IB BIOLOGY | C4.2 | SL

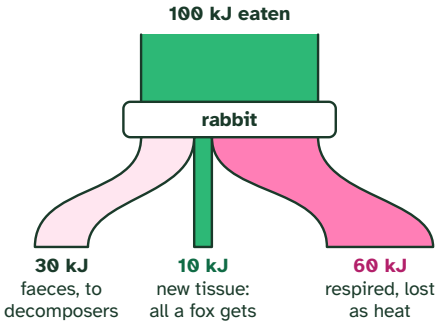
REVISION ON TWO PAGES

Energy *flows*, matter cycles

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

Energy arrives as light and leaves as heat, so it passes through once. Carbon and every other element are recycled.



Follow 100 kJ. Band widths are to scale: only the green tenth reaches the next level.

C4.2.12 to 14 START HERE

Energy is *lost* at every step

- Only a small share of one level's energy, often **about a tenth**, ends up in the next level.
- **The rest:** parts not eaten and food not absorbed (faeces) go to decomposers; most absorbed energy is **respired and lost as heat**.
- No transfer is 100% efficient: heat is released **when ATP is made and when it is used**, in autotrophs and heterotrophs alike. No organism turns heat back into chemical energy.
- Less energy each step means fewer or smaller organisms: **less biomass**, but not less energy per gram. So chains rarely have **more than five levels**.

WHERE A LEVEL'S ENERGY GOES

1. **Not eaten** roots, bark, bones, bodies
2. **Not absorbed** out in the faeces
3. **Respired** lost as heat
4. **Passed on** about 10%, to the next level

C4.2.1, C4.2.2

Light in, *heat* out

- Sunlight, caught in photosynthesis, is the **principal energy source** for most ecosystems.
- **Exceptions:** **caves**, and the **deep ocean** below about 200 m.
- **Nature of science:** this is like a **law**: it describes a pattern and predicts, but does not explain. Vent communities, found in 1977, narrowed it to "most".

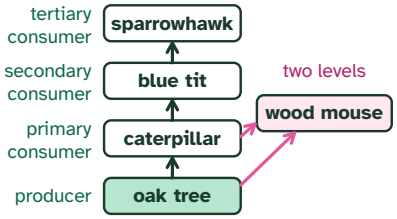
Open system energy and matter cross
A wood or a pond: most ecosystems.

Closed system only energy crosses
A sealed jar: light in, heat out.

C4.2.3, 4, 10

Chains and *trophic levels*

- Feeding passes the food's **carbon compounds**, and the **chemical energy** in them, to the consumer.
- Arrows point **from the eaten to the eater**: the way energy and biomass go.
- Chains link into a web. A varied diet puts an animal on **different levels in different chains**.



C4.2.5

Food for *decomposers*

- **Faeces**, **dead parts** and **whole dead organisms** are still **carbon compounds holding energy**.
- Decomposers respire them, releasing CO_2 and heat, and leave **mineral ions** that plants take up.
- Not drawn on food chains, but **energy from every level** reaches them.

Detritivores digest inside
Earthworms, woodlice and millipedes eat dead matter.

Saprotrophs digest outside
Most fungi and many bacteria secrete enzymes, then absorb.

C4.2.6 to 9 AUTOTROPHS AND HETEROTROPHS

Make it or *take it*

ORGANISM	CARBON FROM	ENERGY FROM	EXAMPLE
P **Photoautotroph** an autotroph	**Simple inorganic substances**: CO_2, water, ions such as nitrate.	**Light.**	Plants, algae and cyanobacteria.
C **Chemoautotroph** an autotroph	The same: it **fixes CO_2**, like a plant.	**Oxidation reactions.** Oxidising inorganic chemicals releases energy.	**Iron-oxidising bacteria**: Fe^{2+} to Fe^{3+}, orange rust in iron-rich streams.
H **Heterotroph** takes from others	Carbon compounds **from other organisms**: digested, absorbed, then **assimilated** into its own.	**Its food.**	Animals digest in the gut; fungi and many bacteria outside their cells.
R **All of them** C4.2.9	Every organism, autotroph or heterotroph, **respires**.	**Respiration.** Oxidising carbon compounds releases energy.	Plants respire day and night, as foxes do.

Autotrophs need energy for **carbon fixation** and the **anabolic** reactions that build macromolecules.

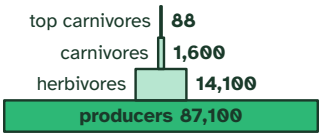
Heterotrophs digest proteins and nucleic acids first.

