

Name	Date started	Target end date
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GCE A LEVEL – BIOLOGY UNIT 3 QUESTION PACK

1074 (Legacy BY4) + 1075 (Legacy BY5) · New spec Unit 3 Topic 13 · A2 unit, first sat 2017, 90 marks, 2h paper

REVISE

.wales

BIOLOGY – UNIT 3 · ECOSYSTEMS – ENERGY FLOW & NUTRIENT CYCLES

3.7 Ecosystems – trophic levels, productivity, energy flow and nutrient cycling

Trophic levels, pyramids of numbers / biomass / energy, gross and net primary productivity, photosynthetic efficiency, the < ~10% energy transfer between trophic levels, and the cycling of mineral nutrients (sulphur, nitrogen, carbon) by decomposers and microorganisms in ecosystems.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~1 h 15 min

Derived from the legacy BY4 / BY5 papers' pace of ~1.3 min/mark, padded for long-prose answers (47 marks over 5 questions).

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC BY4 (and BY5, where relevant) papers (2008 modular spec, 2011–2017) that maps onto new-spec A2 Unit 3 Topic 13 (3.7).

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working – quality of written communication will affect marks. A calculator is allowed. Diagrams included in answers must be fully annotated.

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Q	Source	Max	Mark	Q	Source	Max	Mark
1	BY5 Jun 12 Q1	5		4	BY5 Jun 16 Q5	13	
2	BY5 Jun 13 Q6	8		5	BY5 Jun 17 Q2	8	
3	BY5 Jun 15 Q6	13					
Total						47	

Ecosystems – Energy Flow & Nutrient Cycles – what the new spec asks

WJEC GCE A Level Biology (from 2015) · Unit 3: Energy, Homeostasis & the Environment · Topic 3.7.

Trophic levels

- Producers (autotrophs) → primary, secondary, tertiary consumers.
- Decomposers act at every level, recycling nutrients.
- Pyramids of numbers, biomass and energy summarise structure.

Primary productivity

- GPP = total chemical energy fixed by producers per unit area per time.
- NPP = GPP – respiration losses by producers.
- Limited by light, water, nutrients and temperature.

Energy transfer

- Only ~10% of energy passes between consumer trophic levels.
- Losses: respiration, heat, unconsumed parts, faeces.
- Why food chains rarely have more than 4–5 levels.

Improving efficiency

- Confining animals (heated sheds, less movement) reduces respiration losses.
- Selective breeding for fast growth.
- Ethical and welfare costs vs efficiency gains.

Nitrogen cycle

- Fixation → ammonification → nitrification → uptake by plants.
- Denitrification returns nitrate to atmospheric N_2 .
- Lightning + Haber-Bosch process also fix atmospheric N_2 .

Carbon & sulphur cycles

- Photosynthesis fixes CO_2 ; respiration + combustion release it.
- Carbon stored in biomass, dead matter, fossil fuels, oceans.
- Sulphur cycle: similar to nitrogen, with oxidation / reduction by soil microbes.

Ecosystems – Energy Flow & Nutrient Cycles in one page

Quick-reference notes – revisit before each question.

Trophic levels

Producers → primary → secondary → tertiary consumers.

Decomposers cross-cut all levels.

Pyramids

Numbers: count of individuals (can be inverted).

Biomass: dry mass per area (usually correct shape).

Energy: $\text{kJ m}^{-2} \text{yr}^{-1}$ (always correct shape).

Productivity

GPP = total light energy fixed.

NPP = GPP – producer respiration.

Limited by light, water, temperature, nutrients.

Energy transfer

~10% efficient between consumer levels.

Losses: respiration, heat, faeces, unconsumed parts.

Why food chains rarely > 4–5 levels.

Improving yield

Heat sheds → less respiration loss.

Restrict movement → less muscle / activity loss.

Ethical / welfare concerns vs efficiency.

Photosynthetic efficiency

~1–3% of incident light typically fixed.

Limited by reflection, transmission, wavelength range.

Crop breeding aims to improve this.

