hydrogen sulfide

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Q2.42 What term describes an organism that obtains its **energy** by eating other organisms?

ⓐ Autotroph
ⓑ Consumer (heterotroph)
ⓒ Primary producer
ⓓ First trophic level

Q2.43 How do fungi and bacteria (**decomposers**) break down dead organic **matter**?

ⓐ By secreting digestive enzymes outside their bodies
ⓑ By photosynthesis
ⓒ By preying on other organisms
ⓓ By absorbing sunlight directly

Q2.44 In an **energy**-flow model, where do the trophic levels (**except** the **first**) get their energy from?

ⓐ From the level after them
ⓑ From the level before them
ⓒ Directly from sunlight
ⓓ From rocks and minerals

Q2.45 Which statement is **correct**?

ⓐ Humans are autotrophs and the basis of all ecosystems
ⓑ Without decomposers and detritivores, the biosphere would fill with dead organisms
ⓒ The giraffe is an omnivore
ⓓ In photosynthesis plants change oxygen and water into carbohydrates and release CO_2

Q2.46 What is the simple model that shows how **energy** moves along **one path only** from one organism to another?

ⓐ Biogeochemical cycle
ⓑ Ecological pyramid
ⓒ Food web
ⓓ Food chain

Q2.47 In a **food chain** drawing, what do the arrows between organisms point to?

ⓐ The organism that receives the energy
ⓑ The organism that loses the energy
ⓒ The direction of the wind
ⓓ The nonliving factors

Q2.48 Which model is more complex and realistic because it shows overlapping food chains and many **energy** pathways?

ⓐ Water cycle
ⓑ Pyramid of numbers
ⓒ Food web
ⓓ Food chain

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Q2.49 According to the "10% rule" in the **pyramid of energy**, what percentage of **energy** passes to the next **trophic level**?

ⓐ 90% ⓑ 10% ⓒ 50% ⓓ 100%

Q2.50 In the **pyramid of energy**, what happens to the remaining **energy** that does **not** pass to the next level?

ⓐ It becomes fresh water
ⓑ It is lost as heat or used in life processes
ⓒ It becomes nitrogen gas
ⓓ It is stored in rocks

Q2.51 Which **ecological pyramid** shows the total **mass** of living **matter** at each **trophic level**?

ⓐ Pyramid of biomass ⓑ Pyramid of numbers
ⓒ Pyramid of energy ⓓ Pyramid of water

Q2.52 What happens to the number of organisms and to **biomass** as we move up an **ecological pyramid**?

ⓐ Producers disappear completely
ⓑ They stay the same at all levels
ⓒ They increase greatly
ⓓ The number decreases and biomass decreases because energy is lost

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Q3 · Multiple-Choice Question (Electronic) · 3 marks

The Carbon Cycle

Learning outcome: Describe the carbon cycle and the processes that move carbon between the biotic and abiotic parts of an ecosystem.

Student Book: Check Your Progress – Ex 1, 2 · p. 24

Explanation

Matter is **not** used up – it is **recycled** through **biogeochemical cycles** between the **biotic** (living) and **abiotic** (non-living) parts of the biosphere. The four important cycles are the **water**, **carbon/oxygen**, **nitrogen** and **phosphorus** cycles (Ex 1 p. 24).

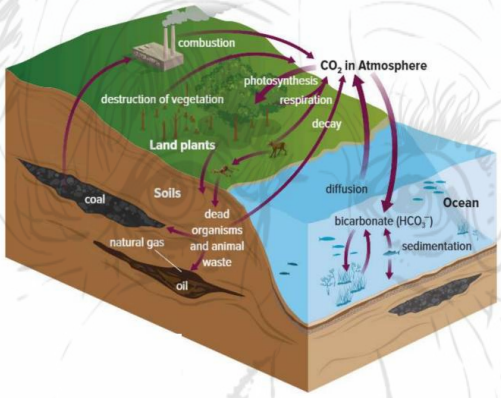


Figure 19 – Carbon and oxygen cycle through land, ocean and atmosphere.

Process	Direction of carbon
Photosynthesis	CO_2 in the atmosphere / water → **into producers** (glucose)
Cellular respiration	Glucose in organisms → **CO_2 released** to the atmosphere
Decomposition (decay)	Dead organisms and wastes → CO_2 returned to air and soil
Combustion (burning)	Fossil fuels and wood → **large amounts of CO_2** released
Fossil-fuel formation (long-term cycle)	Dead organisms buried under pressure → coal, oil, natural gas
Diffusion / sedimentation in oceans	CO_2 dissolves in water → bicarbonate; shells → limestone rock

⚠ Human impact

- Burning fossil fuels and **destruction of vegetation** add CO_2 to the atmosphere faster than photosynthesis can remove it, which increases atmospheric CO_2.

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Key Ideas from the Student Book

- **Law of conservation of mass:** matter is **not** created or **destroyed**, so it must be **recycled** in the biosphere.
- **Matter:** anything that takes up space and has mass. **Nutrient:** a chemical substance an organism needs to sustain life (water, carbon, nitrogen, phosphorus).
- **Biogeochemical cycle:** the exchange of matter through the biosphere, involving living organisms (bio), geological processes (geo) and chemical processes (chemical).
- Grass takes matter from air, soil and water; it moves to a cow when the cow eats the grass. **Decomposers return nutrients** to the cycle at every trophic level. **Energy** enters from the Sun through producers.
- **Photosynthesis removes CO_2** from the atmosphere; **cellular respiration** returns it – both are basic parts of the carbon cycle.

How do human activities upset this balance?

Human activity	Cycle affected	Result
Burning fossil fuels (industry, homes, cars)	Carbon and oxygen	**Carbon stored for millions of years is released → more CO_2 in the atmosphere**
Cutting down trees and plants	Carbon	**Less photosynthesis → less CO_2 removed from the air**
Too much chemical fertilizer	Nitrogen	**More nitrates in water → more algae growth**
Polluting water	Water	**Less fresh water suitable for organisms**

Remember

- Matter is **not** created or **destroyed**, so it **cycles** in biogeochemical cycles.
- Burning fossil fuels and cutting trees **increase** CO_2 in the atmosphere.

Questions

Q3.1 Which process **removes carbon dioxide** from the atmosphere?

ⓐ Combustion ⓑ Cellular respiration
ⓒ Photosynthesis ⓓ Decomposition

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Q3.2 Which of the following is **not** one of the four **main** biogeochemical cycles?

ⓐ Water cycle ⓑ Nitrogen cycle ⓒ Phosphorus cycle ⓓ Energy cycle

Q3.3 Which process releases carbon that was stored for millions of years?

ⓐ Combustion of coal, oil and natural gas
ⓑ Photosynthesis by land plants
ⓒ Diffusion into the ocean
ⓓ Formation of sediments

Q3.4 What is the role of **decomposers** in the **carbon cycle**?

ⓐ They convert light energy into chemical energy
ⓑ They break down dead organisms and return CO_2 to the environment
ⓒ They store carbon in rocks
ⓓ They produce fossil fuels directly

Q3.5 Analyze the roles of **photosynthesis** and **cellular respiration** in the **carbon cycle**. Which statement is correct?

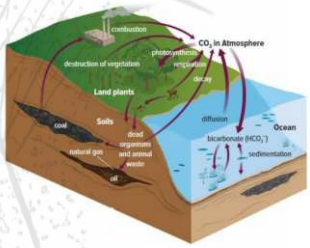
ⓐ Both remove carbon from the atmosphere
ⓑ Both add carbon to the atmosphere
ⓒ Photosynthesis removes CO_2 from the air, while respiration returns CO_2 to the air
ⓓ Respiration stores carbon in limestone

Q3.6 Carbon in the shells of marine organisms can become limestone. This is part of the …

ⓐ short-term carbon cycle ⓑ long-term carbon cycle
ⓒ nitrogen cycle ⓓ water cycle

Q3.7 What could be the environmental impact of disrupting the **carbon cycle** through **increased carbon dioxide emissions**?

ⓐ A decrease in global temperatures due to the greenhouse effect
ⓑ An increase in the growth of plants due to excessive carbon dioxide
ⓒ An increase in biodiversity caused by climate change
ⓓ A decrease in the carbon long-term cycle in the bicarbonate form



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Q3.8 What is **matter**?

ⓐ the ability to do work
ⓑ a combination of two or more substances that keep their properties
ⓒ anything that takes up space and has mass
ⓓ a pure substance formed when two or more atoms combine

Q3.9 Iron, water, and sugar are examples of **matter** that are **nutrients**.

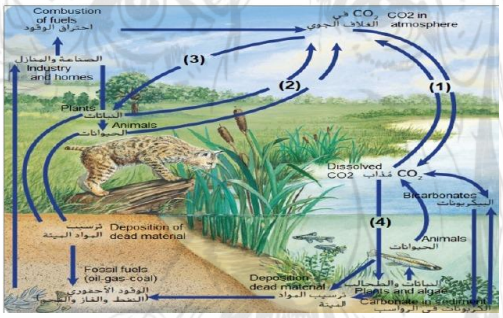
ⓐ True ⓑ False

Q3.10 Which is part of the **biogeochemical cycle**?

ⓐ solar radiation traveling to Earth ⓑ helium gas escaping into space
ⓒ carbon trapped on the ocean floor ⓓ lava flowing from an active volcano

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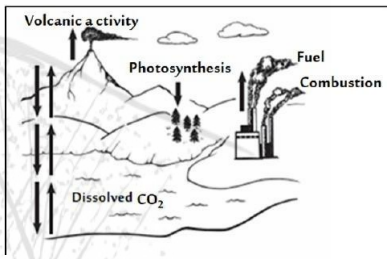
Q3.11 The figure below is an illustration of the carbon and oxygen cycles.
Which of the following refers to the process of **photosynthesis**?



ⓐ 1 and 2 ⓑ 2 and 3 ⓒ 3 and 4 ⓓ 4 and 2

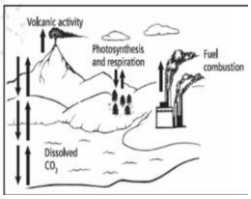
Q3.12 Which part of the diagram below relates to carbon moving from an **abiotic** to a **biotic** part of the **ecosystem**?

ⓐ Dissolved CO_2 ⓑ Fuel combustion
ⓒ Volcanic activity ⓓ Photosynthesis



Q3.13 Which part of the diagram below relates to carbon leaving a long-term cycle?

ⓐ Dissolved CO_2
ⓑ Volcanic activity
ⓒ Fuel combustion
ⓓ Photosynthesis and respiration



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Q3.14 How is carbon released from calcium carbonate?

ⓐ burned as fossil fuels
ⓑ by a process of erosion
ⓒ by decomposition
ⓓ by a process of diffusion

Q3.15 The white cliffs of Dover (calcium carbonate) are part of which cycle?

ⓐ the long-term carbon and oxygen cycle
ⓑ the water cycle
ⓒ the short-term carbon cycle
ⓓ the nitrogen cycle

Q3.16 What are the two **main** biological processes in which carbon and oxygen enter and leave living things?

ⓐ coal formation and photosynthesis
ⓑ fuel combustion and forest fires
ⓒ death and decay
ⓓ photosynthesis and respiration

Q3.17 Which process is related to the long-term recycling of **matter** in the **biosphere**?

ⓐ decomposition of organic matter by decomposers
ⓑ formation of food compounds used by organisms
ⓒ formation of minerals and weathering of rocks
ⓓ movement of fresh water from land to water bodies by runoff

Q3.18 What is the negative effect of building the Glen Canyon Dam on the water of the Colorado River and its native fish?

ⓐ The water temperature rose to 50 °C all year
ⓑ The water stayed constant and cold (7–10 °C), threatening three native fish species with extinction
ⓒ The river dried up completely
ⓓ Native fish increased because the temperature was constant

Q3.19 What environmental problem is caused by an increase in nitrates in waterways from chemical fertilizers?

ⓐ River water freezes
ⓑ Algae grow excessively in the waterways
ⓒ Evaporation stops
ⓓ All nitrogen-fixing bacteria are killed

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Q3.20 How does burning **fossil fuels** (coal, oil and gas) in industry and homes affect the **carbon cycle**?

ⓐ It increases oxygen production
ⓑ It traps carbon in limestone
ⓒ It decreases CO_2 in the air
ⓓ It increases CO_2 in the atmosphere

Q3.21 In a forest **food web**, what happens to the **consumers** (gray squirrels and moles) if oak trees are cut down or become diseased?

ⓐ They are negatively affected and decline because they lose their food source and habitat
ⓑ They increase because they no longer need trees
ⓒ They become autotrophs
ⓓ The food web is not affected at all

Q3.22 What is the **scientific law** stating that **matter** is **not** created or destroyed but is recycled to support **ecosystem** functions?

ⓐ Law of conservation of mass
ⓑ 10% rule for energy
ⓒ Trophic level model
ⓓ Mutualism

Q3.23 In the short-term carbon and oxygen cycle, which two complementary biological processes cycle carbon and oxygen between living things?

ⓐ Weathering and erosion
ⓑ Percolation and transpiration
ⓒ Evaporation and condensation
ⓓ Photosynthesis and cellular respiration

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Q4 · Multiple-Choice Question (Electronic) · 3 marks

Modeling Photosynthesis in Carbon Cycling

Learning outcome: Use a model to describe the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere and geosphere.

Student Book: Check Your Progress – Ex 5, 6 · p. 24

Explanation

A **model** (diagram, flowchart or equation) shows how carbon atoms move between the four spheres of Earth. Photosynthesis is the **entry point** of carbon into living things; cellular respiration, decomposition and combustion return it.

Sphere	Where carbon is found	How carbon enters / leaves
Atmosphere	Carbon dioxide gas (CO_2)	Leaves by **photosynthesis**; enters by respiration, decay, combustion
Biosphere	Glucose and other organic molecules in organisms	Enters by photosynthesis; passes along food chains by **feeding**
Hydrosphere	Dissolved CO_2 and bicarbonate (HCO_3^-) in oceans	Diffusion between air and water; used by algae
Geosphere	Fossil fuels, limestone and soil	Burial and sedimentation; released by combustion and weathering

Flow of energy and matter in a food web that begins with algae (Ex 6 p. 24)

- **Matter** (carbon, nitrogen, phosphorus) **cycles**: algae → small consumers → larger consumers → decomposers → nutrients back to the water for algae.
- **Energy flows in one direction**: sunlight → algae → consumers, and about 90% is **lost as heat** at each step. Energy is **not recycled**.

Phosphorus (Ex 5 p. 24): rocks weather → phosphate in soil and water → absorbed by plants → passed to animals by feeding → returned by decomposers. In the long-term cycle it forms sediments and new rock.

Key Ideas from the Student Book

- **Carbon** forms the backbone of proteins, carbohydrates and fats; **oxygen** is needed in many life processes.
- **Photosynthesis:** plants and algae change CO_2 and water into carbohydrates and release oxygen. **Cellular respiration** returns CO_2 when carbohydrates are used for energy.

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- **Long-term carbon cycle:** buried organic matter becomes peat, coal, oil and gas (**fossil fuels**); burning them releases carbon and raises CO_2 in the air.
- Carbon and oxygen combine with calcium to form **calcium carbonate ($CaCO_3$)** in shells of coral and molluscs; the White Cliffs of Dover trap carbon until the rocks are weathered.
- **Water cycle:** evaporation → condensation (clouds) → precipitation → runoff and groundwater; **transpiration** from plants gives about 10% of water vapour (90% comes from oceans, lakes and rivers). Only about 3% of Earth's water is fresh, and 69% of it is frozen in ice caps.
- **Nitrogen** is part of proteins; its largest store is the atmosphere, but plants and animals **cannot** use N_2 directly. **Nitrogen fixation** (nitrogen-fixing bacteria or lightning) changes N_2 into compounds plants use; fertilizers also add nitrogen.
- Plants turn nitrogen compounds into proteins; consumers get them by eating plants. Wastes and dead organisms are changed by decomposers into **ammonia**. **Denitrification:** soil bacteria change nitrogen compounds back into N_2.
- **Phosphorus:** short-term cycle (soil and water → producers → consumers → decomposers) and long-term cycle (sediments form rock → slow **weathering**). Phosphorus is a **limiting factor** for producers.

	Nitrogen fixation	Denitrification
Change	N_2 gas → compounds plants can use	Nitrogen compounds → N_2 gas
Done by	Nitrogen-fixing bacteria, lightning	Soil bacteria

Remember

- Photosynthesis takes in CO_2 and releases O_2; respiration and combustion return CO_2.
- Carbon is stored for a long time in **fossil fuels** and **limestone ($CaCO_3$)**.
- Phosphorus: short cycle through living things, long cycle through rocks and weathering.

Questions

Q4.1 In a model of the **carbon cycle**, which arrow should connect the **atmosphere** to the **biosphere**?

ⓐ Combustion ⓑ Photosynthesis ⓒ Respiration ⓓ Decay

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Q4.2 In a **food web** beginning with algae, what happens to **matter** and **energy**?

ⓐ Both matter and energy are recycled
ⓑ Matter flows one way and energy is recycled
ⓒ Matter is recycled, while energy flows in one direction and is lost as heat
ⓓ Neither matter nor energy moves

Q4.3 How does carbon move from the **hydrosphere** to the **geosphere**?

ⓐ Photosynthesis by land plants
ⓑ Combustion of fuels
ⓒ Shells and sediments form limestone on the ocean floor
ⓓ Transpiration

Q4.4 Through which process does phosphorus become available to land plants again after it forms rock?

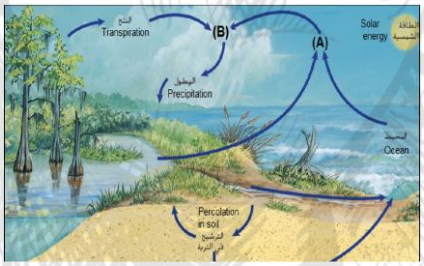
ⓐ Weathering and erosion of rocks
ⓑ Photosynthesis
ⓒ Nitrogen fixation
ⓓ Evaporation

Q4.5 Which model **best** represents the movement of carbon through a simple **food chain**?

ⓐ CO_2 → grass → rabbit → fox → decomposers → CO_2
ⓑ Fox → rabbit → grass → Sun
ⓒ O_2 → fox → rock
ⓓ Water → Sun → grass

Q4.6 The figure below is an illustration of the **water cycle**.

What do the letters (A) and (B) represent?



ⓐ (A): Evaporation and (B): Condensation
ⓑ (A): Condensation and (B): Evaporation
ⓒ (A): Lake and (B): Runoff
ⓓ (A): Runoff and (B): Lake

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Q4.7 Where is the **largest** percentage of Earth's fresh water found?

ⓐ groundwater ⓑ lakes and rivers
ⓒ ice caps and glaciers ⓓ the atmosphere

Q4.8 About what percentage of water vapor comes from **transpiration** by plants?

ⓐ 10% ⓑ 50% ⓒ 90% ⓓ 3%

Q4.9 Which organisms capture atmospheric nitrogen for the process of **nitrogen fixation**?

ⓐ Fungi ⓑ Plants ⓒ Animals ⓓ Bacteria

Q4.10 What is the name of the process in which bacteria and lightning convert nitrogen into compounds that are useful to plants?

ⓐ denitrification ⓑ nitrate cycling
ⓒ nitrogen fixation ⓓ ammonification

Q4.11 What process involves the capture and conversion of nitrogen into a form usable by plants?

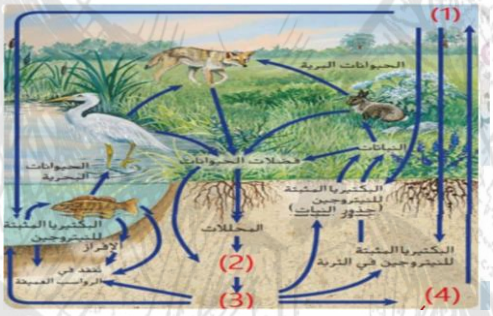
ⓐ phosphate cycle ⓑ nitrogen fixation
ⓒ condensation ⓓ denitrification

Q4.12 The process of changing nitrates to nitrogen gas is called:

ⓐ Denitrification ⓑ Nitrogen fixation
ⓒ Ammonification ⓓ Nitrogen cycle

Q4.13 The figure below is an illustration of the **nitrogen cycle**. Nitrogen is used and reused as it is cycled continuously through the **biosphere**.

What does the number (4) refer to?



ⓐ Denitrifying bacteria ⓑ Nitrifying bacteria
ⓒ Atmospheric nitrogen ⓓ Soil nitrates

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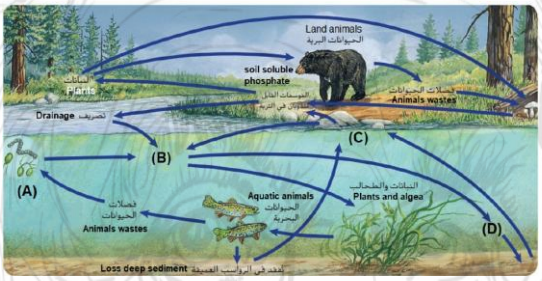
Q4.14 In the **nitrogen cycle**, which type of organisms break down nitrogen compounds in dead organisms and recycle them into the soil?

ⓐ green plants ⓑ autotrophs ⓒ bacteria ⓓ herbivores

Q4.15 The phosphorus has a short-term cycle and a long-term cycle.
Which of the following returns the phosphorus to the soil?

ⓐ Land animals ⓑ Rainwater ⓒ Decomposers ⓓ Photosynthesis

Q4.16 The figure below is an illustration of the **phosphorus cycle**.
What do the letters (A) and (B) represent?



ⓐ (A): Decomposers and (B): Phosphates in solution
ⓑ (A): Phosphates in solution and (B): Decomposers
ⓒ (A): Rocks and minerals and (B): Precipitates
ⓓ (A): Precipitates and (B): Rocks and minerals

Q4.17 Which process locks phosphorus in a long-term cycle?

ⓐ Organic materials buried at the bottom of oceans
ⓑ Rain eroding mountains
ⓒ Animals and plants eliminating wastes
ⓓ Phosphates released into the soil

Q4.18 Which of the following has both a short-term and a long-term cycle?

