Contents

Chapters

1 Energy Flow, Food Chains and Food Webs 3
Notes p. 4 · Practice p. 23 · Answers p. 257

2 The Carbon Cycle and Global Warming 37
Notes p. 38 · Practice p. 59 · Answers p. 262

3 DNA, Genes and Chromosomes 74
Notes p. 75 · Practice p. 91 · Answers p. 267

4 Reproduction in Humans 105
Notes p. 106 · Practice p. 132 · Answers p. 271

5 Monohybrid Inheritance 147
Notes p. 148 · Practice p. 167 · Answers p. 276

6 Variation, Sex Determination and Mutation 181
Notes p. 182 · Practice p. 201 · Answers p. 282

Preliminary Examination 1

P1 Paper 1: multiple-choice questions 216
Answers and mark scheme p. 287

P4 Paper 4: structured and free-response questions 222
Answers and mark scheme p. 289

Preliminary Examination 2

P1 Paper 1: multiple-choice questions 236
Answers and mark scheme p. 296

P4 Paper 4: structured and free-response questions 242
Answers and mark scheme p. 298

Answers and Mark Schemes

Chapters 1 to 6 and both examinations 256

Name: _____ Class: _____ Date: _____

SECONDARY 4 · BIOLOGY · ENERGY FLOW, FOOD CHAINS AND FOOD WEBS

Energy Flow, Food Chains and Food Webs

Theory and worked examples

Recap from Sec 3: photosynthesis and respiration

This chapter uses two processes you met in Sec 3. In photosynthesis, green plants and algae use light energy, absorbed by chlorophyll, to make glucose from carbon dioxide and water; oxygen is given off. Light energy is converted into chemical energy stored in the glucose and in the starch, proteins and fats made from it. In aerobic respiration, every living cell breaks down glucose using oxygen, giving carbon dioxide and water and releasing energy. The cell uses this energy for growth, movement and other activities, and much of it is lost to the surroundings as heat.

KEY IDEA

Photosynthesis stores light energy as chemical energy in food. Respiration releases the chemical energy in food; much of it ends up as heat.

- Photosynthesis: carbon dioxide + water → glucose + oxygen (light energy, chlorophyll).
- Aerobic respiration: glucose + oxygen → carbon dioxide + water (energy released).

	Photosynthesis	Aerobic respiration
Which organisms	plants, algae and phytoplankton (producers)	all living organisms, including plants
Energy change	light energy → chemical energy in glucose	chemical energy in glucose → energy for the cell, much lost as heat
Gases	takes in CO_2, gives out O_2	takes in O_2, gives out CO_2
When	only in the light	all the time, day and night

TRY THIS

A plant both photosynthesises and respires. Which of the two processes releases energy that the plant then loses as heat?

Answer: Respiration. It releases the chemical energy stored in glucose, and much of that energy is lost to the surroundings as heat.

The Sun: where the energy comes from

An ecosystem is a community of different organisms living together and interacting with each other and with their non-living surroundings, such as a mangrove swamp at Sungei Buloh or a pond in the Central Catchment nature reserve. Almost all the energy used by the organisms in an ecosystem comes from the Sun as light. Producers capture some of this light energy by photosynthesis and store it as chemical energy in organic food. Animals and other consumers get their energy by eating that food, directly or indirectly. So the energy in the food you eat was once sunlight.

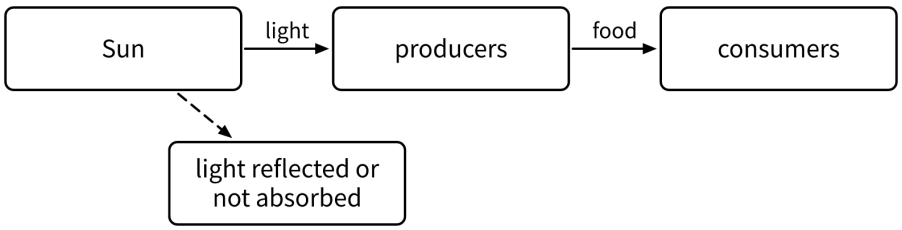
KEY IDEA

Energy enters an ecosystem as light and is changed into chemical energy in food by producers.