Carbon cycle

Photosynthesis fixes; respiration + combustion release.

Reservoirs: atmosphere, oceans, biomass, fossil fuels.

Sulphur cycle

Soil microbes oxidise / reduce S compounds.

Plants take up sulphate.

Burning fossil fuels ⇒ atmospheric SO_2 .

1. The following list of terms concerns ecology and related topics.

[5]

A	secondary productivity
B	biomass
C	eutrophication
D	trophic efficiency
E	pyramid of energy
F	coppicing
G	monoculture
H	algal bloom
I	carbon footprint

Below are five statements. Select from the above list the **letter** for an appropriate term to match each statement.

- (a) The rate at which consumers accumulate energy in the form of cells or tissue.
- (b) The total level of carbon dioxide due to the actions of an individual, mainly through their energy use, over a period of one year.
- (c) A natural process which results from the build up of nitrates in lakes and rivers.
- (d) A technique whereby trees are cut down close to the ground and then left for several years to re-grow shoots.
- (e) The simultaneous growth of a large number of crop plants of similar age and type within a defined area.

(Total 5 marks)

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6. (a) Explain what is meant by the term *gross primary productivity*. [1]

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(b) It has been found that an increase in temperature has a greater effect on the rate of respiration in a plant than on the rate of photosynthesis. Using this information, explain what effect an increase in temperature has on the net primary productivity. [2]

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(c) (i) Give **two** ways by which energy is lost as it passes from one trophic level to the next. [2]

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(ii) Consumption efficiency is defined as the percentage of net production at one trophic level that is consumed by the next. Suggest why the consumption efficiency of herbivores is much lower than that of carnivores. [2]

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(d) Tropical marine or tropical lake ecosystems generally have one or two more trophic levels than terrestrial ecosystems. Suggest **one** reason why this is the case. [1]

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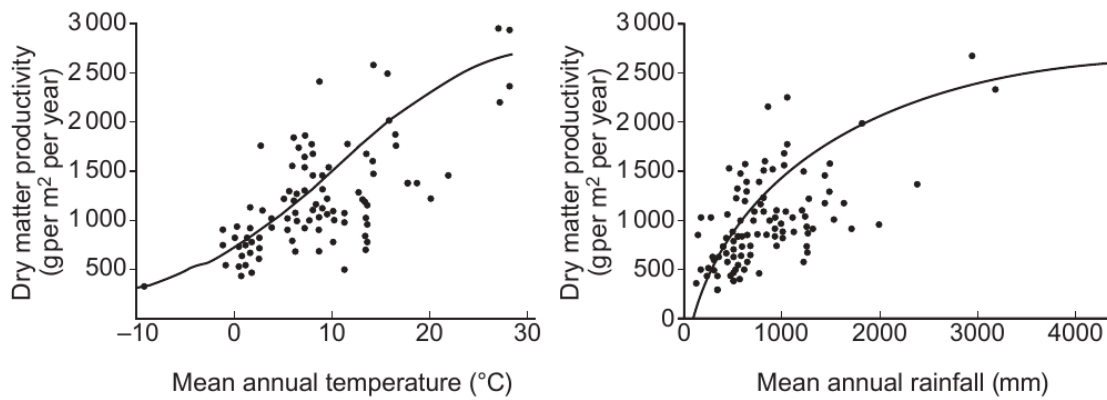
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Examiner only

6. (a) (i) Describe what is meant by the photosynthetic efficiency of a plant. [1]

(ii) Distinguish between Gross Primary Production (GPP) and Net Primary Production (NPP). [1]

(b) The rate of Primary Production is called Primary Productivity. The graphs below show the effect of two environmental factors on Primary Productivity.



(i) Describe the relationship between productivity and the **two** abiotic factors shown. [1]

(ii) Use this information to suggest why tropical rain forest is one of the most productive ecosystems in the world. [1]

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- (c) Estimates of Net Primary Productivity for different types of ecosystem are given in the table below.

