

Energy flow, food chains and food webs

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Read first: [Plant nutrition](#), [Respiration](#)

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What you need to know

This topic follows energy from the Sun into plants and then from one living thing to the next, and shows how feeding links are drawn as food chains, food webs and pyramids. It comes up on every paper: one-mark multiple-choice questions on Papers 1 and 2 (almost every paper has one or two), and parts of longer questions on Papers 3 and 4, nearly always built around a food web. Outcomes marked **Extended only** are tested on Papers 2 and 4 only. By the end of this topic you should be able to:

Energy flow

1. State that **the Sun is the principal source of energy input to biological systems**.
2. Describe how energy flows through living organisms: **light energy** from the Sun is trapped by producers, passes between organisms as **chemical energy**, and is eventually **transferred to the environment** (mostly as heat).

Food chains and food webs

3. Describe a **food chain** as showing the **transfer of energy from one organism to the next, beginning with a producer**.
4. Construct and interpret simple food chains.
5. Describe a **food web** as a **network of interconnected food chains**, and interpret food webs.
6. Describe a **producer** as an organism that **makes its own organic nutrients, usually using energy from sunlight, through photosynthesis**.
7. Describe a **consumer** as an organism that **gets its energy by feeding on other organisms**.
8. State that consumers may be classed as **primary, secondary, tertiary and quaternary** according to their position in a food chain.
9. Describe a **herbivore** as an animal that **gets its energy by eating plants**, and a **carnivore** as an animal that **gets its energy by eating other animals**.
10. Describe a **decomposer** as an organism that **gets its energy from dead or waste organic material**.
11. Use food chains and food webs to describe the impact humans have through **overharvesting** of food species and through **introducing foreign species** to a habitat.
12. Draw, describe and interpret **pyramids of numbers** and **pyramids of biomass**, and discuss the advantages of a pyramid of biomass over a pyramid of numbers.

13. Describe a **trophic level** as the **position of an organism in a food chain, food web or ecological pyramid**, and identify the trophic levels: producers, primary, secondary, tertiary and quaternary consumers.
14. **Extended only:** draw, describe and interpret **pyramids of energy**, and discuss the advantages of a pyramid of energy over pyramids of numbers or biomass.
15. **Extended only:** explain why the **transfer of energy from one trophic level to the next is often not efficient**, and, in terms of energy loss, why **food chains usually have fewer than five trophic levels**.
16. **Extended only:** explain why it is **more energy efficient for humans to eat crop plants than to eat livestock** that have been fed on crop plants.

Photosynthesis is in Plant nutrition and respiration is in Respiration; this note uses both. The carbon cycle, populations and the word "ecosystem" are in Nutrient cycles and populations.

Understand it

Where the energy comes from

Almost every living thing runs on energy that started in the **Sun**. Green plants (and algae) trap **light energy** with **chlorophyll** and use it in **photosynthesis** to make glucose and other organic nutrients. The energy is now stored as **chemical energy** in those molecules. That is why the Sun is called the **principal source of energy input to biological systems**.

Be careful with the word "source". The **producer** is where the energy *enters the food chain*, and **photosynthesis** is the *process* that traps it, but the energy itself *originally* came from the **Sun**. The same is true for a chain that begins with dead leaves or a fungus: the leaves were made by a plant using sunlight, so the energy still came from the Sun.

Producers, consumers and decomposers

- A **producer** makes its own organic nutrients, usually using energy from sunlight, through photosynthesis. Plants and algae (including the phytoplankton in the sea) are producers.
- A **consumer** gets its energy by **feeding on other organisms**. A **herbivore** is an animal that gets its energy by eating **plants**; a **carnivore** is an animal that gets its energy by eating **other animals**. Both are consumers.
- A **decomposer** gets its energy from **dead or waste organic material**: dead plants and animals, fallen leaves, faeces. Most decomposers are bacteria and fungi. They receive energy from **every** level of a food chain, because every organism eventually dies and produces waste.

Food chains

A **food chain** shows how energy passes from one organism to the next. It always **begins with a producer**, and each **arrow points from the food to the organism that eats it**: the arrow shows the direction the energy goes.

grass → grasshopper → frog → snake

The grass is the producer. The grasshopper eats it, so the grasshopper is the **primary consumer** (a herbivore). The frog is the **secondary consumer** and the snake the **tertiary consumer** (both carnivores). An animal that ate the snake would be a **quaternary consumer**.