ⓐ water ⓑ oxygen ⓒ phosphorus ⓓ nitrogen

Q4.19 Which process locks phosphorus in the **long-term** cycle?

ⓐ Phosphate moving into soil
ⓑ Burial of organic matter on the ocean floor
ⓒ Animals and plants eliminating wastes
ⓓ Weathering of mountain rocks

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Q4.20 In which process does water evaporate from the surfaces of plant leaves into the atmosphere (about 10% of water vapour)?

ⓐ Precipitation ⓑ Percolation ⓒ Condensation ⓓ Transpiration

Q4.21 Where is **most** of Earth's fresh water (about 69%) found?

ⓐ Lakes and rivers
ⓑ Groundwater
ⓒ Ice caps and glaciers
ⓓ Water vapour in the atmosphere

Q4.22 How does phosphorus move from the long-term cycle (rocks) back to the short-term cycle (soil and water)?

ⓐ Through lightning in the atmosphere
ⓑ Through weathering and erosion of rocks over a long time
ⓒ Through burning fossil fuels
ⓓ Through transpiration from leaves

Q4.23 Why is phosphorus a **limiting factor** for the growth of **producers**?

ⓐ It exists in small amounts in soil and water
ⓑ It is a toxic gas in the air
ⓒ Plants do not need it
ⓓ It always changes into nitrogen gas

Q4.24 What term describes a chemical substance that an organism must obtain from its environment to carry out life processes?

ⓐ Nutrient
ⓑ Biogeochemical cycle
ⓒ Law of conservation of mass
ⓓ Runoff

Q4.25 In the **water cycle**, in which process does water vapour change into clouds?

ⓐ Evaporation ⓑ Precipitation ⓒ Percolation ⓓ Condensation

Q4.26 In which process does water seep into the ground to form groundwater?

ⓐ Transpiration ⓑ Condensation ⓒ Runoff ⓓ Percolation

Q4.27 Which element forms the **backbone** of important biological molecules (proteins, carbohydrates, fats)?

ⓐ Carbon ⓑ Phosphorus ⓒ Nitrogen ⓓ Sulfur

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Q4.28 The exchange of **matter** through the **biosphere** between the **biotic** and **abiotic** parts is called …

ⓐ Biogeochemical cycles ⓑ Matter
ⓒ Weathering ⓓ Nutrients

Q4.29 Where is the **largest** concentration of nitrogen found?

ⓐ Animals ⓑ Plants ⓒ Bacteria ⓓ The atmosphere

Q4.30 Which element is found in proteins and has its **greatest** concentration in the atmosphere?

ⓐ Carbon ⓑ Nitrogen ⓒ Phosphorus ⓓ Sulfur

Q4.31 How does carbon enter the long-term cycle and become trapped underground for millions of years?

ⓐ Through lightning
ⓑ Through transpiration from leaves
ⓒ Through burial of organic matter that changes into fossil fuel
ⓓ Through respiration of organisms

Q4.32 Which compound forms the shells of molluscs and corals and is a long-term store of carbon?

ⓐ Hydrogen sulfide ⓑ Calcium carbonate
ⓒ Nitrogen gas ⓓ Water vapour

Q4.33 Besides soil bacteria and chemical fertilizers, which natural phenomenon has enough **energy** to change nitrogen gas into nitrates that fall with rain?

ⓐ Runoff ⓑ Lightning (electric storms)
ⓒ Melting ice caps ⓓ Desert winds

Q4.34 What is the **largest** source of water vapour in the atmosphere, providing about 90% through **evaporation**?

ⓐ Plant leaves ⓑ Oceans ⓒ Ice caps ⓓ Groundwater

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Q5 · Multiple-Choice Question (Electronic) · 3 marks

What Is Biodiversity?

Learning outcome: Define biodiversity and identify its three types.

Student Book: Get It? · p. 31

Explanation

Biodiversity

- **Biodiversity** is the **variety of life** in an area, determined by the number of different species in that area. It increases the **stability** of an ecosystem and contributes to the health of the biosphere.

Type	Meaning	Example
Genetic diversity	The variety of **genes or inherited traits** within a population of one species.	Different coat colours of ladybird beetles; varieties of corn
Species diversity	The **number of different species** and the relative abundance of each species in a community.	Giraffes, zebras and antelope at one water hole
Ecosystem diversity	The variety of **ecosystems** in the biosphere.	Arctic coast, tropical rainforest, desert, coral reef



Figure 2 – Many species gather at a water hole: high species diversity.

Species diversity is not evenly distributed

- Species diversity generally **increases** toward the equator; tropical regions have more species than the poles.

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Key Ideas from the Student Book

- **Extinction:** an entire species disappears permanently when its last member **dies**; it **reduces** the variety of species and **threatens** the health of the biosphere.
- **Biodiversity:** the variety of life in an area, determined by the **number of different species**. It increases ecosystem **stability**.
- **Genetic diversity:** the variety of genes or inherited traits in **one population** (Asian ladybird beetles of different colours may also differ in disease resistance).
- **Species diversity:** the number of different species and the relative abundance of each species in a community (giraffes, zebras and gazelles at a water hole).
- Species diversity is **not evenly distributed**: bird diversity increases from the poles (Alaska) toward the equator (Central America).

	Genetic diversity	Species diversity
Level	Within one species (population)	Among different species in a community
Example	Different colours of ladybird beetles	Giraffes, zebras and gazelles at a water hole

Remember

- Biodiversity types: **genetic**, **species**, **ecosystem**.
- Species diversity increases toward the **equator**.

Questions

Q5.1 Which of the following **best** defines **biodiversity**?

ⓐ The number of individuals of one species
ⓑ The variety of life in an area
ⓒ The amount of energy in a food chain
ⓓ The total mass of producers

Q5.2 The variety of **genes** within a **population** of one species is called …

ⓐ species diversity
ⓑ ecosystem diversity
ⓒ genetic diversity
ⓓ population density

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Q5.3 In Figure 2, several kinds of animals drink at the same water hole. Which type of **biodiversity** does this show?

ⓐ Genetic diversity ⓑ Species diversity
ⓒ Ecosystem diversity ⓓ Population size

Q5.4 A region contains deserts, mangroves, mountains and coral reefs. This region has high …

ⓐ ecosystem diversity ⓑ genetic diversity
ⓒ species abundance ⓓ limiting factors

Q5.5 Where is **species diversity** generally **greatest** on Earth?

ⓐ Near the poles ⓑ Near the equator ⓒ On ice sheets ⓓ In deep caves

Q5.6 Which **type of biodiversity** is seen in the figure?

ⓐ Genetic diversity ⓑ Plane diversity
ⓒ Species diversity ⓓ Ecosystem diversity



Use **Figure 3 – Distribution of Bird Species** to answer the next three questions.

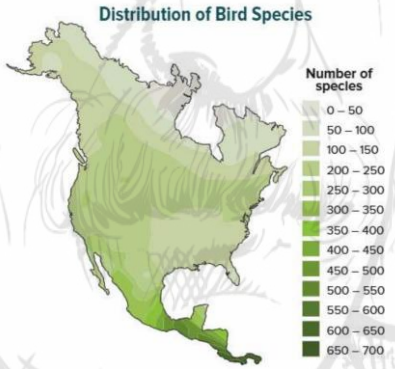


Figure 3 – As you move toward the tropics, biodiversity increases.

Q5.7 Using Figure 3, what is the number of bird species in **southern Florida**?

ⓐ 0 – 50 species ⓑ 50 – 100 species
ⓒ 100 – 150 species ⓓ 150 – 200 species

Q5.8 Using Figure 3, where is the **greatest** diversity of bird species found?

ⓐ Canada ⓑ Costa Rica
ⓒ Mexico ⓓ The United States

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Q5.9 Which statement about the distribution of bird species in North and Central America is correct?

ⓐ Biodiversity increases as we move from the polar regions toward the equator
ⓑ Biodiversity increases as we move from the equator toward the polar regions
ⓒ Biodiversity decreases as we move from the polar regions toward the equator
ⓓ Biodiversity is evenly distributed in the biosphere

Q5.10 What do we call the permanent disappearance of an entire species from the **biosphere** when its last member dies?

ⓐ Genetic diversity
ⓑ Extinction
ⓒ Biological magnification
ⓓ Ecological succession

Q5.11 How does **species diversity** change as we move geographically through the **biosphere**?

ⓐ It decreases toward the equator
ⓑ It is evenly distributed everywhere
ⓒ It increases from the polar regions toward the equator
ⓓ It increases only in frozen regions like Alaska

Q5.12 According to the lesson, what are the **three** types of **biodiversity**?

ⓐ Genetic diversity, species diversity and ecosystem diversity
ⓑ Producers, consumers and decomposers
ⓒ Water, carbon and nitrogen cycles
ⓓ Competition, predation and parasitism

Q5.13 What role does **biodiversity** play in the environment?

ⓐ It threatens the food web
ⓑ It increases ecosystem stability and protects the biosphere
ⓒ It prevents plants and animals from reproducing
ⓓ It causes species to disappear

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Q6 · Multiple-Choice Question (Electronic) · 3 marks

Biodiversity Within a Species and Resilience

Learning outcome: Explain how biodiversity within a species (genetic diversity) increases the resilience of populations.

Student Book: Check Your Progress – Ex 1 · p. 36

Explanation

Genetic diversity gives a population many different traits. When the environment changes (new disease, drought, temperature change), some individuals are likely to carry traits that let them **survive and reproduce**. This makes the population **resilient** – able to **recover** after a disturbance.



Figure 5 – Teosinte contains genes that resist viral diseases; they were used to produce virus-resistant commercial corn.

High genetic diversity	Low genetic diversity
Some individuals resist disease or change	All individuals may be affected the same way
Population can adapt and recover	Population may decline or become extinct
Reservoir of genes for future needs (medicine, crops)	Fewer options for breeding and medicine

Why sustaining biodiversity is essential (Ex 1 p. 36)

- Biodiversity supports life on Earth: it provides food, medicines, clean air and water, and keeps ecosystems **stable**. Preserving genetic diversity keeps a **reservoir of genes** that might be needed in the future.

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Key Ideas from the Student Book

- **Genetic diversity within a species:** individuals differ in genes and inherited traits (colour, disease resistance, ability to use a new food).

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- When the environment changes, a disease spreads or the old food source disappears, individuals with suitable traits **survive and reproduce**, so the species **continues**.
- **Low genetic diversity** makes all individuals alike, so all are affected by the same problem and the species may become **extinct**.

Situation	High genetic diversity	Low genetic diversity
A new disease spreads	Some resistant individuals survive	All individuals may die
Food source disappears	Some individuals adapt to a new food	Weak chance of survival
Continuity of the species	Greater chance	Risk of extinction

Remember

- Genetic diversity gives some individuals traits that help them **survive and reproduce** when conditions change.
- The lower the genetic diversity, the **higher** the **risk** of **extinction**.

Questions

Q6.1 Why is a **population** with high **genetic diversity** more likely to survive a new disease?

ⓐ All individuals are identical
ⓑ Some individuals may have traits that resist the disease
ⓒ The population does not reproduce
ⓓ Genetic diversity prevents all diseases

Q6.2 Genes from the wild teosinte plant were used to make commercial corn resistant to viruses. This shows that **genetic diversity** …

ⓐ has no value to humans
ⓑ can provide genes needed to improve crops
ⓒ only exists in animals
ⓓ reduces crop yield



Q6.3 Which statement explains why **sustaining biodiversity** is essential to life on Earth?

ⓐ It makes ecosystems more stable and provides resources such as food and medicine
ⓑ It reduces the number of species
ⓒ It removes all predators
ⓓ It increases pollution

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Q6.4 A farmer plants only one genetically identical variety of wheat across a whole region. What is the **main risk**?

ⓐ Higher genetic diversity
ⓑ A single disease could destroy the entire crop
ⓒ More species in the region
ⓓ Better resistance to drought

Q6.5 A **population** is described as **resilient**. This means it …

ⓐ cannot change
ⓑ can recover after a disturbance
ⓒ has only one gene
ⓓ never reproduces

Q6.6 What do the different colours and inherited traits of the "Asian ladybird beetles" of the same species represent?

ⓐ Genetic diversity
ⓑ Species diversity
ⓒ Ecosystem diversity
ⓓ Habitat fragmentation

Q6.7 Why is **genetic diversity** (different genes within one **population**) important?

ⓐ It reduces the ability to reproduce
ⓑ It makes the species extinct faster
ⓒ It increases the chance that some individuals survive diseases or changing conditions
ⓓ It prevents organisms from using new food sources

Q6.8 What is the functional unit that controls inherited traits and passes from one generation to the next?

ⓐ Gene
ⓑ Habitat
ⓒ Biome
ⓓ Trophic level

Q6.9 Besides colour, what "hidden traits" can **genetic diversity** give ladybird beetles?

ⓐ Moving from the equator to the poles
ⓑ Changing nitrogen gas into salts
ⓒ Doing photosynthesis
ⓓ Resistance to certain diseases and the ability to survive changing conditions

Q6.10 What do we call "the number of different species and the relative abundance of each species in a community"?

ⓐ Species diversity
ⓑ Genetic diversity
ⓒ Mass extinction
ⓓ Niche

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Q7 · Multiple-Choice Question (Electronic) · 3 marks

Biodiversity Among Communities (Ecosystem Diversity)

Learning outcome: Describe ecosystem diversity and the services that healthy ecosystems provide.

Student Book: Get It? · p. 32 · Check Your Progress – Ex 6 · p. 36

Explanation

Ecosystem diversity is the variety of ecosystems in the biosphere. Each ecosystem has different **abiotic factors** (temperature, water, soil) and different communities. The health of a species is closely tied to the health of its **habitat** (Get It? p. 32).



Figure 4 – Different abiotic factors support different ecosystems: Arctic coast and South American rainforest.

Value of biodiversity	Example
Direct economic value	Food, wood, fibres and **medicines** taken directly from organisms
Indirect economic value	**Ecosystem services**: clean air and water, pollination, soil formation, flood protection
Aesthetic and scientific value	Beauty, recreation, tourism, research

Planning a building project that protects biodiversity (Ex 6 p. 36)

- Keep **green corridors** between habitat patches; plant **native species**; avoid filling wetlands; **reduce** runoff and **pollution**; leave large patches of habitat intact.

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Key Ideas from the Student Book

- **Ecosystem diversity:** the variety of ecosystems in the biosphere; each has populations interacting with the abiotic factors that support them (the desert supports the Arabian oryx; South American rainforest supports tropical birds of Peru).
- Reasons to preserve biodiversity: **economic**, **aesthetic** and **scientific**, and to **protect** species for future generations.
- **Direct economic value:** food, clothing, energy, medicine and shelter. Wild species are **reservoirs of genes** that may be needed to improve crops (teosinte genes gave virus-resistant corn).
- **Indirect economic value:** **benefits** of a **healthy** biosphere – **oxygen release** and CO_2 removal, clean drinking water, recycling of matter, **protection** from floods and drought, **fertile soil**, waste breakdown, climate regulation.
- New York improved its natural watershed for about **1. 5 billion dollars** instead of building a filtration plant costing more than **6 billion** – protecting ecosystems costs **less** than technology.

Direct economic value	Indirect economic value
Food, clothing, medicine, energy, shelter	Oxygen, clean water, flood protection, fertile soil

Remember

- Direct value: food, medicine, clothing, energy. Indirect value: oxygen, **clean water**, flood **protection**.

Questions

Q7.1 Wetlands filter water and reduce flooding at no cost. This is an example of …

ⓐ direct economic value
ⓑ indirect economic value (ecosystem services)
ⓒ genetic diversity
ⓓ an abiotic factor

Q7.2 Why does the Arctic coast support different species than the South American rainforest?

ⓐ They have the same climate
ⓑ They have different abiotic factors such as temperature and rainfall
ⓒ Rainforests have no producers
ⓓ The Arctic has no abiotic factors

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Q7.3 Which statement explains why the health of a species is closely tied to the health of its **habitat**?

ⓐ Species do not depend on their habitat
ⓑ A species depends on its habitat for food, water and shelter
ⓒ Habitats never change
ⓓ Only plants need habitats

Q7.4 A city plans a new highway. Which design **best** maintains **biodiversity**?

ⓐ Cut the forest into many small patches
ⓑ Build wildlife corridors and leave large habitat patches
ⓒ Drain the nearby wetland
ⓓ Replace native plants with lawns

Q7.5 Which is a **direct** economic value of **biodiversity**?

ⓐ Pollination by insects
ⓑ A medicine extracted from a plant
ⓒ Protection from floods
ⓓ Formation of soil

Q7.6 Which of the following is an **indirect economic value** of **biodiversity**?

ⓐ Dependence on plants and animals for food
ⓑ Plants release oxygen and remove carbon dioxide
ⓒ Producing disease-resistant crops
ⓓ Extracting painkillers from willow trees

Q7.7 Which of the following is an **indirect** economic value of **biodiversity**?

ⓐ Energy ⓑ Food ⓒ Flood protection ⓓ Medicine

Q7.8 Which term represents an **indirect** economic value of **biodiversity**?

ⓐ Food ⓑ Clothing ⓒ Flood protection ⓓ Medicines

Q7.9 What does the case study of the Catskill and Delaware watersheds in New York show?

ⓐ Protecting a healthy ecosystem to provide clean water (1.5 billion dollars) costs less than technology (6 billion dollars)
ⓑ Technology is always cheaper than natural ecosystems
ⓒ Ecosystems pollute drinking water
ⓓ New York relied only on desalination

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Q7.10 What term describes the variety of **ecosystems** in the **biosphere** (living organisms interacting with **abiotic factors**)?

ⓐ Ecosystem diversity
ⓑ Genetic diversity
ⓒ Species diversity
ⓓ Economic value

Q7.11 Tropical birds live in the rainforests of Peru and the Arabian oryx lives in the dry desert. What does this represent?

ⓐ Scientific value only
ⓑ Direct economic value
ⓒ Ecosystem diversity
ⓓ Genetic diversity

Q7.12 Among **ecosystem services** (indirect value), what important free role do green plants provide for humans?

ⓐ Regulating climate and protecting from floods
ⓑ Providing oxygen and removing carbon dioxide
ⓒ Breaking down wastes and chemicals
ⓓ Purifying water for organisms

Q7.13 According to the lesson, what are the **main** values that motivate us to protect **biodiversity**?

ⓐ Agricultural, medical and industrial value
ⓑ Climate regulation, recycling and water purification
ⓒ Genetic, species and ecosystem diversity
ⓓ Direct economic value, indirect economic value, and aesthetic and scientific values

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Q8 · Multiple-Choice Question (Electronic) · 3 marks

Genetic Variation and Survival

Learning outcome: Explain how genetic variation within a population affects the survival of organisms.

Student Book: Check Your Progress – Ex 2, 7 · p. 36

Explanation

Genetic variation means individuals of the same species have different traits. When conditions change, individuals with **helpful traits** **survive** and pass them to their offspring, while others may **die**. If a species loses its variation, it is more likely to become **extinct**.

Situation	Result
Population with many variations faces a new disease	**Some resistant individuals survive and reproduce**
Small, isolated population with little variation	**Higher risk of extinction**
Extinction of a species	**Biodiversity decreases**; genes are lost forever (Ex 2 p. 36)

Genetic diversity in domesticated animals (Ex 7 p. 36)

- **Advantages: resistance** to new diseases, adaptation to different climates, more options for breeding.
- **Disadvantages of low diversity:** breeds selected for one trait (e.g. high milk production) may suffer inherited diseases and all can be wiped out by one disease.

⚠ Extinction

- When a species becomes **extinct**, all its genes are **lost**, the species diversity of the community **decreases**, and other species that depended on it are affected.

Key Ideas from the Student Book

- **Evidence:** ladybird beetles with special traits (disease resistance, ability to eat a new food) have a **better chance** to **survive and reproduce** than beetles without these traits.
- **Conclusion:** genetic variation increases the chance that some individuals **survive** when the environment changes or a disease spreads.

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- Biodiversity also has **aesthetic** value (Emerald Bay, Lake Tahoe – harmed by building, runoff and pollution) and **scientific** value (scientists study and protect the environment).

Remember

- Genetic differences give some individuals a **better chance** to **survive and reproduce** in a changing environment.
- Values of biodiversity: direct economic, indirect economic, aesthetic, scientific.

Questions

Q8.1 How does **extinction** affect **biodiversity**?

ⓐ It increases biodiversity
ⓑ It decreases biodiversity because a species and its genes are lost
ⓒ It has no effect
ⓓ It increases genetic diversity

Q8.2 Why is maintaining **genetic diversity** in **domesticated** animals such as chickens important?

ⓐ It makes all chickens identical
ⓑ It reduces the chance that one disease destroys the whole population
ⓒ It stops reproduction
ⓓ It removes useful traits

Q8.3 A **population** of moths has light and dark individuals. Trees darken because of pollution. Which moths are **most likely** to survive?

ⓐ Light moths ⓑ Dark moths ⓒ Both equally ⓓ Neither

Q8.4 Which **population** is at the **greatest** risk of **extinction**?

ⓐ A large population with high genetic variation
ⓑ A small, isolated population with little genetic variation
ⓒ A population that lives in many habitats
ⓓ A population with many offspring and many traits

Q8.5 **Genetic variation** helps a species survive because it …

ⓐ guarantees every individual will survive
ⓑ increases the chance that some individuals have traits suited to new conditions
ⓒ stops the environment from changing
ⓓ reduces the number of offspring

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Q8.6 How do genetic differences in traits among individuals increase the chance that the **population** continues in a changing environment?

ⓐ They increase the chance that some individuals survive and reproduce during a disease outbreak or environmental change

ⓑ They prevent individuals from reproducing or passing on genes

ⓒ They make all individuals affected by a disease in the same way

ⓓ They reduce the ability to use new food sources

Q8.7 What happens to a ladybird **population** with high **genetic diversity** if its old food source disappears?

ⓐ Its genes disappear

ⓑ The beetles become autotrophs

ⓒ The whole population dies the same day

ⓓ Individuals with genetic traits that let them eat a new food source survive and reproduce

---

Q8.8 What does the wish to protect the beauty of "Emerald Bay" at Lake Tahoe and study its **ecosystems** represent?