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only

Type of Ecosystem	Average NPP (kJ/m ² /yr)
Tropical rain forest	35 280
Temperate forest	24 360
Northern coniferous forest	15 120
Woodland and shrubs	10 920
Lakes and streams	9 240
Agricultural crops	8 820
Desert	840

The average value for the solar energy striking the Earth's atmosphere is estimated at 4.41×10^7 kJ/m²/yr.

The ecological efficiency of tropical rain forest is $(35\,280 \div 4.41 \times 10^7) \times 100 = 0.08$

- (i) Calculate the ecological efficiency of agricultural crops. [2]

Answer

- (ii) Calculate the loss in Net Production for one year, if an area of tropical rain forest the size of Wales (21 785 km²) was cleared and used to grow sugar cane (an agricultural crop). [2]

Answer

Examiner
only

(iii) Explain why keeping cattle on the cleared land would be less efficient than growing crops. [2]

.....

.....

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(iv) Suggest a negative impact on the Earth's atmosphere of keeping large numbers of cattle. [2]

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(v) Suggest why growing sugar cane for producing biofuels could be considered carbon neutral. [1]

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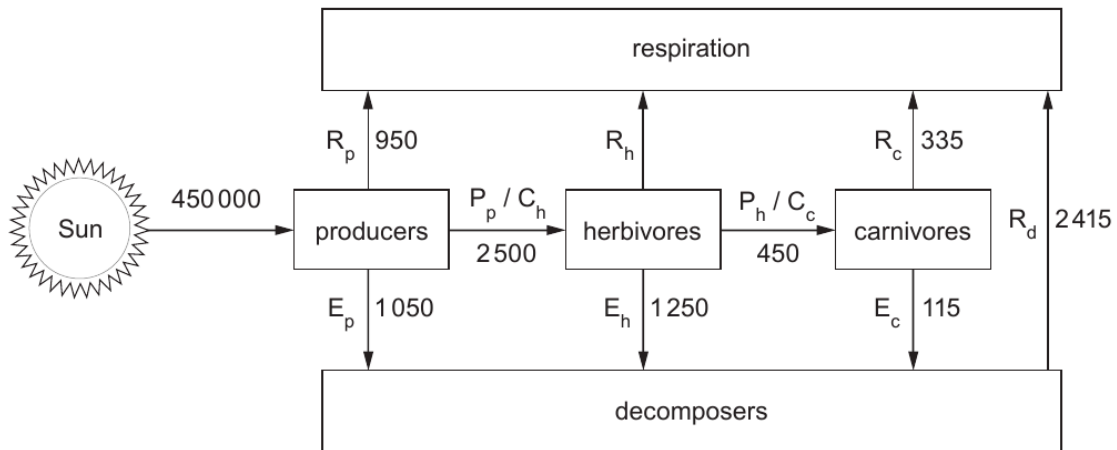
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5. The diagram below shows energy transfer through a model ecosystem, where,
 C = consumption, P = production, R = respiration, E = death, faeces or urine;
 subscripts indicate the feeding group p = producers, h = herbivores, c = carnivores,
 d = decomposers,
 e.g. C_h = consumption in herbivores.



- (a) (i) Define the term *trophic level*. [1]
-
- (ii) Using appropriate letters from the diagram write an equation to represent energy transfer through the herbivores. [1]
- (b) The numbers in the diagram represent energy transfer over a given area of ecosystem in a given time.
- (i) Suggest suitable units for the values. [1]
-

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(ii) Calculate the following:

I. the photosynthetic efficiency of the producers.

[2]

photosynthetic efficiency =

II. R_h

[2]

R_h =

(c) The model assumes that **all** of the biomass produced by one group is transferred to the next group in the food chain. This might not be true in natural ecosystems.

(i) Suggest why this assumption is **not** likely to be true in a woodland ecosystem. [2]

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.....

(ii) State the assumption the model makes about the dead organic material that the decomposers receive. [1]

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.....