Production, and carbon going *round*

C4.2.11 DRAW IT TO SCALE

Energy *pyramids*

- One bar a level, producers at the bottom, width **in proportion to energy**.
- Units: **kJ m⁻² yr⁻¹**. Efficiency = level ÷ level below × 100.
- Never upside down: each level **loses energy** before the next.



Silver Springs, Florida (Odum), kJ m⁻² yr⁻¹

C4.2.15, 16

Building *biomass*

- **Primary:** carbon compounds **accumulating in biomass by autotrophs**, in g m⁻² yr⁻¹.
- **Net** = gross − respiration.
- **Secondary:** biomass built by heterotrophs. **Lower than primary**: much is respired to CO_2 and water.

Net primary production, g m⁻² yr⁻¹

2,000+	<100
rainforest	hot desert

C4.2.21, 22

A two-way *trade*

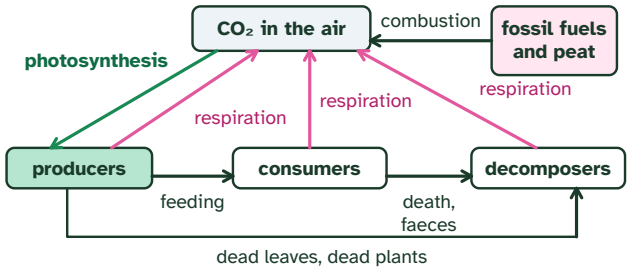
- Aerobic respiration needs **O_2 from photosynthesis**; photosynthesis needs **CO_2 from respiration**.
- On land, 100 billion tonnes of carbon go each way a year: **huge fluxes**.
- **Every element** is recycled; **decomposers** return them.

Photosynthesis autotrophs	CO_2 in, O_2 out.
Respiration all organisms	O_2 in, CO_2 out.

C4.2.17 to 19

The *carbon* cycle, sinks and sources

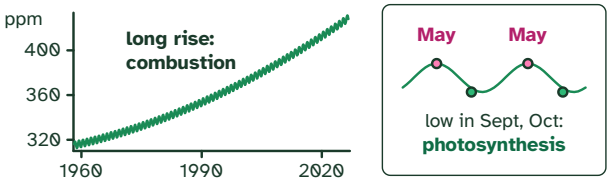
- Energy passes through once; **carbon is recycled** by photosynthesis, feeding and respiration.
- **Sink:** photosynthesis exceeds respiration, a **net uptake of CO_2** (a growing forest, a peat bog). **Source:** a **net release**.
- **Combustion** of biomass, peat, coal, oil and gas releases CO_2. Lightning fires are natural; **humans have greatly increased** the rate.
- **Formed at different times:** wood in years, peat over thousands, coal about 300 million years ago.



C4.2.20

Reading the *Keeling* curve

- Monthly CO_2 at **Mauna Loa**, Hawaii, since 1958: from about 315 to **over 420 ppm**.
- **Yearly wiggle:** most land is northern. In its summer **photosynthesis exceeds respiration** and CO_2 falls; in winter respiration raises it.
- **Long rise:** **combustion of fossil fuels** and deforestation release carbon faster than it is taken back.



WATCH OUT

Six mistakes that *cost marks*

- ✕ **Arrows point to the eater.** Energy goes from rabbit to fox.
- ✕ **Energy is not used up.** It ends as heat; the total is conserved.
- ✕ **Plants respire too.** Every living cell respires, day and night.
- ✕ **Chemoautotrophs fix CO_2.** Iron gives energy, not carbon.
- ✕ **Decay gives plants ions, not energy.** Roots absorb ions.
- ✕ **Winter heating does not cause the wiggle.** Combustion drives the rise; the wiggle is northern photosynthesis.

COVER THE SHEET

Can you *answer these?*

1. Distinguish an open system from a closed one.
2. Draw a food chain and label its trophic levels.
3. State three sources of energy for decomposers.
4. Compare a chemoautotroph with a heterotroph.
5. Calculate producer to herbivore efficiency above.
6. Explain why chains rarely pass five levels.
7. Explain why secondary production is lower.
8. Draw a carbon cycle with three processes.
9. Explain the wiggle and the rise in the Keeling curve.
10. Outline how respiration depends on photosynthesis.

IN THE EXAM

Name the loss and where it goes ("lost as heat in respiration", "in faeces, to decomposers"). For the Keeling curve, **give the wiggle and the rise separate causes**.

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.