ⓐ Direct economic value for farming

ⓑ Overexploitation of natural resources

ⓒ Aesthetic and scientific values of biodiversity

ⓓ Biological augmentation for predators

Q8.9 Why are **most** of the world's food crops at great risk if a plant disease spreads?

ⓐ They have very high genetic diversity

ⓑ They come from a very small number of species and have relatively low genetic diversity

ⓒ They grow only in tropical forests

ⓓ They contain no plant cells

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Q9 · Multiple-Choice Question (Electronic) · 3 marks

Changes in Ecosystem Components Affect Populations

Learning outcome: Explain how changes to biotic and abiotic components of an ecosystem affect populations.

Student Book: Get It? · p. 42 · Check Your Progress – Ex 3 · p. 44

Explanation

Changes to **abiotic** components (temperature, water, pollution, habitat area) and **biotic** components (new species, loss of predators) change the size and distribution of populations. Human-caused (**anthropogenic**) changes **threaten** biodiversity.

Threat	Effect on populations
Habitat loss / destruction	Species lose food and shelter → populations decline
Habitat fragmentation	Small patches; more **edge effects**; animals cannot move between patches
Climate change	An increase in global temperature changes ranges; species that cannot move or adapt may die (Get It? p. 42)
Pollution & biological magnification	Toxins (DDT, PCBs) build up at higher trophic levels
Acid precipitation & eutrophication	Damages forests and lakes; algal blooms reduce oxygen
Overexploitation	Excessive use of a species → extinction risk
Invasive species	Non-native species out-compete native species

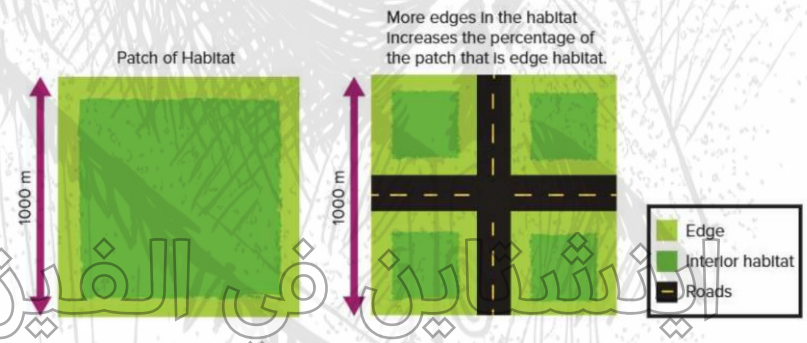


Figure 13 – The smaller the habitat patch, the greater the percentage of the patch that is edge habitat.

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Key Ideas from the Student Book

- Some **human activities** **reduce** biodiversity and can have serious long-term effects on the biosphere.
- **Background extinction:** gradual **extinction** caused by natural changes (other organisms, climate change, natural disasters).
- The current **extinction** rate is estimated at about **1000 times** the background rate – many scientists think we are in a period of **mass extinction** (the last one was about 65 million years ago, when dinosaurs died out).
- Most extinctions since 1600 happened **on islands** (60% of extinct mammals and 81% of extinct birds). Island species evolved without predators, lack **resistance** to new diseases and live in small, isolated populations.
- **Dams** (Glen Canyon): bring electricity, water and tourism, but water temperature became almost constant (7–10 °C instead of 0–29 °C); three native fish species became **extinct** and invasive tamarisk trees release salt that **harms** native plants.
- Keeping a suitable **habitat** is the key to protecting species diversity – usually, the larger the habitat, the greater the diversity.

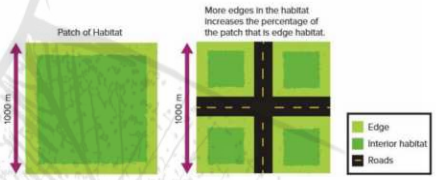
Remember

- Background **extinction** is gradual and natural; mass **extinction** is fast for a large percentage of species.
- Current **extinction** rate ≈ **1000** × background rate, mainly because of humans.

Questions

Q9.1 Building roads through a **habitat** patch …

ⓐ decreases edge habitat
ⓑ increases the percentage of edge habitat
ⓒ has no effect
ⓓ increases interior habitat



Q9.2 How could an increase in global **temperature** threaten **biodiversity**?

ⓐ Species that cannot adapt or move to cooler areas may die out
ⓑ All species will increase
ⓒ It only affects non-living factors
ⓓ It increases the size of all habitats

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Q9.3 A farmer sprays DDT. The **highest** concentration of DDT is found in …

ⓐ producers
ⓑ herbivores
ⓒ top carnivores such as eagles
ⓓ the soil only

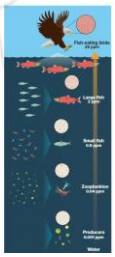
Q9.4 Choose one factor that threatens **biodiversity** and a suitable way to reduce it.

ⓐ Overexploitation – set fishing limits and protected seasons
ⓑ Pollution – add more fertilizer to lakes
ⓒ Habitat loss – cut more forests
ⓓ Invasive species – introduce more non-native species

Q9.5 Excess fertilizer enters a lake. What is the **most** likely effect?

ⓐ Fewer algae
ⓑ Algal bloom and lower oxygen, so fish die
ⓒ Cleaner water
ⓓ More dissolved oxygen

Q9.6 One of the factors that threatens **biodiversity** is the **increasing concentration of toxic substances** in organisms as the **trophic level** in a **food chain** increases, as seen in the figure. What is this factor called?



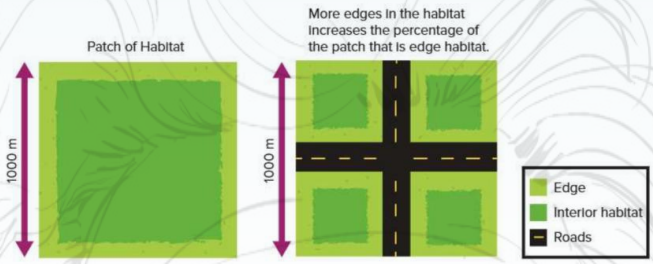
ⓐ Overexploitation
ⓑ Edge effect
ⓒ Biological magnification
ⓓ Eutrophication

Q9.7 Which term refers to the different **environmental conditions** that occur along the **boundaries** of an **ecosystem**?

ⓐ Species diversity
ⓑ Biological magnification
ⓒ Renewable resources
ⓓ Edge effects

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Use the figure of the two habitat patches **A** (one large patch) and **B** (the same patch divided by roads) to answer the next two questions.



Patch A (left) and patch B (right) – edge, interior habitat and roads.

Q9.8 Which **habitat** patch is **more exposed** to **edge effects**?

ⓐ A ⓑ B ⓒ A and B equally ⓓ Neither A nor B

Q9.9 Which **habitat** patch **better supports** natural **biodiversity**?

ⓐ A ⓑ B ⓒ A and B equally ⓓ Neither A nor B

Q9.10 Which of the following are considered as **biotic factors**?

ⓐ Air or water currents
ⓑ Sunlight
ⓒ Migratory animals, such as birds
ⓓ Rainfall and temperature

Q9.11 Which of the following is an **abiotic factor**?

ⓐ A polar bear on an ice floe
ⓑ An ocean current of cold water
ⓒ Fungi and moss on a rotting log
ⓓ A forest of deciduous trees

Q9.12 Which of the following is a **biotic factor**?

ⓐ a cactus plant ⓑ sand winds ⓒ dew drops ⓓ sun rays

Q9.13 Which of the following is an **abiotic factor** for a tree in a forest?

ⓐ a caterpillar eating its leaves
ⓑ a bird building a nest between its branches
ⓒ fungi growing on its roots
ⓓ wind blowing through its branches

Q9.14 Which of the following is a **biotic factor** in soil?

ⓐ the quantity of humus in the soil
ⓑ the water level in the soil
ⓒ worms living in the soil
ⓓ the nutrients in the soil

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Q9.15 What does a decrease in salmon **population** due to an increase in river **temperature** indicate?

ⓐ an abiotic factor affecting a biotic factor
ⓑ an unchanging biological community
ⓒ change in population but not in abiotic factors
ⓓ an effect of predation

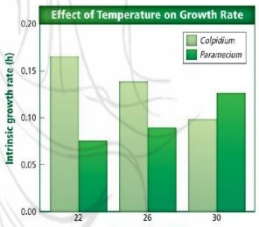
Q9.16 Using Figure 6, what does the portion of the graph from 13°C to 21°C represent?

ⓐ zone of physiological stress
ⓑ zone of intolerance
ⓒ optimum range
ⓓ upper limit

Q9.17 A **biotic** or **abiotic factor** that restricts the numbers of organisms in an **ecosystem** is called a(n) ……

ⓐ limiting factor
ⓑ primary succession
ⓒ tolerating factor
ⓓ end point

Q9.18 The graph shows the effect of **temperature** on the growth rate of Colpidium and Paramecium.
Describe the differences in **population** growth for the two species.



ⓐ Colpidium grows faster than Paramecium at 22°C and 26°C, but Paramecium grows faster at 30°C
ⓑ Colpidium grows faster than Paramecium at 22°C and 30°C, but Paramecium grows faster at 26°C
ⓒ Colpidium grows faster than Paramecium at 30°C and 26°C, but Paramecium grows faster at 22°C
ⓓ Colpidium grows faster than Colpidium at 30°C, but Paramecium grows faster at 22°C and 26°C

Q9.19 By about how many times does the current **extinction** rate exceed the natural background rate?

ⓐ Once
ⓑ 10 times
ⓒ 1000 times
ⓓ 10 000 times

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Q9.20 What is meant by "mass extinction"?

ⓐ An event in which a large percentage of all living species becomes extinct in a relatively short time

ⓑ Slow gradual extinction of one species over millions of years

ⓒ An increase in island populations

ⓓ Migration of birds from the pole to the equator

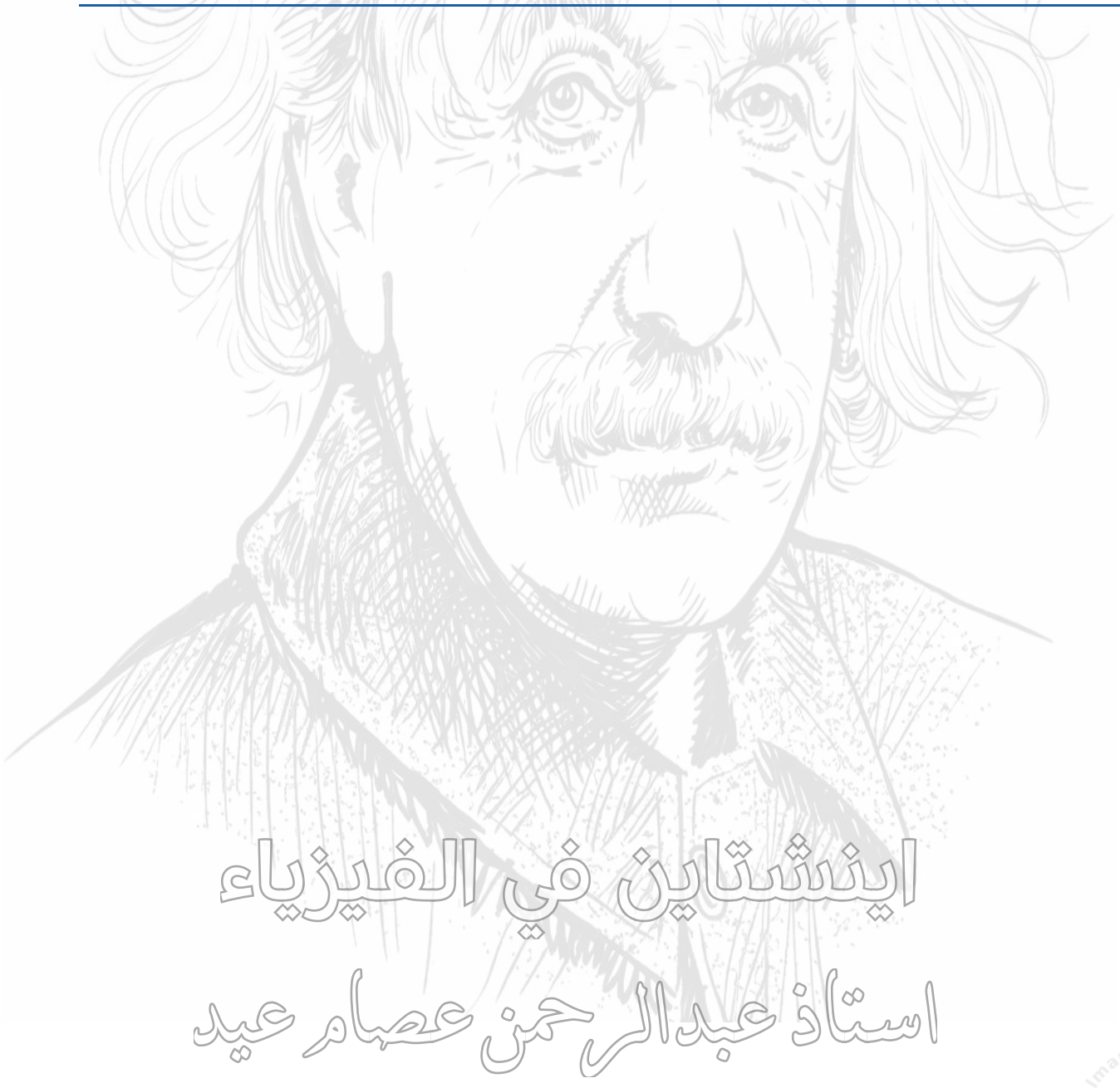
Q9.21 Why are organisms on islands more vulnerable to **extinction** than others?

ⓐ Their populations are very large and move easily

ⓑ They evolved without natural predators, so they cannot escape, have small populations and no resistance to new diseases

ⓒ Islands have no flowering plants or birds

ⓓ Islands are always struck by meteors



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Q10 · Multiple-Choice Question (Electronic) · 3 marks

Disruptions and Shifts in Populations

Learning outcome: Explain how disruptions to an ecosystem cause shifts in populations.

Student Book: Get It? · p. 39 · Check Your Progress – Ex 1 · p. 44

Explanation

An ecosystem changes when a disturbance happens faster than species can **adapt**. If species **cannot adapt** to changes that are too fast, their populations **decline** and may become **extinct** (Ex 1 p. 44). Removing or adding one species can cause shifts throughout the food web.



Figure 15 – *Invasive species, such as the fire ant, can negatively affect biodiversity.*

Disruption	Shift in populations
Overharvesting of fish	Sea lions lose food → decline → killer whales eat sea otters → sea urchins increase → kelp forests destroyed
Introduction of an invasive species	No natural predators → invasive population grows quickly → native species decline
Overexploitation of a species (Get It? p. 39)	Population drops faster than it can reproduce → risk of extinction (e.g. passenger pigeon, American bison)

Island species

- Species on islands are especially vulnerable to **extinction**: small populations, limited habitat and no escape when invasive predators arrive.

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Key Ideas from the Student Book

- **Overexploitation:** excessive use of species with economic value (American bison fell from 50 million to about 1000 in 1889; the passenger pigeon became extinct).
- Today the **number-one cause** of **extinction** is **habitat loss or destruction** (e.g. clearing tropical rainforest, which holds more than half of land species); historically it was overexploitation.
- A **decrease** in **one species** of a food web affects the whole ecosystem (Alaska: fewer sea lions → killer whales eat sea otters → more sea urchins → kelp forests decline). A **keystone species** plays a major role in an ecosystem.
- **Habitat fragmentation** by roads and barriers: smaller areas support **fewer** species; **less** interbreeding → lower genetic diversity; more edges → **edge effects** (higher temperature and wind, lower humidity, more predators and parasites).
- **Biological magnification: toxins** such as **DDT** and **PCBs** increase in concentration at higher trophic levels; DDT made eggshells of bald eagles thin and was banned.
- **Acid precipitation:** sulfur dioxide and nitrogen dioxide react with water to form acids that remove nutrients from soil, **damage** forests and kill fish.
- **Eutrophication:** fertilizers, animal wastes and sewage (N and P) cause algal growth that uses up oxygen. **Invasive species** (fire ants) cause about **40%** of extinctions since 1750.

Threat	Cause	Effect
Biological magnification	Pesticides such as DDT build up	**Thin eggshells, embryos die**
Acid precipitation	SO_2 and NO_2 react with water	**Damaged plants, dead fish**
Eutrophication	Fertilizers and sewage in water	**Algal growth, less oxygen**
Invasive species	Non-native species moved to a new habitat	**Compete with and prey on native species**

Remember

- Number-one cause of **extinction** today: **habitat loss**; historically: **overexploitation**.
- Fragmentation: **less** area, **less** genetic diversity, more edges.
- Losing one **keystone species** affects the whole food web.

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Questions

Q10.1 What happens when species **cannot adapt** to **ecosystem** changes that are too fast?

ⓐ Their populations increase
ⓑ Their populations decline and they may become extinct
ⓒ They become producers
ⓓ Nothing changes

Q10.2 Explain how **overexploitation** relates to species **extinction**.

ⓐ Using a species faster than it can reproduce can lead to extinction
ⓑ Overexploitation increases population size
ⓒ It only affects abiotic factors
ⓓ It always helps biodiversity

Q10.3 Fire ants were introduced into a new area with no natural predators. What is the **most** likely result?

ⓐ The fire ant population decreases
ⓑ Native species decline as fire ants spread
ⓒ Biodiversity increases
ⓓ Fire ants become prey for every species



Q10.4 **Overharvesting** of fish reduced sea-lion numbers, so killer whales ate more sea otters. Which change followed?

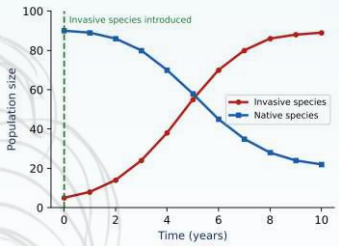
ⓐ Sea urchins decreased
ⓑ Kelp forests increased
ⓒ Sea urchins increased and kelp forests decreased
ⓓ No change in the ecosystem

Q10.5 Why are species on islands **particularly vulnerable** to **extinction**?

ⓐ They have very large populations
ⓑ They have limited habitat and small populations
ⓒ They have no predators ever
ⓓ They all live in the ocean

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Q10.6 The graph shows the populations of a native species and an **invasive species** after the invasive species was introduced. Which conclusion is **best supported** by the graph?



ⓐ The invasive species helped the native species grow

ⓑ As the invasive population increased, the native population decreased

ⓒ Both populations stayed constant

ⓓ The native species out-competed the invasive species

Q10.7 Which of the following is **not** one of the ways species lose their habitats?

ⓐ Background extinction ⓑ Destruction

ⓒ Disruption ⓓ Pollution

Q10.8 Which event started a chain of events off the coast of Alaska that caused kelp forests to disappear?

ⓐ Decrease in plankton

ⓑ Increase in sea otters

ⓒ Overfishing that reduced sea lion and harbour seal populations

ⓓ Pollution from insecticides

Q10.9 What is the effect of **habitat fragmentation** into small areas?

ⓐ Lower temperature and higher humidity at the edges

ⓑ Larger edge areas (edge effects) and fewer chances of interbreeding, which reduces genetic diversity and species number

ⓒ Larger safe interior area and higher genetic diversity

ⓓ Predators and parasites disappear from the edges

Q10.10 Why do introduced species reproduce in large numbers and become **invasive species** that threaten **biodiversity** in their new **habitat**?

ⓐ Because natural controls such as predators and parasites are absent or few in the new habitat

ⓑ Because they carry out photosynthesis in the dark

ⓒ Because they do not compete with native species for food

ⓓ Because they increase soil fertility and purify water

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Q10.11 Which animal's numbers dropped from 50 million to about 1000 because of overhunting?

ⓐ Wild cat ⓑ Bison ⓒ White rhinoceros ⓓ Sea lion

Q10.12 Which example in the lesson of "habitat destruction" leads **directly** to the **extinction** of many species?

ⓐ Building river dams
ⓑ Planting trees in the desert
ⓒ Clearing tropical rainforests
ⓓ Fishing in ocean water

Q10.13 What do we call the species that plays a major role in an **ecosystem**, whose decline disrupts the whole **food web**?

ⓐ Keystone species
ⓑ Introduced species
ⓒ Extinct species
ⓓ Endangered species

Q10.14 Which gases released by burning **fossil fuels** react with water in the air to form "acid precipitation"?

ⓐ Sulfur dioxide and nitrogen oxides
ⓑ Carbon monoxide only
ⓒ Methane and ozone
ⓓ Oxygen and hydrogen

Q10.15 How does acid **precipitation** harm plants in an **ecosystem**?

ⓐ It speeds up growth of leaves and stems
ⓑ It protects plants from harmful insects
ⓒ It removes nutrients such as calcium and potassium from soil and damages roots
ⓓ It increases oxygen in the soil

Q10.16 Which substances flowing into waterways cause **eutrophication** and excessive algae growth?

ⓐ Fertilizers rich in nitrogen and phosphorus
ⓑ Mineral salts such as iron and copper
ⓒ Toxic insecticides
ⓓ Plastic waste

Q10.17 In **eutrophication**, what causes fish to suffocate and die under the water surface?

ⓐ An increase in calcium in the water
ⓑ A sharp drop in water temperature
ⓒ Water turning into a strong acid
ⓓ Oxygen used up as dead algae decompose

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Q11 · Multiple-Choice Question (Electronic) · 3 marks

Biodiversity as a Measure of Ecosystem Health

Learning outcome: Explain that the integrity of biodiversity is a measure of the health of an ecosystem, and describe ways to conserve it.

Student Book: Get It? · p. 48 · Check Your Progress – Ex 1 · p. 52

Explanation

An ecosystem with **high biodiversity** is healthier and more **stable**: it **recovers** faster from disturbances and provides more ecosystem services. A **loss** of species is a warning sign that the ecosystem is unhealthy.

Approach to slow extinction (Ex 1 p. 52)	How it works
Sustainable use of resources	Use resources at a rate that allows them to be replaced
Protected areas (national parks, reserves)	Protect whole habitats, not single species
Biodiversity hotspots	Protect regions with many **endemic** species that are threatened
Corridors between fragments	Allow animals to move safely between habitat patches
Laws and legislation	Protect endangered species, air and water

Renewable vs nonrenewable resources (Ex 2 p. 52)

- **Renewable resources** are replaced by natural processes faster than they are used (sunlight, forests if managed, fresh water).
- **Nonrenewable resources** are found in limited amounts or replaced very slowly (fossil fuels, minerals).