- Producers capture only a small fraction (often about 1-2%) of the light energy that reaches them.
- Some light is reflected from the leaf surface, some passes straight through the leaf, and some falls on the ground or on parts with no chlorophyll.
- Producers also use some of the energy they capture for their own respiration, and this is lost as heat.

WORDS TO KNOW

ecosystem	a community of organisms interacting with each other and with their non-living environment
organic food	carbon compounds made by living things, such as glucose, starch, proteins and fats, that store chemical energy



TRY THIS

Light energy of 800 000 kJ per m^2 per year reaches a field of grass. Suggest two reasons why the grass stores less than 2% of it as chemical energy.

Answer: Any two: some light is reflected from the leaves; some passes through the leaves without being absorbed by chlorophyll; some falls on bare ground between the plants; some of the energy captured is used by the grass in respiration and lost as heat.

Producers, consumers and decomposers

Every organism in an ecosystem has a role in passing on energy. Producers make their own organic food from simple inorganic substances using light energy. Consumers cannot make their own food: they get energy and nutrients by eating other organisms. Decomposers, mainly bacteria and fungi, feed on dead organisms and waste such as faeces and fallen leaves. They break down the organic matter, releasing mineral salts (such as nitrates) into the soil or water; their respiration releases carbon dioxide into the air. Producers can use both again.

WORDS TO KNOW

producer	an organism that makes its own organic food from inorganic substances using light energy (green plants, algae, phytoplankton)
consumer	an organism that gets its energy by feeding on other organisms
herbivore	an animal that feeds on plants only (a primary consumer)
carnivore	an animal that feeds on other animals
omnivore	an animal that feeds on both plants and animals
decomposer	an organism (mainly bacteria and fungi) that breaks down dead organisms and waste, releasing carbon dioxide and mineral salts

Role	How it gets energy	What it does in the ecosystem	Examples
Producer	light energy, by photosynthesis	converts light energy into chemical energy in food for all other organisms	mangrove trees, grass, seagrass, algae, phytoplankton
Consumer	by eating other organisms	passes energy and nutrients along the food chain	crab (herbivore, eats leaves), heron (carnivore), monkey (omnivore)
Decomposer	from dead organisms and waste	breaks down organic matter; returns CO_2 and mineral salts for producers	bacteria, fungi such as mushrooms and moulds

WORKED EXAMPLE

At Pulau Semakau, seagrass grows on the shallow sea floor. Sea urchins graze on the seagrass, and crabs eat the sea urchins. Bacteria in the mud feed on dead seagrass and on the faeces of the animals. (a) Classify each organism as a producer, a consumer or a decomposer. (b) Describe the role of the bacteria.

1. What is asked: a role for each organism, then what decomposers do.
2. Idea: a producer makes food by photosynthesis; a consumer eats other organisms; a decomposer feeds on dead matter and waste.
3. Seagrass photosynthesises, so it is the producer. Sea urchins eat seagrass, so they are consumers (herbivores). Crabs eat sea urchins, so they are consumers (carnivores).
4. Bacteria feed on dead seagrass and faeces, so they are decomposers.

(a) Producer: seagrass. Consumers: sea urchins and crabs. Decomposer: bacteria. (b) The bacteria break down dead organisms and waste; their respiration releases carbon dioxide, and mineral salts are released into the water and mud, to be used again by the seagrass.

TRY THIS

Explain why an ecosystem with no decomposers would soon run short of mineral salts.

Answer: Dead organisms and waste would not be broken down, so the mineral salts in them would stay locked up and would not be returned to the soil or water for producers to absorb.

