

Exercise walk-through

4.2

Productivity and energy transfer (statements 5.9–5.10)

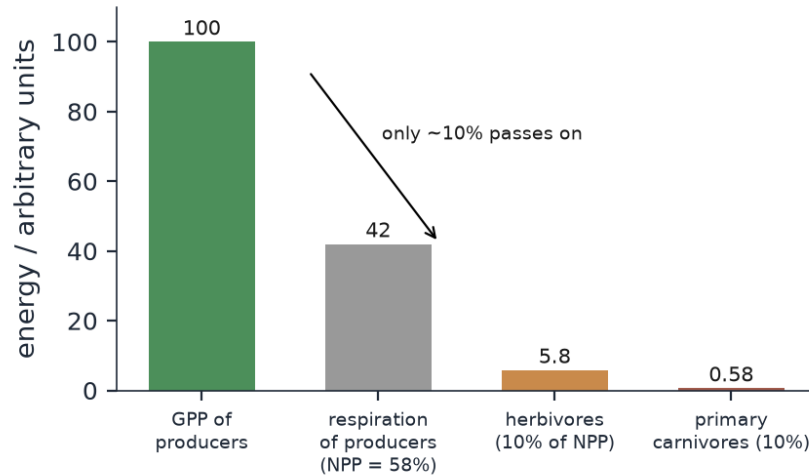
Pearson Edexcel · International A-Level · Biology

Energy in, energy through, energy lost

Follow the energy: photosynthesis fixes it, food chains lose it, microbes recycle it, and immunity spends it.

- WBI14 is the first IA2 paper.
- 105 minutes, 90 marks, all compulsory.
- Topics 5 and 6 together on one paper.
- Calculation-heavy after Unit 1.

Ten per cent, four losses



- 1 **Fix** grassland fixes 45 000 kJ per square metre per year
- 2 **Subtract** respiration spends 19 000, so $NPP = 26\ 000$
- 3 **Transfer** cattle keep about 2 600; humans eating cattle keep 260

Check yourself

Your turn

Grassland NPP is 40 000 kJ per square metre per year. At 10% per transfer, what reaches second-order consumers?

- A. 400 kJ - two transfers of 10%
- B. 4 000 kJ - one transfer
- C. 40 kJ - three transfers
- D. 400 000 kJ - the food chain multiplies energy

Exercises 2.1·2.3

2.1 Define net primary productivity and give its units. [2]

2.2 State two reasons energy is lost between a rabbit and the fox that eats it. [2]

2.3 Producers fix $80\,000\text{ kJ m}^{-2}\text{ yr}^{-1}$ and respire 30 000. Calculate the energy reaching second-order consumers if each transfer is 10 % efficient. [2]

Exercises 2.1·2.3

2.1 Define net primary productivity and give its units. [2]

2.1 The energy fixed by photosynthesis minus the producers' own respiration; units $\text{kJ m}^{-2} \text{yr}^{-1}$.

2.2 State two reasons energy is lost between a rabbit and the fox that eats it. [2]

2.2 Any two: rabbit respiration lost as heat; egestion of cellulose; excretion; parts of the rabbit never eaten by the fox.

2.3 Producers fix $80\,000 \text{ kJ m}^{-2} \text{yr}^{-1}$ and respire $30\,000$. Calculate the energy reaching second-order consumers if each transfer is 10 % efficient. [2]

2.3 $\text{NPP} = 50\,000$; herbivores keep $5\,000$; second-order consumers keep $500 \text{ kJ m}^{-2} \text{yr}^{-1}$.

Exercise 3.1

3.1 The table shows the energy entering and leaving each trophic level of a lake ($\text{kJ m}^{-2} \text{yr}^{-1}$).

Level	Energy in	Respiration	Egestion + excretion	Eaten by next level
Algae	55 000 (fixed)	22 000	3 000	?
Zooplankton	?	2 400	900	470
Fish	470	210	60	44

Calculate the algae's NPP, the transfer efficiency from algae to zooplankton, and the efficiency from zooplankton to fish. [5]

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3.1 Algae NPP = $55\,000 - 22\,000 = 33\,000$. Zooplankton intake = algae's passed-on energy: $33\,000 - 3\,000$ egestion = $30\,000$; transfer efficiency $2\,400 + 900 + 470 = 3\,770$... consistent intake is $3\,770$: efficiency = $3\,770/30\,000 \approx 12.6\%$. Zooplankton to fish: $470/3\,770 \times 100 = 12.5\%$. Allowing for zooplankton production only ($470 +$ respiration + losses): full credit for consistent ratios.

Exercises 3.2·3.3

3.2 Explain why a vegetarian human population can be larger than a meat-eating one on the same land, referring to the energy losses at each transfer. [4]

3.3 A farmer measures biomass transfer from grass to cattle at 8 % in a cold winter and 15 % in summer. Suggest why the winter percentage falls, referring to respiration, and state one management change that would raise it. [4]

Exercises 3.2-3.3

3.2 Explain why a vegetarian human population can be larger than a meat-eating one on the same land, referring to the energy losses at each transfer. [4]

3.2 Each transfer loses ~90 % of the energy to respiration and waste; eating plants directly removes one whole transfer, so the same land supports roughly ten times the human energy intake.

3.3 A farmer measures biomass transfer from grass to cattle at 8 % in a cold winter and 15 % in summer. Suggest why the winter percentage falls, referring to respiration, and state one management change that would raise it. [4]

3.3 In cold conditions the cattle respire more to maintain body temperature, so a larger share of intake leaves as heat instead of biomass. Management: housing or windbreaks to reduce heat loss; or higher-energy feed so more intake remains after maintenance.