Get It? p. 48

- Protecting **large areas** and **corridors** is better than protecting small isolated parks because many species need large ranges, and connected habitats keep populations genetically diverse.

Key Ideas from the Student Book

- **Natural resources:** all the materials and organisms in the biosphere. Per-person consumption is much higher in developed countries; a long-term plan is needed to control resource use.

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- **Renewable resources** are replaced by natural processes faster than they are used (solar energy, crops, animals, clean water and air).
- **Nonrenewable resources** exist in limited amounts or are replaced over very long periods (fossil fuels, uranium, mineral deposits); **extinct species** are also **nonrenewable**.
- Context matters: one tree in a large forest is **renewable**, but a **clear-cut** forest is **nonrenewable** because it no longer provides a habitat.
- **Sustainable use:** using resources at a rate that allows them to be replaced or **recycled** while keeping the biosphere **healthy** in the long term.
- A **complete** (intact) biodiversity is a sign of a **healthy** ecosystem; losing species is a sign of **decline**. **Hotspots** are regions where endemic species are **threatened**.

	Renewable	Nonrenewable
Replacement	Faster than it is used	Limited or takes a very long time
Examples	Solar energy, water, air, plants	Fossil fuels, uranium, minerals

Remember

- Integrity of biodiversity is a **measure of ecosystem health**.
- **Sustainable use** allows resources to be replaced.

Questions

Q11.1 Which **ecosystem** is **most likely** to be the healthiest?

ⓐ A field planted with one crop
ⓑ A forest with many species of plants and animals
ⓒ A polluted lake with algal blooms
ⓓ A parking lot

Q11.2 Which approach helps **slow the rate of extinction**?

ⓐ Draining wetlands
ⓑ Establishing protected areas and biodiversity hotspots
ⓒ Introducing invasive species
ⓓ Overharvesting fish

Q11.3 Which of the following is a **nonrenewable** resource?

ⓐ Sunlight ⓑ Wind ⓒ Petroleum ⓓ Managed forests

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Q11.4 A **biodiversity hotspot** is a region that …

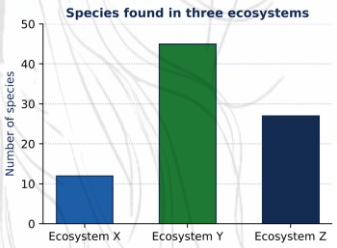
ⓐ has no endemic species
ⓑ has many endemic species that are threatened with extinction
ⓒ is always a desert
ⓓ has only one ecosystem

Q11.5 Using a resource at a rate that allows it to be replaced is called …

ⓐ overexploitation
ⓑ sustainable use
ⓒ fragmentation
ⓓ biological magnification

Q11.6 The **bar graph** shows the number of species found in three **ecosystems**. Which **ecosystem** is **most likely** the healthiest and **most** stable?

ⓐ Ecosystem X
ⓑ Ecosystem Y
ⓒ Ecosystem Z
ⓓ All are equally healthy



Q11.7 When does a forest or a **population** change from a "renewable resource" into a "nonrenewable resource"?

ⓐ When the whole forest is cut without leaving enough area to provide a habitat, or when a species becomes extinct forever
ⓑ When new trees are planted after cutting a few
ⓒ When seasonal rain falls on the forest
ⓓ When a natural reserve is created around the forest

Q11.8 What term describes "using resources at a rate that allows them to be replaced or recycled while keeping the biosphere healthy in the long term"?

ⓐ Overexploitation
ⓑ Biological magnification
ⓒ Sustainable use
ⓓ Background extinction

Q11.9 What do we call a species that lives **only** in one specific geographic area?

ⓐ Endemic species
ⓑ Introduced species
ⓒ Continental species
ⓓ Detritivore species

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Q11.10 Why is the rate of natural-resource use per person high in developed countries compared with developing countries?

ⓐ Developed countries do not use fuel or industry

ⓑ Because of industrial development, higher standards of living and high consumption of resources and energy

ⓒ Developing countries consume all the world's oil

ⓓ Natural resources are equally distributed among all countries

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Q12 · Multiple-Choice Question (Electronic) · 3 marks

Ecosystems Are Dynamic

Learning outcome: Explain that ecosystems are dynamic and can recover from disturbances; describe restoration techniques.

Student Book: Check Your Progress – Ex 2, 3 · p. 52

Explanation

Ecosystems are always **changing** (dynamic). Given time, biological communities can **recover** from natural and human-caused disasters. The **recovery time** depends on the **size of the area affected** and the **type of disturbance**.

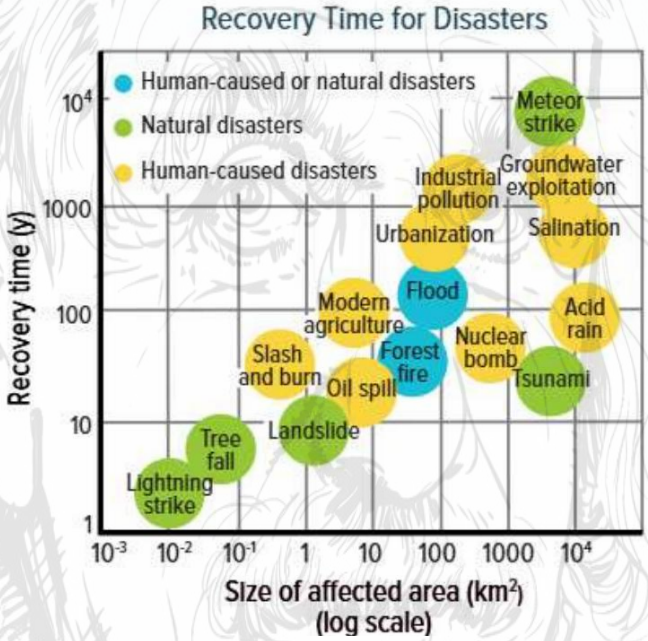


Figure 21 – Recovery time depends on the size of the area affected and on the type of disturbance.

Restoration technique	Description
Bioremediation	Using **living organisms** (bacteria, fungi, plants) to remove toxins from a polluted area, e.g. bacteria that break down oil spills
Biological augmentation	Adding **natural predators** or organisms to a degraded ecosystem, e.g. ladybugs that eat aphids, or plants that remove heavy metals

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Key Ideas from the Student Book

- Sometimes biotic and abiotic factors are **destroyed** (clearing rainforest, mining, oil and chemical spills). Communities can **recover** with time – ecosystems are **dynamic**.
- **Recovery** time depends on the **size of the area affected** and the **type of disturbance**: the larger the area, the longer the **recovery**. A natural or human cause does **not** decide the length.
- Lightning strikes and tree falls (small areas) **recover** quickly; groundwater exploitation and meteor strikes take the longest.
- **Bioremediation:** using living organisms (prokaryotes, fungi, plants) to remove **toxins** – microbes broke down 80 000 gallons of spilled jet fuel into CO_2 (1975); plants remove zinc, lead and nickel from soil.
- **Biological augmentation:** adding natural predators to a degraded ecosystem.

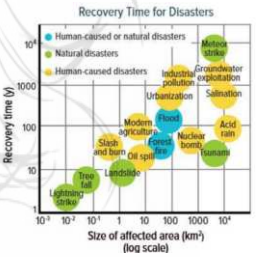
Remember

- Ecosystems are dynamic: they are **damaged** and then **recover** with time.
- **Recovery** time increases with the **size** of the **damaged** area.

Questions

Q12.1 About how long does it take an area to recover from a **landslide**?

ⓐ 1 year
ⓑ About 10 years
ⓒ About 1000 years
ⓓ About 10 000 years



Q12.2 Which disaster needs the **longest** recovery time?

ⓐ Tree fall ⓑ Lightning strike ⓒ Meteor strike ⓓ Forest fire

Q12.3 Bacteria are added to soil to break down spilled oil. This technique is called …

ⓐ biological augmentation
ⓑ bioremediation
ⓒ overexploitation
ⓓ eutrophication

Q12.4 Ladybugs are released into a farm to **control** aphids. This is an example of …

ⓐ bioremediation
ⓑ biological augmentation
ⓒ habitat fragmentation
ⓓ acid precipitation

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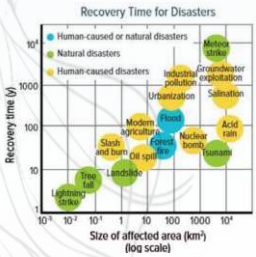
Q12.5 Which two factors determine how long an **ecosystem** needs to recover?

ⓐ Size of the area affected and type of disturbance
ⓑ Number of roads and cars
ⓒ Colour of the soil and water
ⓓ Time of day and season

Use **Figure 21 – Recovery Time for Disasters** to answer the next two questions.

Q12.6 Which **human-caused** disaster requires the **longest** recovery time?

ⓐ Groundwater exploitation
ⓑ Industrial pollution
ⓒ Urbanization
ⓓ Slash and burn



Q12.7 Which **natural** disaster requires the **shortest** recovery time?

ⓐ Lightning strike ⓑ Tree fall ⓒ Tsunami ⓓ Meteor strike

Q12.8 Which recovery process is used to restore **biodiversity** and balance to the **ecosystem** in the figure (ladybugs feeding on aphids)?



ⓐ Genetic engineering
ⓑ Bioremediation
ⓒ Biological augmentation
ⓓ Biological corridors

Q12.9 What is the term that describes **adding natural predators** to a degraded **ecosystem**?

ⓐ Bioremediation
ⓑ Biological augmentation
ⓒ Overexploitation
ⓓ Sustainable use

Q12.10 Which of the following terms refers to a method used to **restore biodiversity** in a polluted or damaged area?

ⓐ Biological augmentation
ⓑ Biological corridor
ⓒ Renewable resource
ⓓ Sustainable use

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Q13 · Multiple-Choice Question (Electronic) · 3 marks

Evaluating Design Solutions

Learning outcome: Evaluate design solutions that reduce human impact on the environment and biodiversity.

Student Book: Check Your Progress – Ex 4 · p. 52

Explanation

A good **design solution** balances the needs of **people** (jobs, food, housing) with the needs of the **environment**. To evaluate a solution, compare it against **criteria** (benefits, cost, effect on biodiversity, social and cultural impact) and **constraints** (money, time, laws).

Problem	Possible design solution	Evaluation
Habitat fragmentation by roads	Wildlife bridges / tunnels (corridors)	**Animals move safely**; cost is high
Overfishing	Fishing quotas, protected seasons, marine reserves	**Fish recover**; short-term income may drop
Local family needs resources in a hotspot (Ex 4 p. 52)	Eco-tourism, sustainable harvesting, community reserves	**Income for family and protected species** – a compromise
Oil spill	Bioremediation with bacteria	**Natural, low toxicity**; slower than mechanical clean-up
Invasive species	Biological control with a natural predator	Must be tested so the predator does not become invasive

⚠ Careful evaluation

- A solution that solves one problem can create another. For example, a predator introduced for **biological control** can itself become an **invasive species**.

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Key Ideas from the Student Book

- **Hotspot criteria:** at least **1500** species of endemic vascular plants and at least **70%** of the original habitat **lost**; there are 34 hotspots holding about half of all plant and animal species.
- **Competing views:** focusing on hotspots saves the most species, but others prefer funding other regions that provide more ecosystem services (water filtering, flood control).
- **Corridors** connect small patches of habitat so organisms can move **safely**; they support more species and genetic diversity, but may **spread disease** and increase edge effects.
- **Biological augmentation:** ladybugs eat aphids that destroy crops without harming the crops.
  Legal protection: the U.S. Endangered Species Act (1973) and **CITES** (1975), which bans trade in endangered species (ivory, rhino horn).
- Large reserves with **buffer zones** (Costa Rica) allow **sustainable use** while protecting diversity. UAE **protected** areas include Sir Bani Yas Island and Ras Al Khor.

Solution	Advantages	Limitations
Corridors	**Safe movement, larger area, more genetic diversity**	**Spread disease, more edge effects**
Large reserves	**Fewer edges, protect more species**	**Hard to maintain, costly**
Biological augmentation	**Alternative to chemical pesticides**	**Predator must not harm crops**
Bioremediation	**Removes toxins naturally**	**Relatively new and slow**

Remember

- Evaluate a design solution by comparing **advantages** and **limitations** (cost, services, number of species protected).

Questions

Q13.1 A family in a **biodiversity hotspot** needs to earn a living from the forest. Which solution is the **best compromise**?

ⓐ Clear-cut the forest for farming
ⓑ Ban all use of the forest with no support for the family
ⓒ Develop eco-tourism and sustainable harvesting
ⓓ Introduce an invasive tree species

Q13.2 Which design solution **best** reduces animal deaths on a highway that crosses a forest?

ⓐ Build wildlife bridges or tunnels
ⓑ Remove all trees beside the road
ⓒ Increase the speed limit
ⓓ Build a second highway

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Q13.3 An engineer must choose between two solutions to an oil spill. Which criterion is **most important** for protecting **biodiversity**?

ⓐ The colour of the equipment
ⓑ How little harm the method causes to living organisms
ⓒ The name of the company
ⓓ How loud the machines are

Q13.4 What is a possible **disadvantage** of introducing a **predator** to **control** an **invasive species**?

ⓐ The predator may also harm native species
ⓑ The invasive species will always increase
ⓒ It never works
ⓓ It increases pollution

Q13.5 Which solution reduces overfishing while still allowing fishing?

ⓐ Fishing quotas and protected breeding seasons
ⓑ Unlimited fishing all year
ⓒ Dumping waste in the sea
ⓓ Using larger nets

Q13.6 What are the two criteria an area must meet to be classified as a "biodiversity hotspot"?

ⓐ It has oil refineries and fossil fuels
ⓑ It lies in Antarctica with no human activity
ⓒ It has 100 migrating mammal species and is 100% intact
ⓓ It has at least 1500 species of endemic vascular plants and has lost at least 70% of its original habitat

Q13.7 What is the advantage of **habitat corridors**?

ⓐ They increase edge effects in the area
ⓑ Diseases move easily between areas
ⓒ Parasites move easily between areas
ⓓ Individuals can move safely between areas, which improves genetic diversity

Q13.8 What are the two **main** disadvantages of using **corridors** between **habitat** patches?

ⓐ Diseases and parasites move easily between areas, and edge effects increase
ⓑ Animals cannot move and genetic diversity decreases
ⓒ The interior habitat increases and edges decrease
ⓓ Vascular plants become endemic species

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Q13.9 What was the legal importance of signing the international treaty on trade in endangered species (CITES) in 1975?

ⓐ It removed all international reserves
ⓑ It required DDT use in all countries
ⓒ It allowed unlimited hunting of whales and bison
ⓓ It banned trade in endangered species and their parts, such as elephant ivory and rhino horn

Q13.10 What negative point must be considered when designing **habitat corridors** between reserves?

ⓐ Diseases, parasites and forest fires can move easily from one patch to another
ⓑ Birds cannot fly
ⓒ The number of plant species decreases
ⓓ Plant-eating animals become predators

Q13.11 Which action is an application of "biological augmentation" to protect crops?

ⓐ Spraying crops with toxic DDT
ⓑ Burning infested fields completely
ⓒ Removing trees to expand soil exposed to wind
ⓓ Adding ladybugs as natural predators to feed on aphids without chemical pesticides

Q13.12 What percentage of the world's land has been set aside as natural reserves?

ⓐ 7% ⓑ 20% ⓒ 70% ⓓ 50%

Q13.13 To classify an area as a **hotspot**, it must contain at **least** 1500 species of …

ⓐ Endangered large mammals ⓑ Endemic vascular plants
ⓒ Migrating birds ⓓ Coral-reef fish

Q13.14 Some predatory insects (ladybugs and praying mantises) are useful to farmers because they …

ⓐ Increase soil fertility
ⓑ Are used to control harmful insects instead of pesticides
ⓒ Fix nitrogen in the soil
ⓓ Pollinate all types of crops

Q13.15 Using microorganisms (bacteria or fungi) to break down oil spills and remove toxins from soil is called …

ⓐ Biological magnification ⓑ Bioremediation
ⓒ Biological augmentation ⓓ Overexploitation

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Q14 · Multiple-Choice Question (Electronic) · 3 marks

Analyzing Experimental Data

Learning outcome: Analyze and interpret experimental data to draw conclusions.

Student Book: Get It? · p. 60

Explanation

After an experiment, scientists **organize** data in tables and graphs, look for **patterns** and **trends**, and decide whether the data **support** the hypothesis. All results must be recorded honestly – including unexpected results.

Time (min)	Room A (°C)	Room B (°C)	Room C (°C)
0	16	16	16
5	17	17	16.5
10	19	19	17
15	20	21	17.5
20	20	23	18
25	20	25	18.5

Table 6 / Figure 14: A builder installed different thermostats in classrooms A, B and C and recorded the temperature every 5 minutes after turning on the heat.



Figure 14 – Classroom temperature against time for thermostats A, B and C.

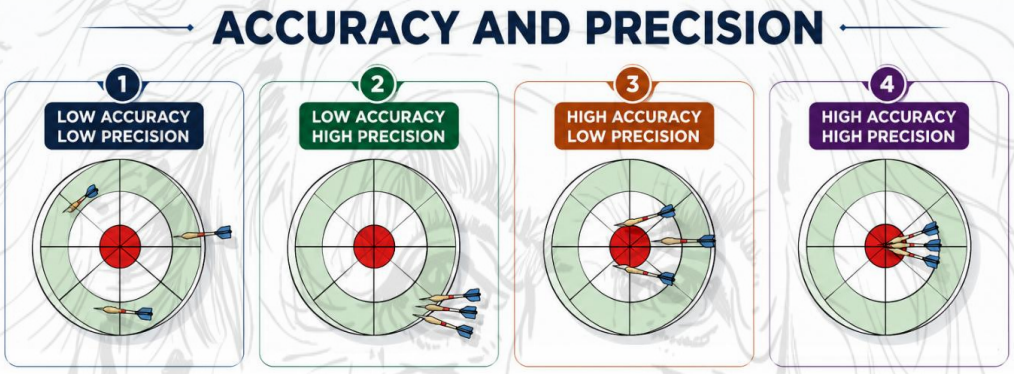
Reading the graph

- Room A rises and then **levels off at 20 °C** – its thermostat works (the control).
- Room B **keeps rising** – its thermostat did **not** turn the heat off.
- Room C rises **slowly** – its heater is **weak**.

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Precision and Accuracy

Definitions
▸ **Precision** describes how close repeated measurements are to **one another** (their spread). An instrument with smaller divisions gives higher precision; a smaller uncertainty means a more precise measurement.
▸ **Accuracy** describes how close a measurement (or the average of measurements) is to the **accepted (true) value**.



Accuracy and precision shown on targets.

Repeated measurements are…	Precise?	Accurate?
Close together and close to the accepted value	Yes	Yes
Close together but far from the accepted value	Yes	No
Spread out, average close to the accepted value	No	Yes
Spread out and far from the accepted value	No	No

Key Ideas from the Student Book

- **Analyzing data:** record observations and organize them in tables and graphs; include **all** results, even unexpected ones.
- **Inference:** a logical conclusion based on observations and evidence (seeing a line of ants, Khalid infers that sugar was spilled).
- Scientists **share data** in reports and conferences so others can check them. To accept a hypothesis, the experiment must give the **same data every time** it is repeated.
- **Bias** occurs when a scientist's expectations change how results are analyzed; **reduce** it by repeating trials, recording precise details and using **blind experiments**.

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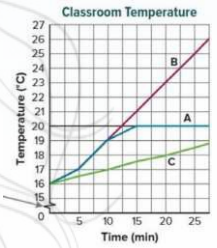
- **Peer review:** scientists in the same field evaluate the procedures and results before publication. Measurable, repeatable data allow results to be compared.

Remember

- An accepted experiment gives the **same results** when repeated.
- **Bias** is reduced by repeated trials and blind experiments.

Questions

Q14.1 Which thermostat kept the room at a **constant 20 °C** after 15 minutes?



ⓐ A ⓑ B
ⓒ C ⓓ None of them

Q14.2 What is the **temperature** of Room B after 20 minutes?

ⓐ 20 °C ⓑ 21 °C ⓒ 23 °C ⓓ 25 °C

Q14.3 Which conclusion is **best supported** by the data?

ⓐ Thermostat B is not working correctly because the temperature keeps rising
ⓑ All three thermostats work the same
ⓒ Room C heats faster than Room B
ⓓ Room A never warms up

Q14.4 In this investigation, what is the **independent variable**?

ⓐ Temperature ⓑ Time after turning on the heat
ⓒ Room size ⓓ The builder

Q14.5 What should a scientist do with **unexpected** results?

ⓐ Delete them ⓑ Record and report them honestly
ⓒ Change them to match the hypothesis ⓓ Ignore them

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Q14.6 In an experiment to measure the **melting point of sucrose**, three students recorded the data below. Which student's data are considered **not precise nor accurate**? (Accepted value: 185 °C)

	Student A	Student B	Student C
Trial 1	190.0 °C	183.9 °C	199.2 °C
Trial 2	189.8 °C	185.3 °C	187.3 °C
Trial 3	189.7 °C	184.7 °C	191.0 °C
Mean	**189.8 °C**	**184.6 °C**	**192.5 °C**

ⓐ Student A ⓑ Student B ⓒ Student C ⓓ Students A and B

Q14.7 In another experiment on the melting point of sucrose, three students recorded the data below. Which student's data are the **most precise**?

	Student A	Student B	Student C
Trial 1	180.4 °C	188.9 °C	190.0 °C
Trial 2	184.8 °C	185.3 °C	189.8 °C
Trial 3	191.0 °C	180.7 °C	189.7 °C
Mean	**185.4 °C**	**184.9 °C**	**189.8 °C**

ⓐ Student A ⓑ Student B ⓒ Student C ⓓ Students A and B

Q14.8 Three students measured the **density** of an unknown substance (sucrose, accepted density 1.59 g/cm^3). Whose data are **both accurate and precise**?