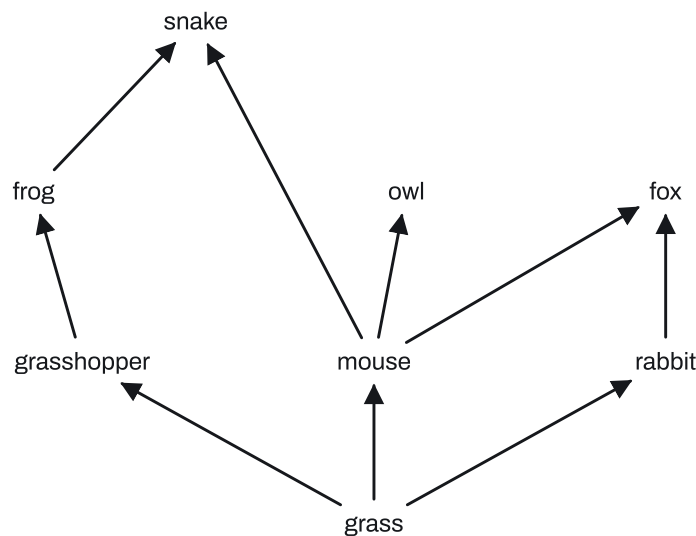
Each of these positions is a **trophic level**, the position of an organism in a food chain, food web or ecological pyramid. Count them starting from the producer:

Trophic level	Name	Feeds on
1	producer	makes its own food
2	primary consumer	producers (so a herbivore)
3	secondary consumer	primary consumers (a carnivore)
4	tertiary consumer	secondary consumers
5	quaternary consumer	tertiary consumers

So a tertiary consumer is at trophic level **4**, not 3: the producer is level 1.

Food webs

In a real habitat most animals eat more than one kind of food and are eaten by more than one predator. Joining all the food chains together gives a **food web**: a **network of interconnected food chains**.



To read a food web, follow the arrows. Here:

- the **producer** is grass (no arrows point into it);
- the **primary consumers** (herbivores) are the grasshopper, the mouse and the rabbit;
- the **secondary consumers** are the frog, the owl, the fox and the snake (the snake eats mice);

- the snake is also a **tertiary consumer**, when it eats frogs. It **feeds at more than one trophic level** (levels 3 and 4);
- the longest chain, grass → grasshopper → frog → snake, has **4 trophic levels**, so the web has 4 trophic levels;
- there are **8** organisms in the web.

When one population changes

Because the organisms are linked, a change in one population spreads through the web. Work it out one arrow at a time: an organism's **food** is what points into it, and its **predators** are what it points to.

Suppose a disease kills most of the frogs in the web above:

- **grasshoppers increase**, because fewer are eaten by frogs;
- the **grass decreases**, because more grasshoppers eat it;
- the **snakes** lose one food source, so they may **eat more mice**; then the **mice decrease**, and the owls and foxes have less food (more **competition** for mice).

Humans change food webs too:

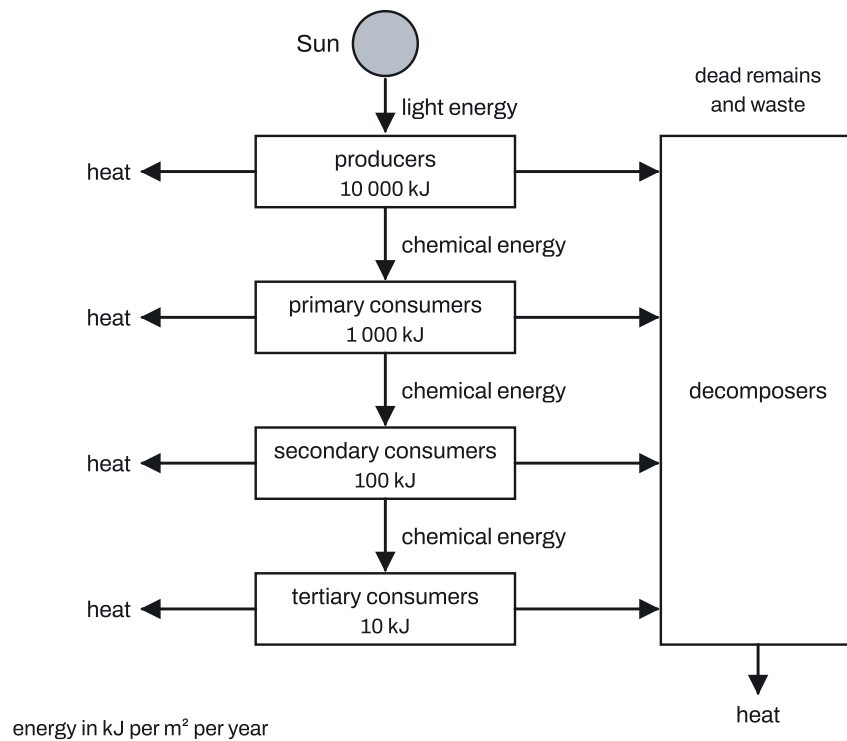
- **Overharvesting** a food species (overfishing, or hunting too many animals) removes it faster than it can reproduce. Its predators lose food and may decrease; its prey have fewer predators and may increase; and other predators that shared it now compete harder for what is left.
- **Introducing a foreign species** (one that doesn't naturally live there) can upset the web: the new species may **eat** the native organisms, **compete** with them for food, or carry disease, and it often has **no natural predators** in its new home, so its population grows unchecked.