Food chains and trophic levels

A food chain shows how energy is passed from one organism to the next as food. It always starts with a producer. Each arrow points from the organism that is eaten to the organism that eats it, so the arrow shows the direction of energy flow. The position of an organism in a food chain is its trophic level (feeding level). Producers are at the first trophic level, primary consumers (herbivores) at the second, secondary consumers at the third and tertiary consumers at the fourth. Decomposers feed on dead organisms from every trophic level, so they are not usually drawn in a food chain.

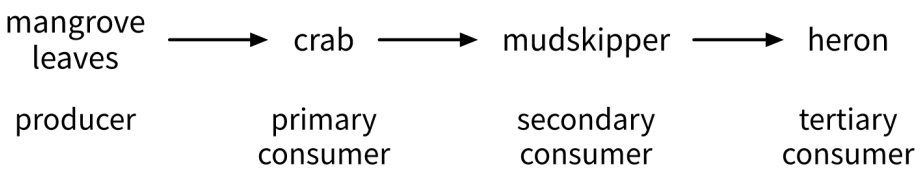
KEY IDEA

Arrows in a food chain point from the eaten to the eater: they show the direction in which energy flows.

WORDS TO KNOW

food chain	a sequence of organisms, each eaten by the next, showing the transfer of energy from producer to consumers
trophic level	the position (feeding level) of an organism in a food chain

Trophic level	Name	Feeds on	In the chain above
1st	producer	makes its own food	mangrove leaves
2nd	primary consumer (herbivore)	producers	crab
3rd	secondary consumer (carnivore)	primary consumers	mudskipper
4th	tertiary consumer (carnivore)	secondary consumers	heron



WORKED EXAMPLE

The diagram shows a food chain in the Central Catchment nature reserve. (a) Name the producer. (b) Name the secondary consumer. (c) State the trophic level of the changeable hawk-eagle. (d) State what the arrows represent.

leaves of rain tree → caterpillar → magpie-robin → hawk-eagle

1. What is asked: read each organism's position along the chain.
2. Idea: the chain starts with the producer; count along the arrows for the trophic levels.
3. Leaves (level 1, producer) → caterpillar (level 2, primary consumer) → magpie-robin (level 3, secondary consumer) → hawk-eagle (level 4, tertiary consumer).

(a) The rain tree (its leaves). (b) The magpie-robin. (c) The fourth trophic level (tertiary consumer). (d) The transfer (flow) of energy from the organism eaten to the organism that eats it.

TRY THIS

A student writes the food chain: owl → rat → rice plant. What is wrong with it?

Answer: The arrows point the wrong way. They must point from the eaten to the eater, in the direction of energy flow: rice plant → rat → owl.

CHAPTER 1

Practice Questions

Part 2: Energy Flow, Food Chains and Food Webs



In the practice questions

23 questions, 70 marks. For each multiple-choice question, write the letter of the correct option (A, B, C or D) in the brackets. Write your other answers on the lines given. The answers are on page 257.

- Section A: Multiple-Choice Questions: 15 questions, 15 marks
- Section B: Structured Questions: 6 questions, 35 marks
- Section C: Free-Response Questions: 2 questions, 20 marks

Name: _____ Class: _____ Date: _____

SECONDARY 4 · BIOLOGY · ENERGY FLOW, FOOD CHAINS AND FOOD WEBS

Energy Flow, Food Chains and Food Webs

INSTRUCTIONS

- 23 questions, 70 marks in total.
- Answer all questions in the spaces provided.
- For MCQs, write the letter (A, B, C or D) in the brackets.
- Write your other answers on the lines given, in full sentences.

Section A: Multiple-Choice Questions

1 Which statement describes the role of producers in an ecosystem? ( ) [1]

(A) They break down dead organisms and release mineral salts.
(B) They convert light energy into chemical energy stored in organic food.
(C) They obtain their energy by feeding on other organisms.
(D) They release energy from food by photosynthesis.