	Student A	Student B	Student C
Trial 1	1.54 g/cm^3	1.40 g/cm^3	1.70 g/cm^3
Trial 2	1.60 g/cm^3	1.68 g/cm^3	1.69 g/cm^3
Trial 3	1.57 g/cm^3	1.45 g/cm^3	1.71 g/cm^3
Mean	**1.57 g/cm^3**	**1.51 g/cm^3**	**1.70 g/cm^3**

ⓐ Student A ⓑ Student B ⓒ Student C ⓓ None of them

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Q14.9 Three students measured the length of a postage stamp (accepted length 2.71 cm). Which student's measurements are the **most accurate**?

	Student 1	Student 2	Student 3
Trial 1	2.60 cm	2.70 cm	2.75 cm
Trial 2	2.72 cm	2.69 cm	2.74 cm
Trial 3	2.65 cm	2.71 cm	2.64 cm
Mean	**2.66 cm**	**2.70 cm**	**2.71 cm**

ⓐ Student 1 ⓑ Student 2 ⓒ Student 3 ⓓ Students 1 and 2

Q14.10 The three arrows represent three measurements taken during an experiment. Based on the figure, which statement **best** describes the measurements in terms of **precision** and **accuracy**?



ⓐ The measurements are precise and accurate.
ⓑ The measurements are accurate but not precise.
ⓒ The measurements are not precise and not accurate.
ⓓ The measurements are precise but not accurate.

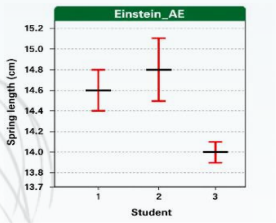
Q14.11 The three arrows represent three measurements for an experiment. Which of the following statements is correct regarding **precision** and **accuracy**?



ⓐ Measurements are precise but not accurate
ⓑ Measurements are accurate but not precise
ⓒ Measurements are neither accurate nor precise
ⓓ Measurements are accurate and precise

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Q14.12 Three students conducted a MiniLab to investigate how increasing **mass** affects the length of a spring. Each student made repeated measurements and reported the average measurement (black line) together with the uncertainty range (red line), as shown in the figure. The accepted length of the spring is 14.8 cm. Which of the following statements is **incorrect**?



ⓐ Student 3 has the most precise measurement.

ⓑ The measuring instrument used by Student 3 has the finest scale division.

ⓒ Student 3 has the most accurate measurement.

ⓓ Student 3's measurements are not in agreement with those of Students 1 and 2.

Q14.13 Khalid stepped on a digital scale four times. His accepted **mass** is 65.0 kg. Which statement **best** describes Khalid's measurements?

Trial	1	2	3	4
Mass (kg)	65.1	65.0	64.9	65.0

ⓐ The measurements are only precise.

ⓑ The measurements are only accurate.

ⓒ The measurements are both accurate and precise.

ⓓ The measurements are neither accurate nor precise.

Four students measured the mass of the same wooden box three times. The accepted mass of the box is **2. 5 kg**. Use the table to answer the next two questions.

Student	Trial 1	Trial 2	Trial 3
Mahmoud	2.3 kg	2.5 kg	2.7 kg
Hamdan	2.2 kg	2.6 kg	2.9 kg
Adam	2.8 kg	2.9 kg	2.8 kg
Sultan	2.6 kg	3.3 kg	2.9 kg

Q14.14 Which student has the **most precise** measurements?

ⓐ Mahmoud ⓑ Hamdan ⓒ Adam ⓓ Sultan

Q14.15 Which student has the **most accurate** measurements?

ⓐ Mahmoud ⓑ Hamdan ⓒ Adam ⓓ Sultan

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Four students measured the length of the same book three times. The accepted length of the book is **30.3 cm**. Use the table to answer the next two questions.

Student	1st attempt	2nd attempt	3rd attempt
Sheikha	33.9 cm	31.1 cm	29.0 cm
Awatef	30.2 cm	30.1 cm	30.4 cm
Aysha	32.5 cm	32.4 cm	32.5 cm
Laila	32.3 cm	29.8 cm	34.1 cm

Q14.16 Which student has the **most accurate** measurements?

ⓐ Sheikha ⓑ Awatef ⓒ Aysha ⓓ Laila

Q14.17 Which student has the **most precise** measurements?

ⓐ Sheikha ⓑ Awatef ⓒ Aysha ⓓ Laila

Q14.18 Four groups measured the **mass** of a paper clip. The accepted mass is 1.04 g. Which group obtained measurements that are **both accurate and precise**?

Group	Trial 1	Trial 2	Trial 3
Group 1	1.03 g	1.05 g	1.02 g
Group 2	1.13 g	1.10 g	1.11 g
Group 3	1.04 g	1.41 g	1.52 g
Group 4	0.99 g	1.00 g	1.19 g

ⓐ Group 1 ⓑ Group 2 ⓒ Group 3 ⓓ Group 4

Q14.19 Two laboratories use radiocarbon dating to measure the age of two wooden spear handles found in the same grave. Lab A finds an age of 2250 ± 40 years for the **first** object; lab B finds an age of 2215 ± 50 years for the **second** object. Which is true?

ⓐ Lab A's reading is more accurate than lab B's.
ⓑ Lab A's reading is less accurate than lab B's.
ⓒ Lab A's reading is more precise than lab B's.
ⓓ Lab A's reading is less precise than lab B's.

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Q14.20 On a **line graph**, a horizontal line means that the **dependent variable** …

ⓐ Increases quickly
ⓑ Does not change
ⓒ Decreases slowly
ⓓ Doubles

Q14.21 A **break** in the axis of a graph is used to …

ⓐ Hide some data
ⓑ Expand the space where the data are
ⓒ Change the unit
ⓓ Increase the number of points

Q14.22 Khalid noticed a line of ants in the kitchen and concluded that someone had spilled sugar. What scientific term describes this thinking?

ⓐ Scientific law
ⓑ Inference (a logical conclusion based on observations and evidence)
ⓒ Blind experiment
ⓓ Objective bias

Q14.23 Which scientific procedure do scientists use to evaluate their colleagues' research and ensure objectivity before publishing results?

ⓐ Public voting on social media
ⓑ Changing unexpected results to please companies
ⓒ Peer review by experts in the same field
ⓓ A television advertisement

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Q15 · Multiple-Choice Question (Electronic) · 3 marks

Testable Hypotheses and Variables

Learning outcome: Formulate testable hypotheses and identify variables, constants and controls.

Student Book: Check Your Progress – Ex 2 · p. 65

Explanation

Hypothesis

- A **hypothesis** is a possible explanation for a problem using what you know and observe. It must be **testable** – it can be **supported** or **not supported** by an experiment. It is often written as "**If** … **then** …".

Term	Meaning	Example (Does fertilizer amount affect plant height?)
Independent variable	The factor that **you change**	Amount of fertilizer
Dependent variable	The factor that is **measured**; it changes because of the independent variable	Plant height
Constants	Factors that are **kept the same**	Water, light, soil, pot size
Control	The **standard** used for comparison	Plants that receive no fertilizer

Theory and law (Ex 2 p. 65)

- A **scientific theory** is an explanation of things or events based on many observations and tests – it explains **why**.
- A **scientific law** describes a pattern in nature but does **not explain why** it happens.
- **A theory cannot become a law** because they do different jobs: a law describes, a theory explains.

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Key Ideas from the Student Book

- **Hypothesis:** a possible answer to a question or solution to a problem, based on what we know and observe (a ceramic material may protect the space shuttle).
- **Experiment:** tests the effect of one thing on another using a **control**. **Variable:** a quantity that can have more than one value.

Term	Meaning	Example – microgravity experiment on the ISS
Independent variable	The variable that is **changed** to test its effect	Microgravity
Dependent variable	Changes according to the independent variable	Plant growth
Constant	A factor that does **not** change	Soil type, plant type, light, water, temperature
Control	The standard for comparing results	Plants growing on Earth

Remember

- We **change** the independent variable, **measure** the dependent variable, keep the constants the same and use a control for comparison.

Questions

Q15.1 Which statement is a **testable hypothesis**?

ⓐ Roses are the most beautiful flowers
ⓑ If plants receive more light, then they will grow taller
ⓒ Plants are interesting
ⓓ Science is fun

Q15.2 Why can a **theory never become a law**?

ⓐ A theory explains why something happens, while a law only describes what happens
ⓑ Laws are less reliable than theories
ⓒ Theories are only opinions
ⓓ Laws are always wrong

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Q15.3 In an experiment on how the **volume** of a gas changes with **temperature**, the **dependent variable** is …

ⓐ temperature
ⓑ volume of the gas
ⓒ type of container
ⓓ time of day

Q15.4 Which group is the **control** in a test of a new plant fertilizer?

ⓐ Plants given twice the fertilizer
ⓑ Plants given no fertilizer
ⓒ Plants given a different water amount
ⓓ Plants in a different soil

Q15.5 A student tests how salt concentration affects seed germination. Which should be kept **constant**?

ⓐ Salt concentration
ⓑ Number of seeds germinating
ⓒ Type of seed and amount of water
ⓓ The results

Q15.6 To study the effect of **temperature** on the rate of dissolving salt in water, a student keeps the amount of salt, the amount of water and the stirring the same in every trial. Why?

ⓐ So that temperature is the only factor that affects the rate of dissolving
ⓑ So that the salt dissolves faster
ⓒ Because the amounts are the dependent variables
ⓓ So that no data need to be recorded

Q15.7 Which of the following represents an **educated guess** that can be tested through scientific investigation?

ⓐ Hypothesis
ⓑ Scientific Theory
ⓒ Scientific Method
ⓓ Model

Q15.8 According to the **scientific method**, which of the following is a **possible explanation** for a problem based on prior knowledge and observations?

ⓐ Scientific Theory
ⓑ Scientific Method
ⓒ Hypothesis
ⓓ Model

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Q15.9 Newton provided an explanation for why objects fall; he proposed that objects fall because the object and Earth are attracted by a force. Which of the following represents what Newton said?

ⓐ A scientific hypothesis
ⓑ A scientific theory
ⓒ A scientific model
ⓓ A scientific law

Q15.10 What is the scientific term for the factor the researcher **changes on purpose** to test its effect in an experiment?

ⓐ Independent variable
ⓑ Dependent variable
ⓒ Constant
ⓓ Control

Q15.11 Why do scientists keep factors such as soil type, amount of water and **temperature** as "constants" when testing the effect of microgravity on plants?

ⓐ To change the hypothesis directly into a law
ⓑ To avoid using precise tools
ⓒ Because these factors never affect plants
ⓓ To make sure that any change in plant growth is caused only by microgravity

Q15.12 If data analysis shows that the results "do not support the hypothesis", what should the scientist do?

ⓐ Change the data to match the expectation
ⓑ Modify the hypothesis and form a new testable one
ⓒ Treat the unsupported hypothesis as a general law
ⓓ Stop the research and cancel the hypothesis

Q15.13 In an experiment that measures the height of a plant every day, the **dependent variable** is …

ⓐ Number of days ⓑ Plant height ⓒ Soil type ⓓ Amount of light

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Q16 · Multiple-Choice Question (Electronic) · 3 marks

Steps of Scientific Methods

Learning outcome: List and describe the steps of scientific methods.

Student Book: Check Your Progress – Ex 1 · p. 65

Explanation

Scientific methods are a series of procedures scientists use to answer questions. The steps are **not** always followed in the same order; some steps may be repeated or skipped.

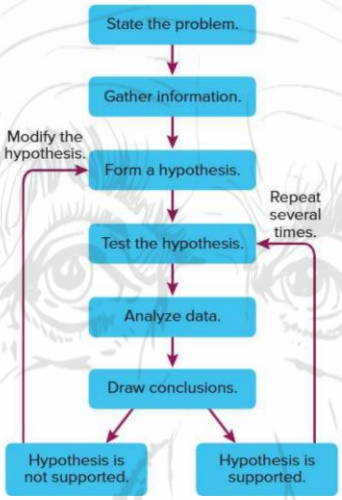


Figure 3 – One way to use scientific methods to solve a problem.

Step	What the scientist does
1. State the problem	Observe something and ask a question
2. Gather information	Research what is already known
3. Form a hypothesis	Propose a testable explanation
4. Test the hypothesis	Experiment, observe or build a **model**
5. Analyze data	Organize results in tables and graphs
6. Draw conclusions	Decide whether the hypothesis is **supported** or **not supported**

Avoiding bias

- **Bias** occurs when a scientist expects a certain result. Repeat trials, use large samples and record all data honestly to **reduce bias**.

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Key Ideas from the Student Book

- **Scientific methods** are general steps followed in investigations; a scientist can add, repeat or skip steps.
- **State the problem:** usually begins with an observation and a "why" or "how" question.
  Gather information: research what is already known from reliable sources.
- After testing, the hypothesis is either **supported** or **not supported**; if it is **not supported**, it is **modified** and tested again several times.
- **Modeling:** building a model that resembles something in order to test it (a model spacecraft); some models show things too small to see (atoms).

Remember

- Steps: problem → information → hypothesis → test → analyze data → conclusion.

Questions

Q16.1 Which step comes **directly after** forming a **hypothesis**?



ⓐ State the problem
ⓑ Test the hypothesis
ⓒ Draw conclusions
ⓓ Gather information

Q16.2 What should a scientist do if the **hypothesis** is **not supported**?

ⓐ Change the data
ⓑ Modify the hypothesis and test again
ⓒ Stop all research
ⓓ Publish the original hypothesis as a law

Q16.3 A student reads articles about bees before designing an experiment. Which step is this?

ⓐ Gather information
ⓑ Analyze data
ⓒ Draw conclusions
ⓓ Test the hypothesis

Q16.4 Which list shows the steps of **scientific methods** in a correct order?

ⓐ Hypothesis → problem → conclusion → test
ⓑ Problem → information → hypothesis → test → analyze → conclusion
ⓒ Conclusion → test → problem
ⓓ Analyze → problem → hypothesis

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Q16.5 Why do scientists **repeat** an experiment several times?

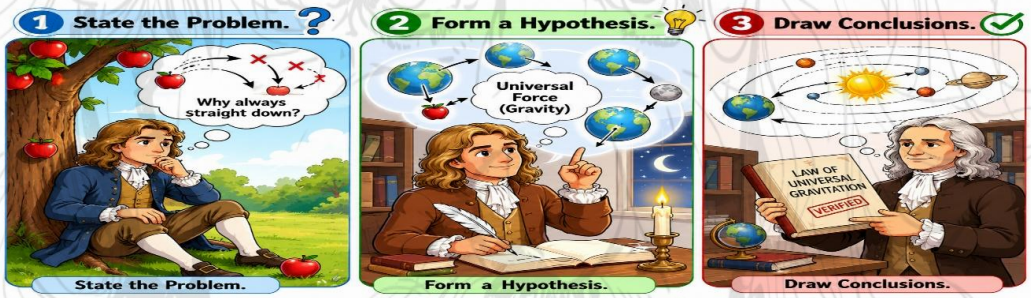
ⓐ To make the results reliable and reduce errors
ⓑ To change the hypothesis each time
ⓒ To use more materials
ⓓ To avoid drawing conclusions

Case study – Isaac Newton

In 1665, Isaac Newton saw an apple fall from a tree. He wondered: **"Why do apples always fall straight down to the ground instead of flying sideways or floating up into the sky?" (1)**

He studied earlier calculations about the Moon's orbit and gathered data about how objects move. He then proposed the idea that **"a hidden, invisible force pulls all objects in the universe toward each other" (2)**, which he called gravity.

He tested his idea with calculations of how planets move. In 1687 he published his book, showing that **"gravity is the universal force that keeps our feet on the ground and the planets in their orbits" (3)**.



Q16.6 Which step of the **scientific method** is represented by the **first** underlined part (1)?

ⓐ Analyze Data
ⓑ Draw Conclusions
ⓒ State the Problem
ⓓ Test the Hypothesis

Q16.7 Which step of the **scientific method** is represented by the **second** underlined part (2)?

ⓐ Form a Hypothesis
ⓑ Gather Information
ⓒ State the Problem
ⓓ Analyze Data

Q16.8 Which step of the **scientific method** is represented by the **third** underlined part (3)?

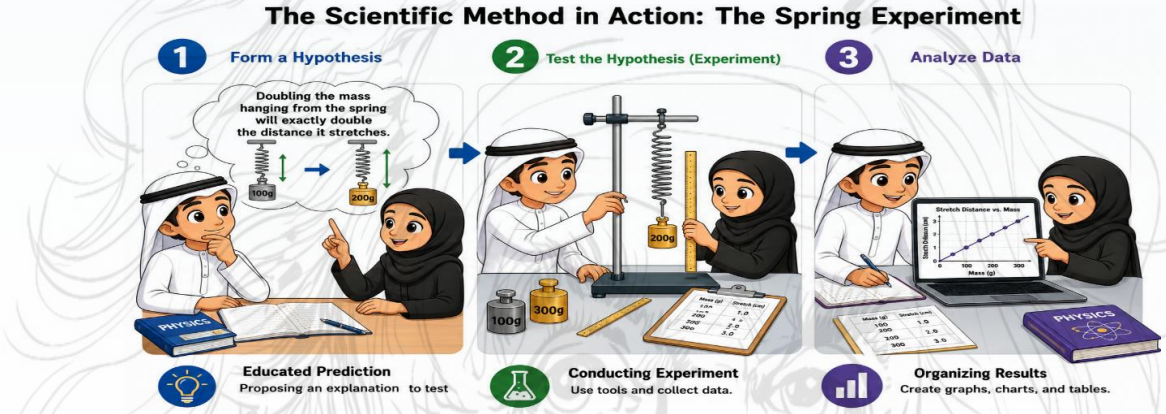
ⓐ State the Problem
ⓑ Form a Hypothesis
ⓒ Gather Information
ⓓ Draw Conclusions

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Case study – The spring lab

Students wanted to know how hanging different weights would change the length of a spring. They searched their textbook about elasticity and thought that **"doubling the mass hanging from the spring would exactly double the distance it stretches" (1)**.

They **"hung weights of 100 g, 200 g and 300 g and carefully measured the stretching distance with a ruler each time" (2)**. Then they **"plotted a straight-line graph showing mass on the x-axis and stretch distance on the y-axis" (3)**. The graph supported their idea.



Q16.9 Which step of the **scientific method** is represented by the **first** underlined part (1)?

ⓐ Form a Hypothesis ⓑ State the Problem
ⓒ Draw Conclusions ⓓ Analyze Data

Q16.10 Which step of the **scientific method** is represented by the **second** underlined part (2)?

ⓐ Gather Information ⓑ Test the Hypothesis
ⓒ Analyze Data ⓓ State the Problem

Q16.11 Which step of the **scientific method** is represented by the **third** underlined part (3)?

ⓐ State the Problem ⓑ Form a Hypothesis
ⓒ Analyze Data ⓓ Draw Conclusions

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Case study – Aristotle and Copernicus

Aristotle proposed that the Earth is at the centre of the universe. Later, Copernicus, through his questions and gathering of information, said that **"the Earth is not the centre of the universe, but the Sun."** He did not test his bold proposal, but later scientists confirmed that the Sun is the centre of our solar system.

Q16.12 In the passage, which step of the **scientific method** is expressed by "Copernicus said that the Earth is not the centre of the universe"?

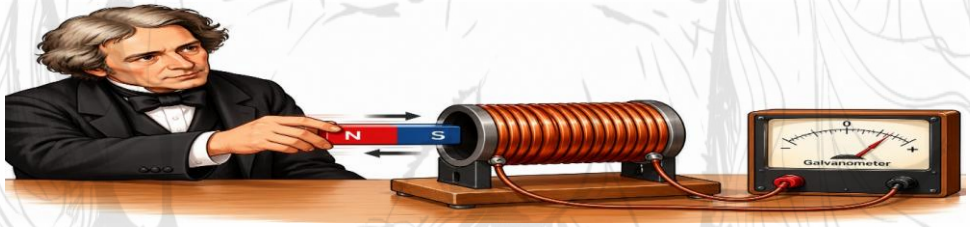
ⓐ State the Problem
ⓑ Form a Hypothesis
ⓒ Research and Gather Information
ⓓ Test a Hypothesis

Case study – Michael Faraday

In 1831, Faraday wondered: **"Can a magnetic field produce an electric current in a wire?" (1)**

He proposed that **"moving a magnet inside a coil of wire will generate an electric current" (2)**.

He **"pushed a bar magnet into and out of a coiled wire connected to a sensitive meter (galvanometer)" (3)**. The needle moved every time the magnet moved, and he concluded that changing magnetic fields produce electricity.



Q16.13 Which step of the **scientific method** is represented by the **first** underlined part (1)?

ⓐ Form a Hypothesis
ⓑ State the Problem
ⓒ Analyze Data
ⓓ Draw Conclusions

Q16.14 Which step of the **scientific method** is represented by the **second** underlined part (2)?

ⓐ Gather Information
ⓑ State the Problem
ⓒ Form a Hypothesis
ⓓ Draw Conclusions

Q16.15 Which step of the **scientific method** is represented by the **third** underlined part (3)?

ⓐ Test the Hypothesis
ⓑ Gather Information
ⓒ Form a Hypothesis
ⓓ State the Problem

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Steps of the scientific method

Q16.16 According to the **scientific method**, if the **hypothesis** is **supported**, which step should be repeated?

ⓐ Draw a Different Conclusion
ⓑ Modify the Hypothesis and Form a New One
ⓒ Test the Hypothesis Again
ⓓ Analyze Data

Q16.17 Which of the following refers to the experimental process used to investigate scientific questions?

ⓐ Hypotheses
ⓑ Scientific Laws
ⓒ Scientific Methods
ⓓ Models

Q16.18 According to the **scientific method**, if the **hypothesis** is **not supported**, which step should be done again?

ⓐ Modify the Hypothesis and Form a New One
ⓑ Test the Hypothesis Again
ⓒ Analyze Data
ⓓ Draw a Different Conclusion

Q16.19 Which of the following is the **first** step in the **scientific method**?

ⓐ Gather Information
ⓑ State the Problem
ⓒ Draw Conclusions
ⓓ Test the Hypothesis

Q16.20 According to the **scientific method**, what should scientists do if the **hypothesis** is supported?

ⓐ Gather Information
ⓑ Continue Testing the Hypothesis
ⓒ State the Problem
ⓓ Form a New Hypothesis

Q16.21 Which of the following terms represents the series of steps or procedure that scientists follow to investigate or solve a problem?