Energy flow and energy loss

Only a small part of the energy at one trophic level ends up in the next. At every level:

- **respiration** releases energy from food, and much of it is lost to the surroundings as **heat**;
- energy is used for **movement** (muscle contraction) and other life processes, and ends up as heat;
- **not all of each organism is eaten** (bones, roots, wood, shells), and **not every organism** at a level gets eaten;
- **not all of what is eaten is digested**: some is lost in **faeces** (egestion), and some in urine (excretion);
- the energy in dead remains and waste passes to **decomposers**.

Only the energy stored in new **biomass** (the body tissue made in growth) can be passed on to the next level when that organism is eaten. A rough rule is that about **10%** is passed on and about **90%** is lost at each step.



With 10% passed on each time, $10\,000 \times 0.1 = 1\,000$ kJ reaches the primary consumers, 100 kJ the secondary consumers and 10 kJ the tertiary consumers. So all the energy that enters a food chain ends up, in the end, transferred to the environment as heat.

Extended only: this is why **the transfer of energy from one trophic level to the next is not efficient**, and why **food chains usually have fewer than five trophic levels**. With 90% lost at each step, after four or five transfers too little energy is left to support a population of another consumer. It isn't because top predators are big: the energy simply runs out along the chain.

Extended only: the same idea explains why it is **more energy efficient for humans to eat crop plants than to eat livestock** fed on crop plants. Eating the crop puts humans at trophic level 2; eating the animal puts us at level 3. Each extra step loses about 90% of the energy (respiration, heat, movement, faeces, parts not eaten), so eating the crop directly passes about ten times as much of the crop's energy to people, and the same area of land can feed more people.

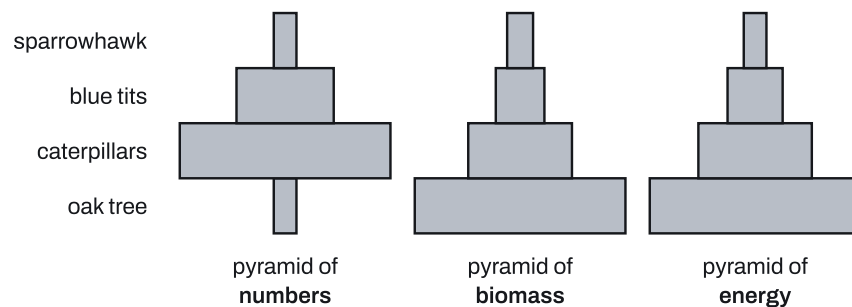
Pyramids of numbers and biomass

An **ecological pyramid** has one horizontal bar for each trophic level, with the producers at the bottom. The width of each bar shows how much there is at that level.

- A **pyramid of numbers** shows the **number of organisms** at each level.
- A **pyramid of biomass** shows the **total mass of living organisms** at each level (number $\times$ mass of one organism), usually as dry mass per unit area.

For a woodland food chain, oak tree $\rightarrow$ caterpillars $\rightarrow$ blue tits $\rightarrow$ sparrowhawk:

Organism	Number	Mass of one / g	Biomass / g
oak tree	1	1 500 000	1 500 000
caterpillars	6 000	2	12 000
blue tits	30	11	330
sparrowhawk	1	250	250

not to scale

The **pyramid of numbers** is not a pyramid shape here: one tree feeds thousands of caterpillars, so the bottom bar is narrow. Numbers pyramids are also odd shapes when there are **parasites** (one dog carries hundreds of fleas, so the flea bar is wider than the dog bar).

The **pyramid of biomass** is a proper pyramid: 1 500 000 g, then 12 000 g, 330 g and 250 g. Because biomass takes the **size of each organism** into account, one large tree gives the widest bar. That is the **advantage of a pyramid of biomass over a pyramid of numbers**: it isn't distorted by a few very large organisms or by many tiny ones, so it shows the food available at each level more usefully.