(iii) Conditions in peat bogs are acidic. Describe and explain how this will affect the rate of decomposition. [2]

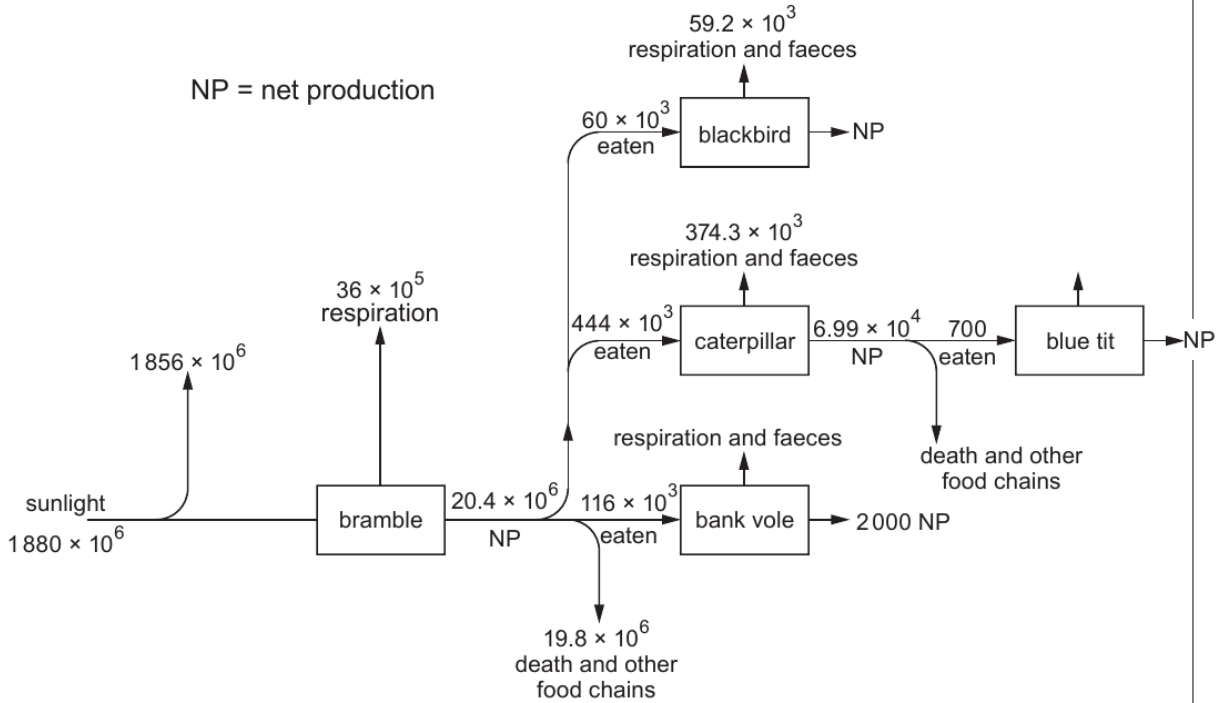
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(iv) Explain whether the assumption the model makes about the dead organic material that the decomposers receive is likely to be true in peat bogs. [1]

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2. The diagram below shows the energy flow in a **small portion** of a woodland ecosystem. Figures are given in $\text{kJ m}^{-2} \text{ yr}^{-1}$.

Examiner only



(a) Which of the organisms are:

(i) autotrophic;

[1]

.....

(ii) secondary consumers?

[1]

.....

5



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only

(b) Calculate the following values:

(i) the gross primary production of brambles;

[2]

gross primary production of brambles = $\text{kJ m}^{-2} \text{yr}^{-1}$

(ii) the net production of blackbirds;

[2]

net production of blackbirds = $\text{kJ m}^{-2} \text{yr}^{-1}$

(iii) how much energy is lost via respiration and faeces by bank voles.

[2]

energy lost = $\text{kJ m}^{-2} \text{yr}^{-1}$

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END OF QUESTION PACK

5 questions · 47 marks · ~1 h 15 min

Source: WJEC BY4 + BY5 (2008 modular spec, 2011–2017)

Curated for WJEC Biology 2015 spec A2 Unit 3 – Topic 13 (3.7)

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