ⓐ Scientific method
ⓑ Hypothesis
ⓒ Scientific law
ⓓ Scientific theory

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Applied scenarios

Q16.22 Mr. Abdelrahman wanted to investigate how the length of a pendulum affects its period. He changed the length of the pendulum, measured the time for each trial, and recorded the results. Which step of the **scientific method** is he performing?



ⓐ State the problem
ⓑ Form a hypothesis
ⓒ Test the hypothesis
ⓓ Draw conclusions

Q16.23 Mr. Abdelrahman is planning a trip to Dubai. Before traveling, he searches magazines and travel guides to learn about tourist attractions and hotels. Which step of the **scientific method** does this action represent?



ⓐ Form a Hypothesis
ⓑ Gather Information
ⓒ State the Problem
ⓓ Analyze Data

Q16.24 Mr. Abdelrahman conducted an experiment to determine the acceleration of a moving car and investigate the relationship between speed and time. After recording the measurements in a data table, he plotted the results on a graph. Which step of the **scientific method** is illustrated by this action?

ⓐ State the problem
ⓑ Form a hypothesis
ⓒ Analyze data
ⓓ Draw conclusions

Q16.25 Mr. Abdelrahman investigated the relationship between speed and time. After analyzing the experimental data and graph, he concluded that the car's acceleration remained **constant** throughout the experiment. Which step of the **scientific method** is illustrated by this action?

ⓐ State the problem
ⓑ Test the hypothesis
ⓒ Analyze data
ⓓ Draw conclusions

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Q17 · Multiple-Choice Question (Electronic) · 3 marks

Arithmetic Interpretations of Data

Learning outcome: Use arithmetic (averages, percentages, conversions and graph readings) to interpret data.

Student Book: Figure 14 · p. 74 · Check Your Progress – Ex 12 · p. 77 · Ex 7 · p. 72

Explanation

∑ Formula

$$\text{Average} = \frac{\text{sum of values}}{\text{number of values}} \qquad \text{Percentage} = \frac{\text{part}}{\text{whole}} \times 100\%$$

∑ Formula

$$\text{Angle in a circle graph} = \frac{\text{part}}{\text{whole}} \times 360^\circ \qquad \text{Density} = \frac{\text{mass}}{\text{volume}}$$

Data to show	Best graph
Change over time (temperature, growth)	Line graph
Comparing separate categories	Bar graph
Parts of a whole (percentages)	Circle graph

Worked example – circle graph (Ex 12 p. 77)

- 144 people: 75 bus, 45 car, 15 carpool, 9 walk. Parts of a whole → **circle graph**.
- Bus angle $= \frac{75}{144} \times 360^\circ = 187.5^\circ$; Car $= \frac{45}{144} \times 360^\circ = 112.5^\circ$.

Exact standards (Ex 7 p. 72)

- Exact standards of measurement (SI) are important so that scientists everywhere get the **same value** for the same quantity and can **compare and repeat** each other's results.

Key Ideas from the Student Book

- **Average (mean)** = sum of values ÷ number of values. Squirrel breaths in 5 minutes: 65, 73, 67, 71, 62 → sum 338 → 338 ÷ 5 = 67.6 breaths per minute.
- **Conversion factor:** a ratio equal to 1 used to change units; multiply so that the old unit cancels (1.255 L × 1000 mL/1 L = 1255 mL; 3075 mm × 1 cm/10 mm = 307.5 cm; 1.5 L = 1500 cm^3).

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- Steps: write the known value with its unit → choose the factor with the new unit on top → multiply and cancel units → check: a **smaller unit gives a larger number**.
- **Circle-graph angle** = fraction × 360°; e.g. 18 ÷ 72 = 0.25 and 0.25 × 360° = 90°.

Remember

- Mean = sum ÷ number of values.
- 1 mL = 1 cm³; kilo = 1000, centi = 0.01, milli = 0.001.

Questions

Q17.1 A squirrel takes 65, 73, 67, 71 and 62 breaths in five minutes. What is the **average** number of breaths per minute?

ⓐ 65.0 ⓑ 67.6 ⓒ 68.2 ⓓ 338

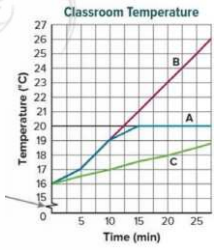
Q17.2 Which graph **best** shows how 144 people travel to work (bus, car, carpool, walk)?

ⓐ Line graph ⓑ Circle graph
ⓒ Scatter plot ⓓ Distance–time graph

Q17.3 In a survey, 56 out of 245 people prefer orange juice. What percentage of a **circle graph** is this?

ⓐ 22.9% ⓑ 43.8% ⓒ 5.6% ⓓ 56%

Q17.4 By how many degrees did Room B warm between 0 min and 25 min?



ⓐ 4 °C ⓑ 9 °C ⓒ 16 °C ⓓ 25 °C

Q17.5 Why is it important to have **exact standards** of measurement?

ⓐ So that measurements can be compared and repeated by everyone
ⓑ So that each country uses its own units
ⓒ So that results are always different
ⓓ Because units are not needed

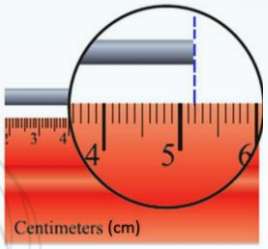
Q17.6 An unknown metal has a **mass** of 158 g and a **volume** of 20 mL. What is its **density**?

ⓐ 3.16 g/mL ⓑ 7.9 g/mL ⓒ 138 g/mL ⓓ 0.13 g/mL

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Q17.7 A student recorded the length of the metal tube shown in the figure as 5.00 cm. What is the **percent error** of this measurement?

ⓐ 2.20% ⓑ 3.33% ⓒ 3.85% ⓓ 4.76%



Q17.8 The length of a test tube is 14.75 cm. A student measured it as 14.65 cm. What is the **percent error** in the student's measurement?

ⓐ 0.950% ⓑ 0.750% ⓒ 0.678% ⓓ 0.569%

Q17.9 What is the **volume** of a book with the dimensions: length = 31.4 cm, width = 21.6 cm, height = 2.58 cm? Round the answer to the correct number of **significant figures**.

ⓐ 1751 cm^3 ⓑ 1750 cm^3 ⓒ 1749.8 cm^3 ⓓ 1749 cm^3

Q17.10 A cube has a **mass** of 44.5 g and a **volume** of 5.65 cm^3. Which material is the cube made of?

ⓐ Aluminum (2.70 g/cm^3) ⓑ Iron (7.87 g/cm^3)
ⓒ Copper (8.96 g/cm^3) ⓓ Silver (10.49 g/cm^3)

Q17.11 A graph of **mass** against **volume** for aluminum passes through the points (10.0 cm^3, 27 g) and (20.0 cm^3, 54 g). What is the **density** of aluminum?

ⓐ 0.27 g/cm^3 ⓑ 0.37 g/cm^3 ⓒ 2.7 g/cm^3 ⓓ 3.7 g/cm^3

Q17.12 A metal piece of **mass** 147 g and **density** 7.0 g/cm^3 is placed in a graduated cylinder containing 20.0 mL of water. What will the new water level be?

ⓐ 21.0 mL ⓑ 27.0 mL ⓒ 41.0 mL ⓓ 167 mL

Q17.13 Express the number 6 550 000 in **scientific notation**.

ⓐ 6.55×10^5 ⓑ 6.55×10^6 ⓒ 65.5×10^6 ⓓ 6.55×10^{-6}

Q17.14 Find $(4 \times 10^7) + (5 \times 10^7)$ and write the answer in **scientific notation**.

ⓐ 9×10^7 ⓑ 9×10^{14} ⓒ 20×10^7 ⓓ 9×10^{49}

Q17.15 Round 4.86351 to **four significant figures**.

ⓐ 4.863 ⓑ 4.864 ⓒ 4.86 ⓓ 4.8635

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Q17.16 How many **significant figures** does the measurement 807.00 cm contain?

ⓐ 3 ⓑ 4 ⓒ 5 ⓓ 2

Q17.17 Using a conversion factor, if you have 1.255 L of a liquid, what is this **volume** in millilitres (mL)?

ⓐ 12.55 mL ⓑ 125.5 mL ⓒ 0.001255 mL ⓓ 1255 mL

Q17.18 What is the correct **scientific notation** for 0.00052?

ⓐ 5.2×10^{3} ⓑ 5.2×10^{-4} ⓒ 52×10^{-3} ⓓ 0.52×10^{-2}

Q17.19 Using dimensional analysis, how many seconds are there in two hours?

ⓐ 120 s ⓑ 720 s ⓒ 3600 s ⓓ 7200 s

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Q18 · Multiple-Choice Question (Electronic) · 3 marks

Measurement Tools and SI Units

Learning outcome: Choose the appropriate measurement tool and SI unit for a quantity, and convert between units.

Student Book: Practice Problem – Ex 5 · p. 68

Explanation

Quantity	SI unit	Tool
Length	metre (m)	Metric ruler, metre stick, **tape measure**, **micrometer** (very small lengths)
Mass	kilogram (kg)	Balance
Volume of a liquid	litre (L) / cubic centimetre (cm^3)	Graduated cylinder
Temperature	kelvin (K)	Thermometer
Time	second (s)	Stopwatch, clock



Figure 11 – A tape measure measures in metres; a micrometer measures very small lengths.

Prefix	Symbol	Multiplying factor
kilo-	k	1000
centi-	c	0.01
milli-	m	0.001
micro-	μ	0.000 001
nano-	n	0.000 000 001

Ex 5 p. 68 – worked conversion

- Pencil length = 11 cm. Since 1 cm = 10 mm: $11\ \text{cm} \times \frac{10\ \text{mm}}{1\ \text{cm}} = 110\ \text{mm}$.

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Key Ideas from the Student Book

- **SI** is an improved version of the metric system (1960); its standards are accepted worldwide and based on physical constants. Seven **base units**; all other units are **derived**.
- Prefixes are based on **multiples of ten**: kilo (k) 1000, deci (d) 0.1, centi (c) 0.01, milli (m) 0.001, micro (μ) 0.000 001, nano (n) 0.000 000 001.
- **Length:** distance between two points (metre, a little longer than a yard). Choose the unit by object size: tape measure for metres, micrometer for very short lengths, kilometre for long distances.
- **Volume:** space occupied by an object; for a rectangular solid $V = l \times w \times h$ (cm^3 or m^3). Liquids are measured in millilitres: 1 mL = 1 cm^3.
- **Temperature:** water freezes at 0 °C and boils at 100 °C (body temperature 37 °C); 32 °F and 212 °F on the Fahrenheit scale; 273 K and 373 K on the Kelvin scale. Absolute zero: 0 K ≈ −273 °C.
- K = °C + 273 (27 °C = 300 K). Do **not** use the degree sign with kelvin: write 273 K, **not** 273 °K.

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Remember

- SI base units: m, kg, s, A, K, mol, cd.
- Celsius to kelvin: **add 273**.

Questions

Q18.1 A pencil is 11 cm long. How long is it in millimetres?

ⓐ 1.1 mm ⓑ 110 mm ⓒ 1100 mm ⓓ 0.11 mm

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Q18.2 Which tool is **best** for measuring the **thickness of a wire**?

ⓐ Tape measure ⓑ Micrometer
ⓒ Graduated cylinder ⓓ Thermometer



Q18.3 What is the SI **base unit** of **mass**?

ⓐ gram ⓑ kilogram ⓒ newton ⓓ litre

Q18.4 Convert 27 °C to **kelvins**.

ⓐ 246 K ⓑ 300 K ⓒ 273 K ⓓ 327 K

Q18.5 Which unit is **most appropriate** for the distance from your home to school?

ⓐ millimetre ⓑ centimetre ⓒ kilometre ⓓ micrometre

Q18.6 Which tool measures the **volume of a liquid**?

ⓐ Balance ⓑ Graduated cylinder
ⓒ Metre stick ⓓ Stopwatch

Q18.7 Thermometers A and B show the **same temperature**.
Thermometer A reads 25 °C. What does thermometer B read?

ⓐ 25 K ⓑ 248 K ⓒ 298 K ⓓ 323 K

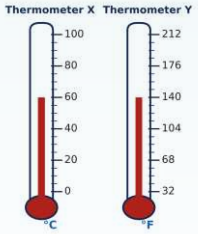


Q18.8 Compare the scales of thermometers A (°C) and B (K). Which statement is correct?

ⓐ One division on the Celsius scale equals one division on the Kelvin scale
ⓑ One kelvin is larger than one degree Celsius
ⓒ Zero on both scales is the same temperature
ⓓ The Kelvin scale can have negative values

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Q18.9 Thermometer X (°C) and thermometer Y (°F) show the same **temperature**. How many **degrees** are there between the freezing and boiling points of water on each scale?

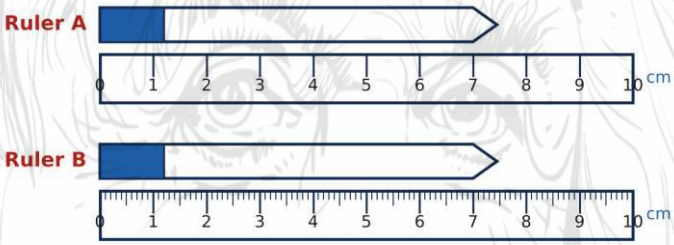


ⓐ 100 on X and 100 on Y ⓑ 100 on X and 180 on Y
ⓒ 180 on X and 100 on Y ⓓ 212 on X and 100 on Y

Q18.10 Thermometer X reads 60 °C. What does thermometer Y read?

ⓐ 92 °F ⓑ 108 °F ⓒ 140 °F ⓓ 333 °F

Q18.11 The same pencil is measured with Ruler A and Ruler B. Which statement is correct?

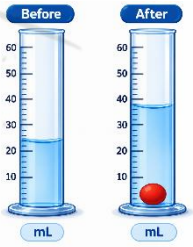


ⓐ Ruler A is more precise because it has fewer divisions
ⓑ Ruler B is more precise because its smallest division is 1 mm
ⓒ Both rulers have the same precision
ⓓ Ruler A gives the reading 7.45 cm

Q18.12 What is the **best** reading of the pencil length using **Ruler B**?

ⓐ 7 cm ⓑ 7.4 cm ⓒ 7.45 cm ⓓ 8 cm

Q18.13 A small stone is placed in the graduated cylinder. What is the **volume of the stone**?



ⓐ 14 mL ⓑ 24 mL ⓒ 38 mL ⓓ 62 mL

Q18.14 If the stone in the graduated cylinders has a **mass** of 42 g, what is its **density**?

ⓐ 0.33 g/mL ⓑ 1.75 g/mL ⓒ 3.0 g/mL ⓓ 588 g/mL

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Q18.15 Which of the following is **not** a **base unit** in the International System of Units (SI)?

ⓐ Luminous intensity (cd) ⓑ Electric current (A)
ⓒ Temperature (K) ⓓ Volume (cm^3)

Q18.16 Which of the following is a **derived** unit?

ⓐ Cubic metre (m^3) ⓑ Second (s) ⓒ Kilogram (kg) ⓓ Metre (m)

Q18.17 Which of the following is a **base** unit?

ⓐ m^3 ⓑ g/cm^3 ⓒ L ⓓ kg

Q18.18 Which group contains **only derived** quantities?

ⓐ Density, volume, speed ⓑ Length, time, temperature
ⓒ Mass, length, density ⓓ Time, speed, mass

Q18.19 What is the correct conversion of the **temperature** $-39\,°C$?

ⓐ 39 °F ⓑ -39 °F ⓒ 234 K ⓓ 312 K

Q18.20 Ethanol boils at 351 K. What is the boiling point of ethanol in degrees **Celsius**?

ⓐ -78 °C ⓑ -22 °C ⓒ 78 °C ⓓ 22 °C

Q18.21 What property is described by the measurement 298 K?

ⓐ Mass ⓑ Temperature ⓒ Time ⓓ Length

Q18.22 The **temperature** of a glass of water rises to $55\,°C$. What is its temperature in **kelvins**?

ⓐ -195 K ⓑ -351 K ⓒ 328 K ⓓ 195 K

Q18.23 Convert $-50\,°C$ to **kelvins**.

ⓐ 223 K ⓑ 323 K ⓒ -223 K ⓓ 50 K

Q18.24 If the **temperature** outside is $36\,°C$, what is the temperature in degrees **Fahrenheit**? ($°F = 1.8\,°C + 32$)

ⓐ 64.8 °F ⓑ 96.8 °F ⓒ 309 °F ⓓ 2.2 °F

Q18.25 The **temperature** in a city reaches $104\,°F$. What is this temperature in degrees **Celsius**?

ⓐ 40 °C ⓑ 72 °C ⓒ 58 °C ⓓ 219 °C

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Q18.26 What is the measurement 4.852 mm in kilometres, expressed in **scientific notation**?

ⓐ 4.852×10^{-2} km ⓑ 4.852×10^{-3} km ⓒ 4.852×10^{-4} km ⓓ 4.852×10^{-6} km

Q18.27 Convert 3.600×10^{3} cm to kilometres.

ⓐ 0.03600 km ⓑ 0.3600 km ⓒ 36.00 km ⓓ 3.600 km

Q18.28 Convert 5000 g to kilograms.

ⓐ 0.5 kg ⓑ 5 kg ⓒ 50 kg ⓓ 5 000 000 kg

Q18.29 What is the name of the prefix that represents 10^{6}?

ⓐ Giga ⓑ Mega ⓒ Kilo ⓓ Micro

Q18.30 What is the unit of **temperature** in the International System of Units (SI)?

ⓐ Fahrenheit (°F) ⓑ Calorie
ⓒ Degree Celsius (°C) ⓓ Kelvin (K)

Q18.31 What is the multiplying factor for the prefixes "milli (m)" and "kilo (k)" respectively?

ⓐ milli = 0.001, kilo = 1000 ⓑ milli = 1000, kilo = 0.001
ⓒ milli = 0.000001, kilo = 1 000 000 ⓓ milli = 0.01, kilo = 100

Q18.32 Why do scientists use an internationally accepted system of units (such as SI)?

ⓐ To share their results internationally
ⓑ To make equations more complicated
ⓒ To use old measuring tools
ⓓ To keep research secret

Q18.33 According to the table of SI base units, which unit is used to measure electric current?

ⓐ Second (s) ⓑ Ampere (A) ⓒ Kelvin (K) ⓓ Candela (cd)

Q18.34 In the table of SI prefixes, what is the numerical value of the prefix "centi (c)"?

ⓐ 0.1 ⓑ 0.000001 ⓒ 0.01 ⓓ 0.001

Q18.35 How can we calculate the **volume** of a regular rectangular solid (such as a brick)?

ⓐ Add length and width ⓑ Multiply length × width × height
ⓒ Divide mass by density ⓓ Measure only the area

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Q18.36 In **volume** measurements, which cubic unit is exactly equal to 1 mL of a liquid?

ⓐ 1 cubic metre
ⓑ 1 cubic kilometre
ⓒ 1 cubic centimetre (cm^3)
ⓓ 1 cubic millimetre

Q18.37 What is the value of "absolute zero" (the lowest possible **temperature**) on the **Celsius** scale?

ⓐ 0 °C ⓑ −100 °C ⓒ −273 °C ⓓ 273 °C

Q18.38 On the **Fahrenheit** scale, at what **temperature** does water freeze?

ⓐ 0 °F ⓑ 32 °F ⓒ 100 °F ⓓ 212 °F

Q18.39 The mole is an SI unit. Which quantity is it used to measure?

ⓐ The number of particles in a substance
ⓑ The compounds that form a substance
ⓒ The number of elements in a substance
ⓓ The total mass of a substance

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Q19 · Multiple-Choice Question (Electronic) · 3 marks

Genetic Variation and Reproduction

Learning outcome: Explain how sexual reproduction produces genetic variation, and why variation matters for future medical and agricultural needs.

Student Book: Check Your Progress – Ex 5 · p. 36

Explanation

	Sexual reproduction	Asexual reproduction
Parents	Two	One
Offspring	Genetically **different** from parents and from each other	Genetically **identical** to the parent (clones)
Genetic variation	**High** – genes from two parents are combined	**Low**
Advantage	Population can adapt to changing environments	Fast; many offspring; no partner needed

Biodiversity and future medical needs (Ex 5 p. 36)

- Many medicines come from organisms: **penicillin** from a fungus, aspirin-like compounds from willow bark, cancer drugs from the Madagascar periwinkle. Losing species and genetic diversity means losing **possible future medicines**.

Key Ideas from the Student Book

- **Direct economic value:** food, clothing, energy, medicine, shelter, and wild genes to improve crops (teosinte).
- Medicines from organisms: **penicillin** from the fungus Penicillium (Alexander Fleming, 1928); **aspirin** from salicin in willow trees; the **Madagascar periwinkle** treats some leukemias – survival rose from 20% to more than 95%.
- **Genetic engineering** moves genes from one species to another to produce insect-resistant crops or crops with higher nutritional value.
- High biodiversity makes an ecosystem more **stable**, better able to provide its services and to withstand change.

Remember

- Wild species are a **reservoir of useful genes** and possible future medicines.

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Questions

Q19.1 Which type of reproduction produces the **greatest genetic variation**?

ⓐ Budding
ⓑ Cloning
ⓒ Sexual reproduction
ⓓ Fragmentation

Q19.2 Offspring produced by **asexual** reproduction are …

ⓐ genetically identical to the parent
ⓑ always stronger than the parent
ⓒ from two parents
ⓓ highly variable

Q19.3 Why is it important to maintain **biodiversity** for **future medical needs**?

ⓐ Many medicines come from organisms, and undiscovered species may provide new medicines
ⓑ Medicines are only made from rocks
ⓒ All medicines have already been discovered
ⓓ Biodiversity increases disease

Q19.4 A **population** of plants that reproduces only asexually faces a new fungus. What is the **most** likely result?

ⓐ All plants survive
ⓑ Many plants may die because they share the same genes
ⓒ The plants change their genes instantly
ⓓ The fungus disappears

Q19.5 Which statement about **sexual reproduction** is correct?