Extended only: a **pyramid of energy** shows the **energy** at each trophic level (energy stored in the organisms, measured per area over time, usually in **kJ per m² per year**). Because energy is lost at every transfer, a pyramid of energy is **always** a true pyramid shape, with the producer bar the widest.

Extended only: advantages of a pyramid of energy over pyramids of numbers or biomass:

- it shows the **energy transferred** (and lost) at each level more accurately, which is what a food chain is really about;
- it takes account of the **different sizes and body composition** of organisms (a gram of fat holds more energy than a gram of bone or wood);
- it takes account of **different rates of reproduction and different life spans**: a fast-breeding organism with a small biomass at any one moment can still pass on a lot of energy over a year;
- it is measured **over time** (a year), so it isn't affected by **seasonal** changes on the day the sample is taken;
- it allows **comparisons between different ecosystems**.

Key facts and formulas

There is no formula list in the IGCSE Biology exam, so everything below must be learnt. "Learn it" means you must remember it.

Formula or fact	Status
The Sun is the principal source of energy input to biological systems	Learn it
Light energy enters (photosynthesis) → chemical energy passes along the chain → heat is lost to the environment	Learn it
Arrows in a food chain or web point from the food to the organism that eats it (the direction of energy flow)	Learn it
Producer = level 1; primary consumer = 2; secondary = 3; tertiary = 4; quaternary = 5	Learn it
Biomass of a level = number of organisms × mass of one organism	Learn it
Percentage transferred = $\frac{\text{energy at the higher level}}{\text{energy at the lower level}} \times 100$	Learn it
Percentage lost = $\frac{\text{energy in} - \text{energy passed on}}{\text{energy in}} \times 100$	Learn it
Energy passed on = energy at the level – energy lost (heat, waste, not eaten)	Learn it
Roughly 10% passed on and 90% lost at each transfer	Learn it
Extended only: pyramid of energy units: kJ per m ² per year; always a true pyramid	Learn it

How to do it

We tagged 117 questions for this topic (2021–2025, Papers 1–4). 17 of them mix types, so the counts add up to 165.

Question type	Questions
Roles and trophic levels	43
The principal source of energy	19
Pyramids of numbers, biomass and energy	18
Population changes in a food web	18

Question type	Questions
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Forms of energy and energy flow diagrams	14
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Energy calculations	6
Why energy decreases along a chain	6
Advantages of each pyramid	3
Eating crops rather than livestock	2

1. Roles and trophic levels (43 questions)

1. **Find the producer:** the organism with no arrows pointing into it (a plant, alga or phytoplankton).
2. **Follow the arrows up.** Anything that eats the producer is a primary consumer (herbivore); anything that eats a primary consumer is a secondary consumer; and so on.
3. **Check every arrow into the organism.** If it eats organisms at two different levels, it feeds at more than one trophic level (for example a secondary and a tertiary consumer).
4. **Give just what is asked:** a name, a number or a level. Use organisms from the figure.

Variations you will meet:

- **"How many trophic levels?"** Count the organisms in the **longest** food chain, **including the producer**. Not the number of organisms in the web.
- **"How many organisms are secondary consumers / feed at more than one level?"** Work methodically through every chain in the web; don't go by where the name is printed on the page.
- **Trophic level numbers.** Producer = 1, so a tertiary consumer is at level 4 and a quaternary consumer at level 5.
- **Pyramids:** the bottom bar is the producers, the second bar the herbivores, and **every bar above the second** contains carnivores. The top bar is a carnivore, never decomposers.
- **Carnivores and herbivores are also consumers.** In a tick table, a frog is both "consumer" and "carnivore".
- **Decomposers** get energy from producers, herbivores and carnivores (all three), because all of them die and produce waste.
- **Evidence that an organism is a producer,** from a web: it is at the start of the food chains; no arrows point to it; other organisms feed on it; arrows lead away from it. Don't just give the definition.
- **An organism that is both a herbivore and a carnivore** (an omnivore) has arrows into it from a plant and from an animal.

2. The principal source of energy (19 questions)

1. The answer is **the Sun** (sunlight, light energy).
2. It is not the producer, photosynthesis, glucose, carbon dioxide, soil, water or heat. Those are either where the energy enters the chain, the process that traps it, or not a source of energy at all.