2 Which row describes a decomposer? ( ) [1]

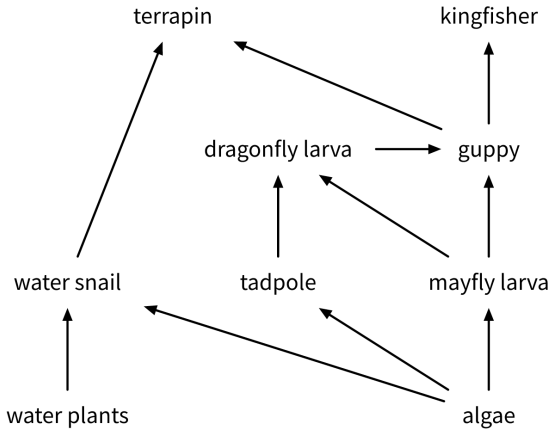
	Feeds on	Releases into the soil and air
A	living plants	oxygen and glucose
B	living animals	carbon dioxide only
C	dead organisms and waste	carbon dioxide and mineral salts
D	dead organisms and waste	oxygen and mineral salts

3 The diagram shows a food chain in the sea. Which organism is the tertiary consumer? ( ) [1]

phytoplankton → zooplankton → anchovy → squid → dolphin

(A) squid (B) dolphin (C) anchovy (D) zooplankton

4 The diagram shows a food web in a pond in the Central Catchment nature reserve. Questions 4, 5 and 6 are about this web. Which organism feeds at more than one trophic level? ( ) [1]



(A) tadpole (B) dragonfly larva (C) water snail (D) guppy

5 How many food chains are there in the food web in Question 4? ( ) [1]

(A) 6 (B) 7 (C) 8 (D) 9

6 A pesticide kills most of the dragonfly larvae in the pond in Question 4. Which statements are likely to be true soon afterwards?

1 The number of tadpoles increases.
2 The guppies eat more mayfly larvae.
3 The number of water snails falls to zero. ( ) [1]

(A) 1 and 2 only (B) 1 and 3 only (C) 2 and 3 only (D) 1, 2 and 3

7 What do the arrows in a food chain represent? ( ) [1]

(A) the direction in which the animals move to find food
(B) the transfer of energy from the organism eaten to the organism that eats it
(C) the transfer of energy from the predator to its prey
(D) the flow of oxygen from producers to consumers

8 Why is the flow of energy through an ecosystem described as non-cyclical? ( ) [1]

(A) Energy is destroyed at each trophic level.
(B) Decomposers return energy to the soil for plants to absorb.
(C) Producers make new energy by photosynthesis.
(D) Energy lost as heat cannot be used again by producers to make food.

9 In a grassland, the producers store 12 500 kJ per m^2 per year and the primary consumers store 1 000 kJ per m^2 per year. What is the efficiency of energy transfer from producers to primary consumers? ( ) [1]

Ⓐ 0.080% Ⓑ 8.0% Ⓒ 12.5% Ⓓ 92%

10 The producers in a food chain store 60 000 kJ of energy. About 10% of the energy is passed on at each trophic level. How much energy reaches the secondary consumers? ( ) [1]

Ⓐ 6 kJ Ⓑ 60 kJ Ⓒ 600 kJ Ⓓ 6 000 kJ

11 A caterpillar eats leaves containing 250 kJ of energy. It loses 140 kJ in its faeces and 85 kJ as heat from respiration. The rest is stored in new body tissue. What percentage of the energy eaten is stored in new body tissue? ( ) [1]

Ⓐ 10% Ⓑ 34% Ⓒ 56% Ⓓ 90%

12 Which of these is NOT a way in which energy is lost between the second and the third trophic levels? ( ) [1]

Ⓐ heat released in the respiration of the herbivores

Ⓑ undigested food in the faeces of the carnivores

Ⓒ parts of the herbivores, such as bones, that are not eaten

Ⓓ energy stored in the new muscle tissue of the herbivores

13 In a field, a large number of grass plants are eaten by a smaller number of grasshoppers. A few mynahs eat the grasshoppers, and each mynah carries many lice that feed on it. Which diagram is the pyramid of numbers for this food chain? ( ) [1]