ⓐ It produces offspring identical to one parent
ⓑ It increases the chance that some offspring survive environmental change
ⓒ It needs only one parent
ⓓ It reduces genetic diversity

Q19.6 What agricultural benefit did the wild teosinte plant give modern corn crops?

ⓐ It gave corn genes that resist viral diseases that destroy crops
ⓑ It removed useful soil worms
ⓒ It increased the irrigation water used
ⓓ It turned corn into floating plants

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Q19.7 From which organisms are the antibiotic "penicillin" and the painkiller "salicin (aspirin)" obtained?

ⓐ Penicillin from oak trees and salicin from bread mould
ⓑ Both from teosinte
ⓒ Penicillin from the mould Penicillium and salicin from the willow tree
ⓓ Both from Asian ladybird beetles

Q19.8 The drug "vinblastine" from the Madagascar periwinkle caused a medical revolution in treating which disease?

ⓐ Lack of oxygen in swamp water
ⓑ Acid-rain diseases in forests
ⓒ DDT poisoning in birds
ⓓ Blood cancer (leukemia) in children, raising survival to more than 95%

Q19.9 Which is an example of the **indirect** economic value of healthy **biodiversity** in **ecosystems**?

ⓐ Natural water purification, nutrient recycling and protecting soil from erosion
ⓑ Extracting aspirin from willow bark
ⓒ Selling timber cut from forests in local markets
ⓓ Harvesting wheat and rice as food for people

Q19.10 How much money did New York save when it decided to clean and protect the natural Catskill watersheds instead of building an industrial water-treatment plant?

ⓐ It spent 100 billion dollars to clean the air
ⓑ It saved only 1000 dollars a year
ⓒ It saved nothing because the plant is much cheaper
ⓓ It saved billions of dollars

Q19.11 Protecting natural places such as Emerald Bay at Lake Tahoe for their beauty and purity from urban expansion represents which kind of importance of **biodiversity**?

ⓐ Direct economic value
ⓑ Indirect economic value
ⓒ Aesthetic and scientific values
ⓓ Ecosystem diversity only

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Q20 · Multiple-Choice Question (Electronic) · 3 marks

Science and Technology

Learning outcome: Explain how scientific knowledge leads to new technology, and how models and simulations are used.

Student Book: Get It? · p. 63 · Figure 7 · p. 64

Explanation

Science is the study of the natural world; **technology** is the practical **use of scientific knowledge** to solve problems and improve life. New science produces new technology, and new technology (microscopes, computers) helps scientists make new discoveries.



Figure 7 – A computer simulation of an aircraft landing: pilots practise in conditions that would be dangerous in a real plane.

Type of model	Use	Example
Physical model	A smaller or larger copy of an object	Globe, model of a cell
Mathematical model	Equations or graphs that describe a system	Population-growth equation
Computer model / simulation	Tests events that are **too large, too slow, too fast or too dangerous**	Flight simulator, weather forecast
Biotechnology	Using organisms to make products	Insulin made by bacteria, virus-resistant crops

Peer review (Get It? p. 63)

- Before results are published, other scientists **check** the methods and conclusions. This helps make sure the information is **reliable** and free from **bias**.

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Key Ideas from the Student Book

- Scientific explanations may need to **change** as knowledge grows or new technology appears: Thomson's atom (1904) → Rutherford's nucleus (1911) → today's electron-cloud model.
- Some investigations are only observing and recording; others are controlled experiments. Rocket studies changed the question from "How do we steer the rocket?" to "How do we protect the instruments?".
- **Science and technology:** investigations (such as finding a material to protect the space shuttle) lead to **technology** that improves our lives.
- **Model:** a representation of an idea, event, structure or object – used when an object is too large or too small, a process takes too long, or a material is **dangerous** (Lord Kelvin's balls in jelly; computer flight simulators).
- **Scientific theory** explains why and how, and can be modified; **scientific law** describes what happens without explaining why. A theory does **not** become a law. Science **cannot** answer questions of opinion or values.

Remember

- Science is changeable; models and technology help us study things we **cannot** observe directly.
- A theory **explains**, a law **describes**.

Questions

Q20.1 What is **technology**?

ⓐ The study of living things
ⓑ The practical use of scientific knowledge
ⓒ An opinion about nature
ⓓ A scientific law

Q20.2 Why are pilots trained using the simulator in Figure 7?



ⓐ Simulators are slower than real planes
ⓑ They can practise dangerous situations safely
ⓒ Real planes do not need pilots
ⓓ Simulators show only historical data

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Q20.3 Scientists use bacteria to produce human insulin. This is an example of …

ⓐ biotechnology ⓑ a scientific law ⓒ peer review ⓓ bias

Q20.4 Why do scientists use **peer review**?

ⓐ To make sure research is reliable before it is published
ⓑ To keep results secret
ⓒ To change data
ⓓ To stop other scientists from repeating experiments

Q20.5 Which is the **best** example of a model that represents something too large to observe **directly**?

ⓐ A model of the solar system ⓑ A real frog
ⓒ A thermometer ⓓ A beaker of water

Q20.6 Research that scientists carry out to gain knowledge **for its own sake** (**not** to solve a practical problem) is called …

ⓐ Pure science ⓑ Technology ⓒ Applied science ⓓ Engineering

Q20.7 The branch of science that studies the relationships between **matter** and **energy**, and how they interact, is:

ⓐ Chemistry ⓑ Physics ⓒ Geology ⓓ Biology

Q20.8 Why do scientists often use "computer simulations" instead of real tests?

ⓐ Computer models always give unreal results
ⓑ It is an old method used only in the 19th century
ⓒ Computer programs remove the need to learn to fly
ⓓ When the process is very dangerous or very costly, such as training pilots in bad weather

Q20.9 Scientists use "……" to represent a process, a system or a **simulation**.

ⓐ Books ⓑ Experiments ⓒ Models ⓓ Pictures

Q20.10 What is the essential difference between a "scientific law" and a "scientific theory"?

ⓐ A law is a first guess and a theory is an absolute fact
ⓑ A law describes "what happens" in nature, while a theory explains "why it happens"
ⓒ A law applies only in space and a theory only on Earth
ⓓ A theory becomes a law just by repeating an experiment 3 times

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Q20.11 Why can a **scientific theory never** change into a **scientific law**, however strong the evidence?

ⓐ Theories are always weak and unreliable
ⓑ Laws are not based on experiments or observations
ⓒ Scientists agreed to stop changing theories in 1960
ⓓ They are two different things: a theory gives a scientific explanation of causes, while a law describes the natural pattern only

Q20.12 Which question **cannot** be answered by science and lies outside the limits of scientific research?

ⓐ Is this oil painting beautiful and attractive?
ⓑ How does light affect the rate of photosynthesis?
ⓒ What is the speed of sound in dry air?
ⓓ What is the boiling point of pure water at sea level?

Q20.13 How do scientific investigations help develop **technology** and improve daily life?

ⓐ By preventing computers in laboratories
ⓑ By limiting science to theoretical equations without products
ⓒ By replacing scientific experiments with random guesses
ⓓ Through practical applications such as artificial limbs and heat-resistant coatings for rockets

Q20.14 What happens to a "scientific theory" when scientists discover new information or advanced evidence?

ⓐ It automatically becomes an unaccepted personal opinion
ⓑ It is modified, developed or replaced by a more complete theory (like the development of atomic models)
ⓒ It changes directly into an SI base unit
ⓓ New information is rejected to protect the old theory

Q20.15 What is the scientific explanation of a natural phenomenon supported by a large number of observations and experiments?

ⓐ Factor ⓑ Hypothesis ⓒ Result ⓓ Theory

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Q21 · Written Question (Paper) · 10 marks

Biotic and Abiotic Factors · Sustainable Ecosystems · Recycling of Matter

Learning outcome: Identify biotic and abiotic factors; distinguish sustainable from unsustainable ecosystems; explain how matter is recycled.

Student Book: Figure 5 · Get It? · p. 8 · Figure 19 · p. 21 · Check Your Progress – Ex 3, 4 · p. 24

Explanation

Biotic factors (living)	Abiotic factors (non-living)
Plants, animals, fungi, bacteria, algae	Temperature, light, water, soil, air, pH, salinity
Deer, frogs, fish, insects in a stream	Water current, rocks, dissolved oxygen, minerals



Figure 5 – The deer is a biotic factor; the water, rocks and air are abiotic factors.

Get It? p. 8 – how organisms depend on each other

- The deer drinks the water (abiotic) and eats plants (biotic); frogs eat insects; algae produce oxygen and food. Organisms depend on others for **food, shelter, pollination and reproduction**.

Sustainable ecosystem	Unsustainable ecosystem
Matter is recycled by decomposers; resources are replaced	**Resources used faster than they are replaced**
Balanced populations of producers, consumers and decomposers	**Loss of species, pollution, overharvesting**
High biodiversity and stability	**Low biodiversity; easily damaged**

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Nitrogen cycle (Ex 3, 4 p. 24)

- **Living parts:** nitrogen-fixing bacteria, plants, animals, decomposers. **Non-living parts:** N_2 in the air, ammonia, nitrates in soil, lightning.

- Plants in the **carbon cycle** take in CO_2 for photosynthesis and release O_2; plants in the **nitrogen cycle** absorb nitrates from the soil to make proteins. In both, plants move matter from the abiotic to the biotic part of the ecosystem.

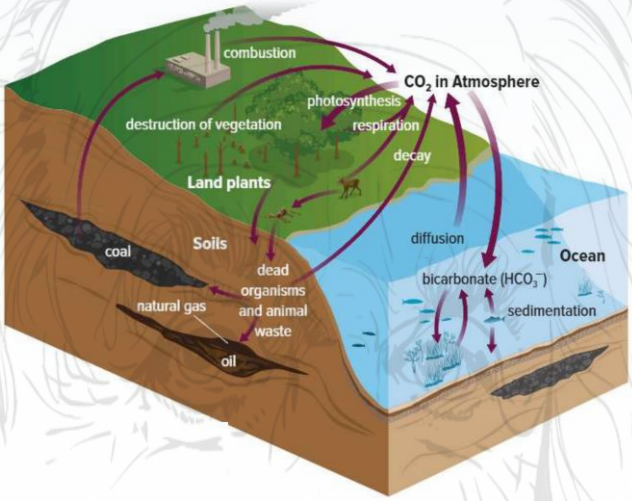


Figure 19 – Carbon moves between the abiotic and biotic parts of the ecosystem.

Key Ideas from the Student Book

- **Biotic factors:** the living factors in an organism's environment – for salmon: other fish, frogs, algae, microorganisms, and birds and animals on nearby land.
- **Abiotic factors:** the nonliving factors – temperature, air or water currents, sunlight, soil type, rainfall, nutrients; for salmon: water temperature, pH and salt concentration.
- An organism moved to an environment with different abiotic factors may **die** if it **cannot adapt** (a green-leaved swamp plant dies in the desert).
- **Cycling of matter supports sustainability:** matter is **not destroyed**; it moves between the biotic and abiotic parts, so it stays available to organisms.

Remember

- Biotic = living; abiotic = nonliving.
- Matter cycles, so ecosystems can be **sustainable**.

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Questions



Q21.1 Study Figure 5, which shows a deer standing on a rock in a stream **community**.

A. Identify **two biotic factors** and **two abiotic factors** in this stream **community**.

.....

.....

B. Explain how the deer depends on **one biotic factor** and **one abiotic factor**.

.....

.....

C. Predict what would happen to the stream **community** if the water became heavily polluted.

.....

.....

Q21.2 Use Figure 19 and your knowledge of the carbon and nitrogen cycles.

A. Describe how carbon moves from the **abiotic** part (atmosphere) to the **biotic** part of the **ecosystem** and back again.

.....

.....

.....

B. Identify the living and non-living parts of the **nitrogen cycle**.

.....

.....

C. Compare and contrast the role of **plants** in the carbon and nitrogen cycles.

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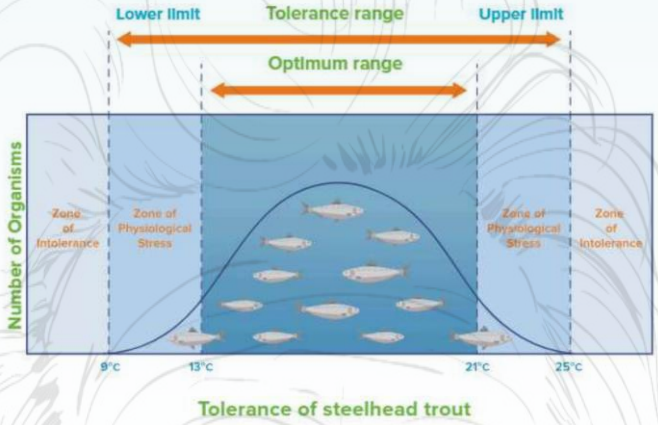
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D. State **one** difference between a sustainable and an unsustainable **ecosystem**.

.....

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Q21.3 Fill in the blanks in the table to compare and contrast between **biotic** and **abiotic** factors. Then use Figure 6 – the **tolerance** of steelhead trout – to answer the questions.



A. Biotic factors – definition and one example.

.....

.....

B. Abiotic factors – definition and one example.

.....

.....

C. Using Figure 6, which factor limits the survival of the trout?

.....

D. What is the ability of organisms to survive **biotic** or **abiotic factors** called?

.....

E. Using Figure 6, state the **optimum range** of **temperature** for the trout.

.....

Q21.4 Deep ocean vents, African wildlife, and arctic glaciers are all part of the ..... .

Word bank: biosphere • ecosystem • population

Answer:

.....

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Q21.5 Classify each factor as **biotic** or **abiotic**.

Statement / Item	Your answer
Temperature	
Algae	
Soil pH	
Soil bacteria content	
Wind	
Plant life	
Predators	
Water	

Q21.6 How do **abiotic factors** affect **biotic factors**? Give an example.

Answer:

.....

.....

.....

Q21.7 The amount of oxygen in a fish tank is a .... that affects the amount of fish that can live in the tank.

Answer:

.....

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Q21.8 In an environment, many factors affect a **population**'s growth and survival. These include …… (1), which are all the living factors in an organism's environment. There are also …… (2), which are all the nonliving factors, such as water, sunlight, **temperature**, and …… (3), which are chemical substances that organisms use to carry out processes and sustain life.

Any factor that restricts the number, distribution, or reproduction of a population is a …… (4). To survive, organisms must have a certain level of …… (5), the ability to survive these factors.

Word bank: limiting factor • nutrients • abiotic factors • biotic factors • tolerance

Answer:

.....

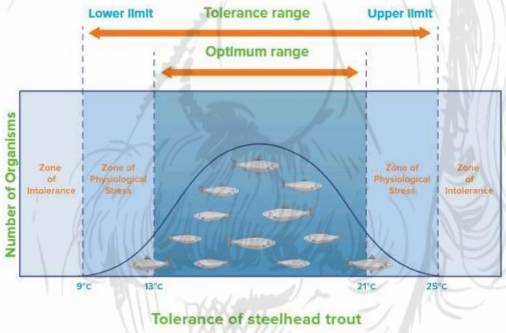
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Q21.9 Predict the general growth trend for steelhead trout in a stream that is 22°C



Answer:

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Q21.10 Match each description to the correct key term.

Word bank: biological community • biome • population • organism

Statement / Item	Your answer
A large school of barracuda	
A barracuda	
All the conifer forests growing in Canada	
All the groups of organisms that interact with each other in the same region	

Q21.11 Match each example to its level of organization.

Word bank: population • biome • ecosystem • biological community

Statement / Item	Your answer
All the salmon living in a lake	
The deciduous forests of the eastern United States	
All the living and nonliving things in an oasis pond in the desert	
All the corals, invertebrates and fish in a coral reef in the Red Sea	

Q21.12 The algae, insect larvae, protozoans, and other living things in a large puddle would be an example of a(n) …… .

Word bank: population • ecosystem • biological community

Answer:

.....

Q21.13 The region of land a jaguar must roam to collect food would be an example of a(n) …… .

Word bank: habitat • biome • ecosystem

Answer:

.....

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Q21.14 An organism in a **community** inhabits a specific physical area, or …… (1). Each organism has a unique role to play, known as its …… (2).

A **biological community** and all the **biotic** and **abiotic factors** that affect it is called a(n) …… (3). When several of these have the same climate and similar communities, they are classified as a(n) …… (4).

Answer:

.....

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.....

Q21.15 Compare between a **habitat** and a **niche**. Give one example of each.

Answer:

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.....

.....

Q21.16 Describe one example each of **competition** and **predation**.

Answer:

.....

.....

Q21.17 A remora fish swimming beneath a shark to collect scraps while the shark remains unaffected is an example of …… .

Answer:

.....

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Q21.18 Choose the type of relationship that **best** defines each scenario.

Word bank: competition • parasitism • predation • commensalism

Statement / Item	Your answer
Red-tailed hawks and black racer snakes prey on the same species of rodents in the same habitat.	
One organism benefits, while another is unharmed during a long-term relationship between the two.	
A tick becomes lodged on the skin of a hiker.	
Coyotes eat mice and rabbits.	

Q21.19 The movement of chemicals on a global scale from **abiotic** through **biotic** parts of the environment is a …… …… .

Answer:

.....

Q21.20 The exchange of **matter** through the …… is called the **biogeochemical cycle**.

Word bank: atmosphere • biosphere • community • population

Answer:

.....

Q21.21 Why is it important to living organisms that **nutrients** cycle?

Answer:

.....

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Q21.22 Write the name of each process in the **water cycle**.

Word bank: evaporation • transpiration • condensation • precipitation • percolation • runoff

Statement / Item	Your answer
Water vapor rises, cools, and forms clouds	
Water evaporates from the surfaces of plants	
Water falls from clouds as rain or snow	
Water seeps through the soil	
Water flows over the surface into streams and rivers	
Water from oceans and lakes changes into water vapor	

Q21.23 Summarize the five **main** processes in the carbon and oxygen cycle.

Answer:

.....

.....

.....

Q21.24 What happens to the carbon in organisms when they die? How is carbon stored in aquatic **ecosystems**?

Answer:

.....

.....

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Q21.25 ..... is the substance formed from decomposing **matter**.

Word bank: Ammonia • Nitrogen • Phosphorus

Answer:

.....

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Q21.26 ..... (1) such as the **water cycle**, the **nitrogen cycle**, and the carbon and oxygen cycles allow the exchange of **matter** through the **biosphere**.

The atmosphere is mostly nitrogen gas. This gas is captured by organisms and converted into a usable form for plants by a process called ..... (2).

Later, the usable nitrogen compounds are converted back into nitrogen gas and returned to the atmosphere by a process called ..... (3).

Word bank: biogeochemical processes • nitrogen fixation • evaporation • denitrification • precipitation

Answer:

.....

.....

.....

Q21.27 Answer the following about the **nitrogen cycle**.

A. How does nitrogen enter the **food web**?

.....

.....

B. How do **consumers** (humans and animals) get nitrogen?

.....

.....

C. How is nitrogen returned to the soil?

.....

.....

Q21.28 The weathering and eroding of rocks releases a substance, which is essential for the growth of many **autotrophs**, called ..... .

Answer:

.....

Q21.29 Why is phosphorus sometimes a **limiting factor** for organisms?

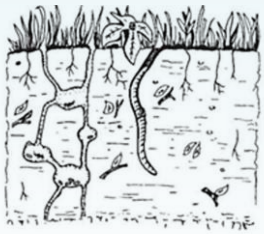
Answer:

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Q21.30 The diagram shows an earthworm living in its burrow in the soil. **Compare** the living and nonliving components of this land **ecosystem**.

A. Identify **two biotic factors** and **two abiotic factors** that affect the earthworm.

.....

.....

B. Explain how the following cycles move **matter** in this soil **ecosystem**: (1) the **nitrogen cycle**, (2) the oxygen cycle, (3) the **carbon cycle**.

.....

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Q21.31 Salmon live in a river **ecosystem**.

A. Give examples of the **biotic** and **abiotic** factors in the salmon's environment.

.....

.....

B. Name the term that describes the ability of organisms to cope with **abiotic factors** in order to survive.

.....

Q21.32 The carbon and oxygen cycle forms a continuous biological balance in the **short-term cycle**. **Compare photosynthesis** and **cellular respiration** in terms of inputs and outputs.

	Photosynthesis	Cellular respiration
Inputs		
Outputs		

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Q21.33 **Explain** how carbon and oxygen are trapped in the **long-term cycle** through the two paths in the lesson (**fossil fuels** and limestone rocks), and how they return to the environment.

A. **Fossil fuels**:

.....

.....

B. Limestone rocks ($CaCO_3$):

.....

.....

Q21.34 **Explain** how water (**matter**) cycles in nature.

A. Name the **three main** processes in the **water cycle**.

.....

B. Briefly explain how water moves between the atmosphere, the hydrosphere and the land.

.....

.....

.....

Q21.35 **Explain** how nitrogen cycles between the **biotic** and **abiotic** parts of the **ecosystem**.

A. What are the ways of **nitrogen fixation**?

.....

.....

B. How does nitrogen return to the air again as a gas?

.....

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Q22 · Written Question (Paper) · 10 marks

Energy Flow and Recombination of Elements

Learning outcome: Explain how energy flows and matter (elements) is recombined through food chains, food webs and ecological pyramids.

Student Book: Check Your Progress – Ex 1, 3, 4, 5, 6 · p. 18

Explanation

Organism	How it gets energy	Example
Producer (autotroph)	Captures energy from the Sun (photosynthesis) or from chemicals (chemosynthesis)	Grass, algae
Consumer (heterotroph)	Eats other organisms: herbivore, carnivore, omnivore	Caterpillar, lizard, human
Decomposer	Breaks down dead organisms and returns nutrients to the soil	Bacteria, fungi

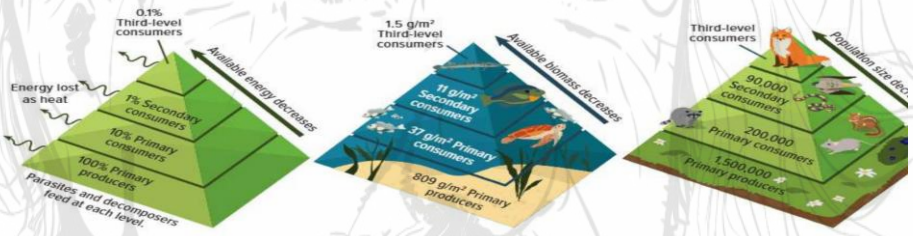


Figure 16 – Ecological pyramids of energy, biomass and numbers.