Variations you will meet:

- **"Where does the energy in the lettuce come from?"**: the Sun.
- **A chain that starts with a fungus, dead leaves or a decomposer**: still the Sun, because the plant material was made using sunlight.
- **"State where organisms in trophic level 1 get their energy"**: the Sun (light).
- **"Which process uses the principal source of energy?"**: photosynthesis (not respiration).

3. Pyramids of numbers, biomass and energy (18 questions)

1. **Read the food chain** and put the producer at the bottom.
2. **Numbers**: make each bar as wide as the number of organisms. Few large producers (one tree, one bush) give a narrow bottom bar; parasites give a wide bar above their host.
3. **Biomass**: work out number $\times$ mass for each level. It is almost always a true pyramid.
4. **Extended only: energy**: always a true pyramid, producer bar widest.
5. **Label every bar** with the organism's name (not pictures) if you draw one.

Variations you will meet:

- **"Which diagram is the pyramid of numbers / biomass?"** Work out the numbers and biomass from the table or story, then match the shapes. One tree with many insects: numbers pyramid has a narrow base, biomass pyramid is upright. A large host with many parasites: the numbers bar for the parasites is wider than the host's; the biomass is still upright.
- **"Which could be a pyramid of biomass?"** Only the ones that get narrower at every level going up.
- **Units for a pyramid of energy**: kJ per m² per year (energy, per area, per time). Not per g or per kg.
- **"What does a pyramid of energy show?"**: the energy **stored** at each trophic level. It does not show the energy lost, the total energy in the ecosystem, or the Sun's input.
- **Draw a pyramid to scale from data** (Core Paper 3): choose a scale, work out each bar's width, then draw the bars centred one above another. For example, if 1 box represents 10 000 organisms, 26 000 organisms fill $26\,000 \div 10\,000 = 2.6$ boxes. Shade or count boxes carefully.
- **Sketch a pyramid** (Paper 3 or 4): the right order of bars, sensible relative widths and a species label on each bar earn the marks.

4. Population changes in a food web (18 questions)

1. **Find the organism that changes** in the figure.
2. **Follow its arrows both ways**: what it eats (its food) and what eats it (its predators).

3. **State the effect on each organism asked about:** increase or decrease.
4. **Give the reason for each**, naming the organisms: "less food because ...", "fewer predators because ...", "more competition for ...", "the predator eats more ... instead".

For example, in the woodland web, if foxes are hunted out: **rabbits increase** because fewer are eaten; then the **grass decreases** because more rabbits eat it; the **mice may increase** because fewer are eaten by foxes, so **owls and snakes** have more food.

Variations you will meet:

- **"Explain how both changes could occur"**: give an increase with one reason and a decrease with another. For example, if humans overharvest rabbits, a predator that shares the rabbits might **decrease** (less food) or **increase** (fewer competitors for the other prey, or the larger predator switches to eating something else).
- **Graphs** (multiple choice): remove the herbivores and the carnivores fall (no food). Remove the carnivores and the herbivores rise, then fall when they run out of food.
- **Why did a population fall?** Less food (its prey decreased), more predators, overharvesting (overfishing, hunting), pollution, disease, habitat destruction, an introduced species, climate change.
- **Overharvesting or an introduced species**: describe the effects through the named organisms in the web, not in general words.

5. Definitions (15 questions)

Learn these with their key words:

- **Producer**: an organism that makes its own **organic nutrients**, usually using **energy from sunlight**, through **photosynthesis**. ("Makes its own food" or "bottom of the food chain" is too vague.)
- **Consumer**: an organism that gets its energy by **feeding on other organisms**.
- **Herbivore**: an **animal** that gets its **energy** by eating **plants**.
- **Carnivore**: an **animal** that gets its **energy** by eating **other animals**.
- **Decomposer**: an organism that gets its **energy** from **dead or waste organic material**.
- **Food chain**: shows the **transfer of energy** from one organism to the next, **beginning with a producer**.
Food web: a **network of interconnected food chains**.
- **Trophic level**: the **position** of an organism in a food chain, food web or ecological pyramid.

Variations you will meet:

- **Gap-fill** versions of the same definitions.
- **"Describe what is meant by the term ecosystem"** (2 marks): a unit containing the **community** of organisms **and their environment**, interacting together. (From Nutrient cycles and populations, but asked alongside food webs.)
- **The role of phytoplankton or algae in a web**: they are the producers; they photosynthesise; they start the food chains and are food for many consumers.