The 10% rule

- Only about **10%** of the energy at one trophic level is passed to the next; about **90%** is **lost** as **heat** through cellular respiration. This is why food chains are short and why pyramids get smaller toward the top.

Trophic level	Grass	Caterpillar	Tiger beetle	Lizard	Snake	Roadrunner
Energy available	100%	10%	1%	0.1%	0.01%	0.001%
Energy lost	–	90%	9%	0.9%	0.09%	0.009%

Pet dog (Ex 3 p. 18)

- A pet dog is a **heterotroph** (it cannot make its own food) and an **omnivore** – it eats meat-based food and plant material such as grains.

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Key Ideas from the Student Book

- **Food chain:** a simple model of **one path** of energy flow; it always starts with a producer, and arrows show the direction of energy (grass → grasshopper → frog → snake → hawk).
- Only part of the energy passes to the next level; most is **lost** as **heat**. A **food web** shows many interconnected food chains and is more realistic.
- **Ecological pyramid:** shows relative amounts of energy, biomass or numbers of organisms at each trophic level. **Pyramid of energy:** about **10%** passes up, 90% is **lost as heat**.
- **Biomass** (total mass of living matter) and the **number of organisms** usually **decrease** toward the top of the pyramid.
- **Elements recombine** into new products: carbon in sugar becomes part of a protein or fat in a consumer and returns as CO_2 through respiration.

Remember
▸ Energy flows in **one direction** and is **lost as heat**, while matter **cycles**.
▸ 10% rule: about 10% of energy passes to the next trophic level.

Questions

Q22.1 A **food chain** is made up of: grass → caterpillar → tiger beetle → lizard → snake → roadrunner. Assume that 100% of the **energy** is available to the grass.

A. Distinguish between **producers**, **consumers** and **decomposers**, giving one example of each.

.....

.....

.....

B. Calculate the percentage of **energy** available to the **lizard** and to the **roadrunner**. Show your working.

.....

.....

.....

C. Explain why the top of the **energy pyramid** is the smallest.

.....

.....

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Q22.2 Study Figure 16.



A. Identify the process by which **autotrophs** at the bottom of the pyramid convert **energy** from the Sun.

.....

B. Explain how **photosynthesis** and **cellular respiration** provide **energy** in each step of a **food chain**.

.....

.....

C. Write a short paragraph that explains the pathway of **energy** transfer through the **pyramid of energy**.

.....

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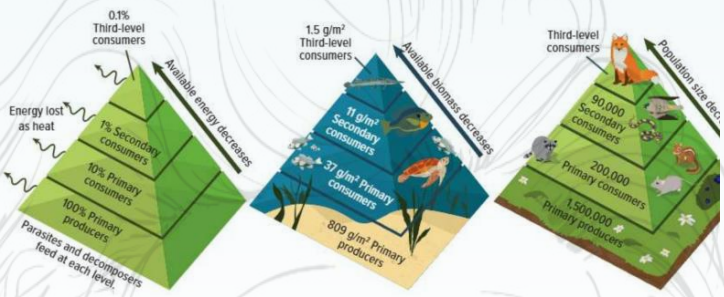
D. Classify a pet dog as an **autotroph** or **heterotroph**, and as a **herbivore**, **carnivore** or **omnivore**. Explain.

.....

.....

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Q22.3 The pyramid (Figure 16) represents a model of **energy** flow through an **ecosystem**. Answer the following questions.



A. What is the name given for the model of **energy** flow represented in the figure?

.....

B. Each level in the figure is represented by a number of organisms. What is this level called?

.....

C. What is the process by which **autotrophs** at the bottom of the pyramid convert **energy** from the Sun?

.....

D. Give two examples of carnivores.

.....

.....

E. Explain how the following are affected by moving from the bottom of the pyramid to the top level (increase or decrease): available **energy** · available **biomass** · **population** size.

.....

.....

.....

Q22.4 A(n) …… collects **energy** from sunlight or inorganic substances to produce food.

Word bank: autotroph • heterotroph • chemotroph

Answer:

.....

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Q22.5 Where does the **energy** for **most ecosystems** originate, and how does it **first** enter an **ecosystem** such as a pond?

Answer:

.....

.....

.....

Q22.6 A mushroom feeding on a dead log is an example of a(n) ..... .

Answer:

.....

Q22.7 Match each definition to its vocabulary term.

Word bank: Herbivore • Carnivore • Omnivore • Detritivore • Autotroph • Heterotroph

Statement / Item	Your answer
an organism that eats only plants	
captures energy from sunlight or inorganic substances to produce its own food	
an organism that preys on other heterotrophs	
decomposes organic material and returns the nutrients to soil, air, and water	
cannot make its own food; gets nutrients and energy by feeding on other organisms	
an organism that eats both plants and animals	

Q22.8 What is the importance of **detritivores** and **decomposers** for the **autotrophs** (plants)?

Answer:

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Q22.9 Use the same illustration (foxes, hawks and owls, squirrels, mice, rabbits, seed-eating birds, green plants).

What does the illustration represent? …… (1) Which organisms in it are **autotrophs**? …… (2)

Word bank: a food pyramid • a food web • a food chain • foxes • green plants • rabbits

Answer:

Q22.10 Give a definition for: a) **food chain** b) **food web**

Answer:

Q22.11 In the **energy pyramid**, how much **energy** is transferred to the next level, and why?

Answer:

Q22.12 What happens to the number of organisms at each **trophic level**, and why?

Answer:

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Q22.13 Use the **food web** to answer the questions. **Explain** how **energy** flows through the organisms.



A. What does the diagram represent (**food chain**, **food web**, **ecological pyramid** or **energy pyramid**)? Explain your answer.

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B. Which organism in the diagram is an **autotroph**? Explain your answer.

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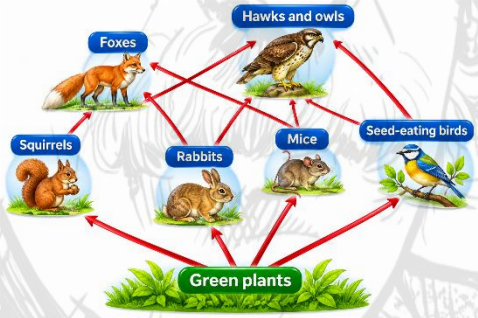
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C. Which of the following is a **detritivore**: cat, mouse, sunflower, shrimp? Explain your answer.

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Q22.14 Use the **food web** to answer the questions.



A. Which part of the **food web** contains the **smallest biomass**: foxes, green plants, mice or rabbits? Explain your answer.

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B. What happens to the **energy** that the fox uses to keep its body **temperature constant**? Explain.

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Q22.15 **Calculate** the **energy** transferred between trophic levels.

A. Determine the total amount of **energy lost** in a **food chain** of three levels if 1000 calories enter the **autotroph** level.

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B. Write a **food chain** of **five** trophic levels and identify the **producer** and the primary **consumer**.

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Q22.16 **Explain** the role of models and organisms in **energy** transfer.

A. Explain why food webs are better models than food chains for describing **energy** transfer and feeding relationships.

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B. Explain the importance of **decomposers** and **detritivores** in the **ecosystem**.

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Q23 · Written Question (Paper) · 10 marks

Importance of Biodiversity and Human Impacts

Learning outcome: Explain the importance of biodiversity and describe how human activities threaten it.

Student Book: Check Your Progress – Ex 2, 4, 5 · p. 44 · Figure 15 · p. 44 · Figure 13 · p. 42

Explanation

Human activity (anthropogenic change)	How it threatens biodiversity
Overexploitation	Species are hunted or harvested faster than they can reproduce
Habitat loss and fragmentation	Habitats are destroyed or split into small patches with more edge (Figure 13)
Pollution	DDT, PCBs, acid precipitation and fertilizers harm organisms; toxins build up in food chains
Introduced (invasive) species	Non-native species such as fire ants (Figure 15) out-compete native species
Climate change	Temperature changes force species to move or die

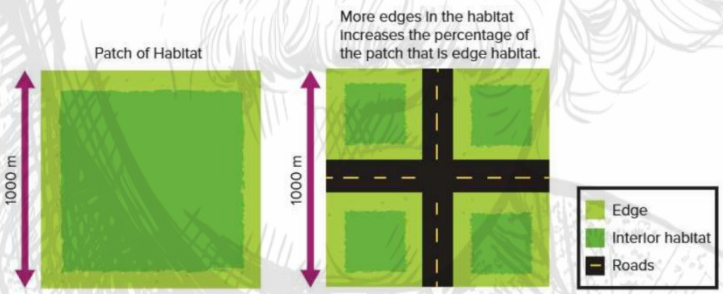


Figure 13 – Roads split one patch into four smaller patches with much more edge habitat.

⚠ Overharvesting a single species (Ex 4 p. 44)

- Fish overharvested → sea lions and seals **decline** → killer whales eat sea otters → sea urchins increase → **kelp forests are destroyed** → many species that depend on kelp lose their habitat.

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Key Ideas from the Student Book

- Human factors that affect ecosystems: **overexploitation**, **habitat loss and fragmentation**, **pollution** (biological magnification, acid precipitation, eutrophication) and **invasive species**.
- These factors upset the balance of ecosystems: they change food webs, **reduce** genetic diversity, increase edge effects and can lead to **extinction**.

Remember

- Number-one cause of **extinction** today: **habitat loss**.

Questions

Q23.1 Study Figure 13 and Figure 15.

A. Explain three ways that anthropogenic (human-caused) changes threaten **biodiversity**.

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B. Using Figure 13, explain how building roads through a **habitat** affects the organisms that live in the interior of the patch.

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C. Using Figure 15, explain why an **invasive species** such as the fire ant can reduce **biodiversity**.

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Q23.2 **Biodiversity** is important for the health of **ecosystems**.

A. Summarize how the **overharvesting** of a single species, such as the fish eaten by sea lions, can affect an entire **ecosystem**.

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B. Design **two** features of a planned **community** that would preserve **biodiversity** and still accommodate the human **population**.

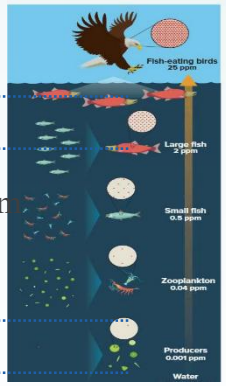
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Q23.3 Based on **Figure 13** (**biological magnification** of DDT):

A. Define **biological magnification**.



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B. Which organism recorded the **highest** concentration of DDT and why? What harm threatened its survival?

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Q23.4 **Explain** how human activities affect the balance of **ecosystems**.

A. Explain how **habitat fragmentation** leads to **edge effects**, and how this negatively affects the **genetic diversity** of populations.

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B. Why is introducing **invasive species** (such as the red imported fire ant) a real danger to the balance of native **ecosystems**?

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Q23.5 **Compare** acid **precipitation** and **eutrophication** in terms of the human cause and the negative effect on the environment.

	Acid precipitation	Eutrophication
Human cause		
Negative effect		

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Q23.6 **Explain** the importance of **biodiversity** for a sustainable **ecosystem**.

A. Scientists classify the importance of **biodiversity** into **direct** and **indirect** economic values. Explain the difference with examples.

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B. How did the New York drinking-water case study prove that protecting **ecosystem services** is cheaper than **technology**?

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C. Explain what is meant by **overexploitation**, give examples of animals affected by it, and explain how losing a **keystone species** leads to the collapse of an **ecosystem**.

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Q24 · Written Question (Paper) · 10 marks

Controlled Experiments, Models, Tables and Graphs

Learning outcome: Design a controlled experiment; use models; organize data in tables and graphs.

Student Book: Get It? · p. 62 · Check Your Progress – Ex 3, 4 · p. 65 · Ex 3 · p. 75 · Get It? · p. 76

Explanation

Part of a controlled experiment	Meaning
Independent variable	The one factor the scientist changes (x-axis)
Dependent variable	The factor that is measured (y-axis)
Constants	All other factors kept the same
Control	The standard for comparison – it shows what happens without the change (Get It? p. 62)

Constructing a line graph (p. 75)

- Put the **independent variable on the x-axis** and the **dependent variable on the y-axis**; choose a suitable scale; label both axes with units; plot each point; give the graph a title. Points on a line graph can be connected because the data change **continuously**.

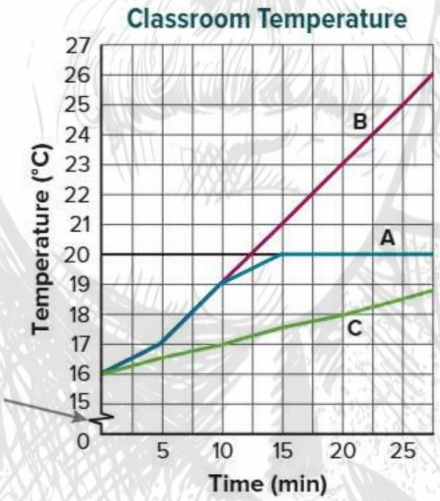


Figure 14 – Classroom temperature recorded every 5 minutes.

Get It? p. 76

- A **bar graph** is better than a line graph when the data are in **separate categories** that are **not** continuous, such as the number of classrooms of each size.

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Key Ideas from the Student Book

- A **controlled experiment** has: a hypothesis, **one** independent variable, a measured dependent variable, constants, a control for comparison, and repeated trials.
- **Graph:** a visual display of data that makes patterns easy to see. The **x-axis** shows the independent variable (e.g. time); the **y-axis** shows the dependent variable (e.g. distance).
- **Line graph:** shows how the dependent variable changes with the independent variable, often with time; several data sets can be plotted together (thermostats A, B, C – the control line at 20 °C).
- A **break** in an axis removes part of the scale (0–15 °C) to give more space to the data. A **best-fit line** shows the general trend and does **not** have to pass through every point.
- **Bar graph:** compares data that do **not** change continuously (number of students in classes). **Circle graph:** shows how a fixed total is divided into parts (percentages).

Graph	When to use it
Line graph	One variable changes continuously with another (with time)
Bar graph	Comparing separate categories
Circle graph	Parts of a whole (percentages)

Remember

- x-axis = independent variable; y-axis = dependent variable.

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Questions

Q24.1 A student wants to test whether the amount of light affects how fast bean plants grow. She has 12 bean plants, identical pots, soil and water.

A. Write a **testable hypothesis** for the investigation.

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B. Identify the **independent variable**, the **dependent variable** and **two** constants.

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C. Describe a suitable **control** and explain why it is needed.

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D. Explain why the student should use several plants in each group.

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Q24.2 An experiment to determine how many breaths a squirrel takes per minute gave these data: minute 1: 65 · minute 2: 73 · minute 3: 67 · minute 4: 71 · minute 5: 62.

A. Organize the data in a table with suitable headings and units.

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B. Calculate the average number of breaths per minute. Show your working.

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C. State which type of variable is plotted on the x-axis and which on the y-axis, and name the **best** type of graph for these data.

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Q24.3 A student wants to study the effect of **temperature** on a balloon. The **volume** of the balloon increases when it is heated.

A. Identify the **independent** variable in this experiment.

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B. Identify the **dependent** variable in this experiment.

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C. Identify one factor that must stay **constant** in this experiment.

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Q24.4 What is the importance of building models for scientists?

Answer:

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Q24.6 Three thermometers (A, B and C) were tested in a refrigerator whose accepted **temperature** is 38.0 °F.

Thermometer	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
A	39.4 °F	48.2 °F	28.1 °F	46.3 °F	34.5 °F
B	37.8 °F	38.3 °F	38.1 °F	37.4 °F	38.0 °F
C	49.6 °F	49.5 °F	49.7 °F	49.9 °F	49.8 °F

A. Classify each thermometer as **accurate** and/or **precise**.

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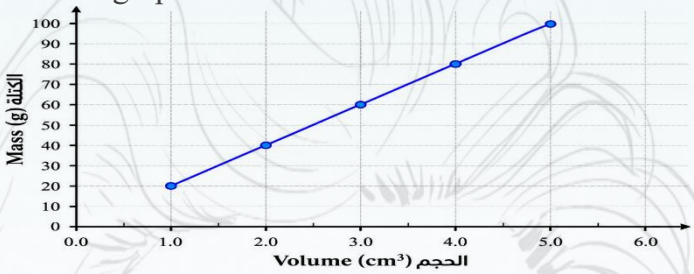
B. Explain your classification of thermometer C.

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Q24.7 The **mass** of different pure gold nuggets was measured for different volumes and plotted on the mass–**volume** graph.



A. Identify the **independent variable**, the **dependent variable** and the type of relationship.

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B. Calculate the **slope** of the graph, including the proper unit.

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C. Write the equation of the line in terms of **mass** m and **volume** V.

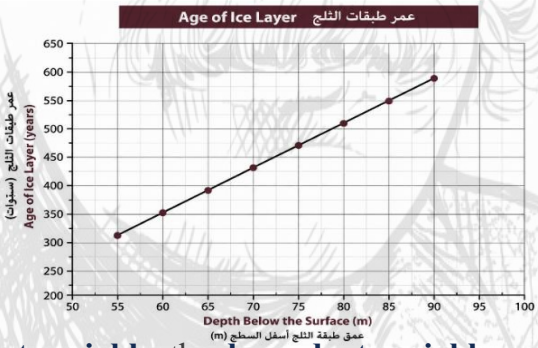
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D. Use the equation to calculate the **mass** of a gold nugget of **volume** 6.0 cm³.

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Q24.8 The graph shows the relationship between the age of an ice layer and its depth below the surface.



A. Identify the **independent variable**, the **dependent variable** and the type of relationship.

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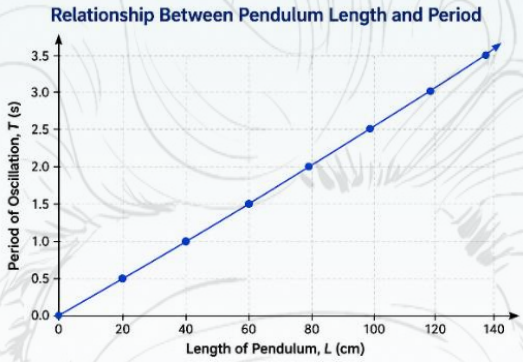
B. Calculate the **slope** of the graph and state its unit.

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Q24.9 A student investigated the relationship between the length of a pendulum and its period of oscillation.



A. Identify the independent and the dependent variables.

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B. What type of relationship is shown? Calculate the **slope**.

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Q24.10 A researcher wants to test the effect of **water temperature** on the breathing rate of a goldfish (the number of times the gill cover opens and closes per minute). **Design a controlled experiment** that includes:

A. The scientific **hypothesis**.

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B. The **independent variable** and the **dependent variable**.

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C. Three constants that keep the experiment controlled.

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D. The **control** group.

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Q24.11 **Choose** the **most** suitable type of graph to display the data in each case, and give the scientific reason.

A. Following the change in air **temperature** every two hours over 24 hours.

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B. Comparing the numbers of students in each grade in your school, collected by counting.

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C. Showing the percentages of **energy** sources used to heat buildings (gas, coal, electricity, steam).

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Q24.12 A survey of **72** buildings in an area was carried out to find the type of fuel used for heating. It showed that **18** of them use steam.

A. Calculate the percentage of buildings that use steam.

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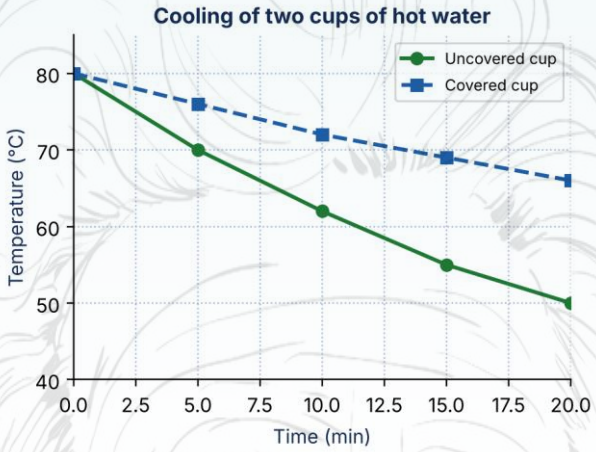
B. Calculate the angle (in degrees) of the circle-graph sector that represents steam.

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Q24.13 The graph shows the cooling of two cups of hot water (an uncovered cup and a covered cup). Study it, then answer.



A. What is the **temperature** of the uncovered cup after 10 minutes?

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B. Which cup cooled faster?

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C. What is the difference between the temperatures of the two cups after 20 minutes?

.....

D. Why does the y-axis start at 40 and **not** at zero?

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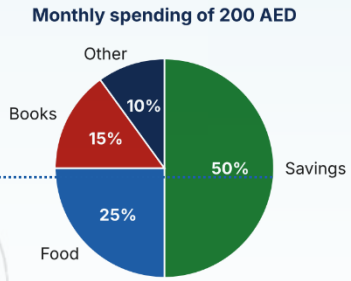
E. Identify the **independent variable** and the **dependent variable**.

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Q24.14 The **circle graph** shows the distribution of a monthly spending of **200 AED**. Study it, then answer.



A. Which is the **largest** sector, and what percentage does it represent?

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B. Calculate the amount spent on food.

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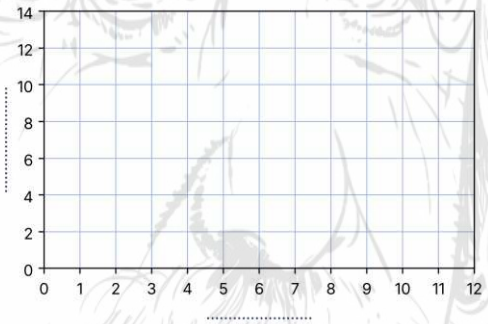
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C. Calculate the angle of the books sector.

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Q24.15 Represent the data in the table with a **line graph** (with a suitable title, labelled axes with units, and a **best**-fit line), then answer.



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Day	0	2	4	6	8	10
Plant height (cm)	2	4	7	8	11	12

A. Estimate from your graph the plant height on day 5.

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B. Predict the plant height on day 14. Is your prediction certain? Why?

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