6. Forms of energy and energy flow diagrams (14 questions)

1. **Sun to producer:** **light** energy.
2. **Between organisms** (producer to animal, animal to animal): **chemical** energy (in food).
3. **Lost to the environment:** mainly **heat** (from respiration).
4. **In a flow diagram**, the order is Sun → producers → herbivores → carnivores, and **decomposers** receive energy from **every** level (dead remains and waste).

Variations you will meet:

- **Flowcharts** in multiple choice: "energy trapped by chlorophyll" comes before "chemical energy stored in carbohydrates in plants".
- **Energy lost from plants** is heat, not light; **energy passed between animals** is chemical, not kinetic.
- **Extended only: full energy flow diagrams** with boxes for losses: label them **respiration** (heat), **excretion** and **egestion** (waste), and **decomposers** (energy in dead organisms and waste).
- **What do the arrows in a food web show?** The **transfer of energy** (from the food to the organism that eats it).

7. Constructing food chains and webs (14 questions)

1. **Start with the producer.**
2. **Write names, not drawings**, and put an arrow between each pair pointing **towards the eater**.
3. **Check the length:** "four trophic levels" means four organisms, producer included, and every link must be in the web.
4. **Include the named organism** if the question gives one.

Variations you will meet:

- **Build a whole web from written notes** (Paper 4): write each organism **once**, then draw one arrow for every "eats" or "provides food for" in the notes. Check every arrowhead points to the eater.
- **Add one feeding relationship** to a web: one arrow, head at the eater.
- **Write the food chain shown by a pyramid:** bottom bar first.
- **Multiple choice "which food chain is part of this web?":** check every arrow in the option exists in the web, in the right direction.

8. Processes that transfer energy (7 questions)

- **Photosynthesis** traps light energy as chemical energy (Sun → producer).
- **Ingestion** (feeding, eating) passes energy from one trophic level to the next.
- **Respiration** releases energy from food; it is where the energy lost as heat at each level comes from.

Wrong options are usually egestion, excretion, transpiration or combustion.

9. Energy calculations (6 questions)

1. **Energy passed on** = energy at a level – energy lost at that level.
2. **Percentage transferred** = $\frac{\text{energy at the higher level}}{\text{energy at the lower level}} \times 100$.
3. **Percentage lost** = $\frac{\text{energy lost}}{\text{energy at the start}} \times 100$, or $100 - \text{percentage transferred}$.
4. **Round last**, to the significant figures asked.

For example, if producers hold 60 000 kJ and primary consumers 4 500 kJ, the percentage transferred is $\frac{4\,500}{60\,000} \times 100 = 7.5\%$ and the percentage lost is $100 - 7.5 = 92.5\%$.

Variations you will meet:

- **Losses on the diagram:** producers hold 30 000 kJ and lose 27 000 kJ, so $30\,000 - 27\,000 = 3\,000$ kJ passes to the primary consumers.
- **Across two levels:** the percentage lost between the producers and the secondary consumers compares those two levels directly. From 1 000 units to 10 units, $\frac{1\,000 - 10}{1\,000} \times 100 = 99\%$ is lost.
- **The 10% rule:** "90% is lost at each step". Multiply by 0.1 once for every transfer.
- **To one significant figure:** 8.38 . . . becomes 8. Each of the calculation and the rounding usually earns a mark.

10. Why energy decreases along a chain (6 questions)

Extended only.

1. Say that **energy is lost** at each trophic level (use the word **energy**).
2. **Name at least two losses:** heat released by **respiration**; energy used for **movement**; parts **not eaten**; parts **not digested**, lost in **faeces**; **excretion**; not every organism is eaten; energy passing to **decomposers**.
3. **Link it to the next level:** so **less energy is available** to the next trophic level, which can support **less biomass** and **fewer organisms**.
4. **Why food chains are short:** after four or five transfers too little energy is left to support another level.

Variations you will meet:

- **"Explain why there are fewer owls than mice":** energy is lost between levels (named example), so less biomass can be supported at the higher level.
- **"Outline how energy in primary consumers becomes biomass in secondary consumers":** the secondary consumer **ingests** the primary consumer, **digests** it, **absorbs** the products and **assimilates** them into its own tissues (growth); some energy is lost along the way as heat from respiration, in faeces and in excretion.
- Growth and reproduction are **not** the losses: the energy they use goes into biomass, which the next level can eat.

11. Advantages of each pyramid (3 questions)

- **Biomass over numbers** (Core): biomass takes the **size** of the organisms into account, so one large tree or many tiny organisms don't distort the shape. "It is more accurate" on its own earns nothing.
- **Extended only: energy over biomass or numbers**: shows energy transfer and loss accurately; takes account of different **body sizes and composition**, different **rates of reproduction** and **life spans**; measured over a **year**, so it covers **seasonal** changes; lets you **compare ecosystems**. Give two for 2 marks.

12. Eating crops rather than livestock (2 questions)

Extended only.

1. Eating crops puts humans at **trophic level 2**; eating livestock puts them at level 3: **one more transfer**.
2. At each transfer about **90% of the energy is lost** (heat from respiration, movement, faeces, parts not eaten).
3. So eating the crop **directly** passes more of the crop's energy to humans, and the same land feeds more people.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **M1** method mark: for a correct method, even if the numbers slip.
- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

Example 1

This question uses the woodland food web in "Understand it" (grass, grasshopper, mouse, rabbit, frog, snake, owl, fox).

- (a) Name the producer in the food web. **[1]**
- (b) Name one primary consumer. **[1]**
- (c) Use the food web to write a food chain with four trophic levels. **[1]**
- (d) Name the organism that feeds at more than one trophic level, and state both levels. **[2]**
- (e) A disease kills most of the frogs. Predict and explain the effect on the grasshoppers and on the mice. **[4]**

(a) Grass **B1**

(b) Grasshopper (or mouse, or rabbit) **B1**

(c) grass → grasshopper → frog → snake **B1** (all four names, all arrows pointing to the eater)

(d) Snake **B1**; secondary consumer (level 3) when it eats mice, and tertiary consumer (level 4) when it eats frogs **B1**.

(e) Grasshoppers increase **B1**, because fewer are eaten by frogs **B1**. Mice decrease **B1**, because snakes have fewer frogs to eat, so they eat more mice **B1**.

Example 2

Extended only. The table shows the energy in each trophic level of a grassland food chain.

Trophic level	Energy / kJ per m ² per year
producers	20 000
primary consumers	2 400
secondary consumers	230
tertiary consumers	17

(a) Calculate the percentage of energy transferred from the primary consumers to the secondary consumers. Give your answer to two significant figures. **[2]**

(b) Calculate the energy lost between the producers and the primary consumers, and the percentage this is of the producers' energy. **[2]**

(c) State two ways in which energy is lost between trophic levels. **[2]**

(d) Explain why this food chain has only four trophic levels. **[2]**

(a) $\frac{230}{2\,400} \times 100 = 9.583 \dots$ **M1** = 9.6% **A1**

(b) $20\,000 - 2\,400 = 17\,600$ kJ per m² per year **B1**; $\frac{17\,600}{20\,000} \times 100 = 88\%$ **B1**

(c) Any two: heat released by respiration **B1**; energy used in movement; parts of the organisms not eaten; food not digested, lost in faeces **B1**.

(d) Energy is lost at every transfer, so less energy is available at each level **B1**; the tertiary consumers only get 17 kJ per m² per year, too little to support another trophic level **B1**.

Example 3

A food chain in an orchard is apple tree → caterpillars → blackbirds → fleas. The fleas are parasites that live on the blackbirds.

Organism	Number	Mass of one / g
apple tree	1	300 000
caterpillars	2 000	3
blackbirds	8	100
fleas	400	0.0005

(a) Calculate the biomass of each trophic level. **[2]**

(b) Describe the shape of the pyramid of numbers for this food chain and explain why it is not a pyramid shape. **[3]**

(c) Describe the shape of the pyramid of biomass. **[1]**

(d) State one advantage of a pyramid of biomass over a pyramid of numbers. **[1]**

(a) Apple tree $1 \times 300\,000 = 300\,000$ g; caterpillars $2\,000 \times 3 = 6\,000$ g; blackbirds $8 \times 100 = 800$ g; fleas $400 \times 0.0005 = 0.2$ g **M1 A1 (M1 for number $\times$ mass)**

(b) The bottom bar (1 tree) is narrow, the caterpillar bar (2 000) is the widest, the blackbird bar (8) is narrow and the flea bar (400) is wider again **B1**. One tree is so large that it feeds thousands of caterpillars **B1**, and many small parasites live on each bird **B1**.

(c) A true pyramid: each bar is narrower than the one below, from 300 000 g down to 0.2 g **B1**.

(d) It takes the size (mass) of the organisms into account, so a single large producer or many tiny parasites don't distort its shape **B1**.

Common mistakes

- **Arrows the wrong way round.** The arrow points to the eater, in the direction the energy flows. Examiners see arrowheads at the wrong end, or missing, every year.
- **Forgetting the producer is a trophic level.** A chain of four organisms has **four** trophic levels, and a tertiary consumer is at level 4.
- **Counting organisms instead of trophic levels**, or writing names when the question asks "how many".
- **Saying the energy comes from the producer or from photosynthesis.** The **original** source is the **Sun**.
- **Not seeing that herbivores and carnivores are consumers too.**
- **Mixing up the forms of energy.** Light in, chemical between organisms, heat out. Not "kinetic energy passed between animals" or "light lost by plants".
- **Saying energy is "used in respiration" or "lost by growth".** Respiration **releases** energy, and most ends up as heat. Energy used for growth and reproduction goes into biomass, so the next level can eat it.
- **Explaining short food chains by size:** "top predators are large and need lots of food" misses the point. It is about **energy lost** at each transfer.
- **"A pyramid of energy shows how energy is lost."** It shows the energy **stored** at each trophic level.

- **"Pyramids of biomass are more accurate"** with no reason. Say **why**: they take the size of the organisms into account.
- **Describing the whole web when asked about one population**, or naming organisms that aren't in the figure. Use the figure and name the organisms.
- **Rounding to decimal places when significant figures are asked.** 8.38 to one significant figure is 8.

How to get the marks

- **"State" or "name"** wants one word or a name from the figure: "Sun", "grass", "snake", "4".
- **"Using Fig. ..."** means organisms from that figure only.
- **Food chains:** names, not drawings; start with the producer; arrows pointing to the eater. One mark usually needs every link right.
- **"Describe the flow of energy"**: light energy from the Sun, trapped by chlorophyll in photosynthesis, stored as chemical energy, passed along the chain by feeding, lost as heat from respiration, with dead material to decomposers.
- **"Explain" a population change:** the direction (increase or decrease) **and** a reason through a named organism ("less food because the frogs have died"). Each part is usually a separate mark.
- **"Explain why energy decreases"** (Extended): the word **energy**, a **named** loss, and the **link** to less biomass at the next level.
- **Calculations:** show the numbers you took from the figure, then the calculation, then the rounding asked for. A mark is often given for each.
- **Sketching a pyramid:** bars in the right order, sensible widths, every bar labelled with the species.
- **Multiple choice:** read every column of a row; follow the arrows in the web, one at a time.

Quick check

1. In the food chain seaweed → limpet → crab → gull, name the secondary consumer and state the trophic level of the gull.
2. What is the principal source of energy input to biological systems? In what form does energy pass from one organism to the next in a food chain?
3. **Extended only.** Producers in a pond hold 15 000 kJ per m² per year and the primary consumers hold 1 200 kJ per m² per year. Calculate the percentage of energy transferred and the energy lost.
4. In a field, 5 000 grass plants are eaten by 1 cow, and 200 ticks live on the cow as parasites. Describe the shape of the pyramid of numbers and of the pyramid of biomass.
5. **Extended only.** A field of wheat holds 50 000 kJ of energy. Assuming 10% is passed on at each transfer, how much reaches humans who eat the wheat, and how much reaches humans who eat cattle fed on the wheat? Explain the difference.
6. Describe what is meant by a decomposer.

Answers

1. The crab is the secondary consumer. The gull is at trophic level 4 (a tertiary consumer).
2. The Sun. Chemical energy (in food).
3. $\frac{1\,200}{15\,000} \times 100 = 8\%$ transferred; $15\,000 - 1\,200 = 13\,800$ kJ per m² per year lost.
4. Numbers: a wide bottom bar for the 5 000 grass plants, a narrow bar for the 1 cow and a wider bar again for the 200 ticks, so it is not a pyramid shape. Biomass: a true pyramid, the grass widest, getting narrower at every level (200 ticks weigh far less than one cow).
5. Eating wheat: $50\,000 \times 0.1 = 5\,000$ kJ. Eating cattle: $50\,000 \times 0.1 \times 0.1 = 500$ kJ. Eating the cattle adds one more transfer, and about 90% of the energy is lost at each transfer (heat from respiration, movement, faeces, parts not eaten), so eating the crop directly gives ten times as much energy.
6. An organism that gets its energy from dead or waste organic material.

Past questions to try

- [0610/42/M/J/23 Q4](#): build a food web from notes, trophic levels, energy becoming biomass, crops versus livestock.
- [0610/32/F/M/24 Q5](#): quaternary consumer, sketch a pyramid of biomass, and overharvesting rabbits.
- [0610/31/M/J/23 Q5](#): a pyramid of numbers and why a pyramid of biomass can be better.
- [0610/42/F/M/24 Q6](#): energy loss along food chains and the advantages of a pyramid of energy.