Name	Date started	Target end date

GCE A LEVEL — BIOLOGY UNIT 3 QUESTION PACK

1074 (Legacy BY4) + 1075 (Legacy BY5) · New spec Unit 3 Topic 7 · A2 unit, first sat 2017, 90 marks, 2h paper

REVISE
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BIOLOGY — UNIT 3 · MICROBIOLOGY — NITROGEN CYCLE & MICROBIAL ECOLOGY

3.4 Microbiology — the nitrogen cycle, nitrogen fixation, nitrification and denitrification

The biological roles of soil bacteria in the nitrogen cycle: free-living and symbiotic nitrogen fixers (Rhizobium, Azotobacter) in legume root nodules, ammonification by saprobionts, nitrification by Nitrosomonas and Nitrobacter, and denitrification by anaerobic bacteria returning N_2 to the atmosphere.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~56 min

Derived from the legacy BY4 / BY5 papers' pace of ~1.3 min/mark, padded for long-prose answers (35 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 7 (3.4).

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
1	BY4 Jun 14 Q1	6	
2	BY4 Jun 15 Q2	8	
3	BY4 Jun 17 Q4	7	
4	BY4 Jan 12 Q5	7	
5	BY4 Jan 14 Q2	7	
	Total	**35**	

Microbiology — Nitrogen Cycle & Microbial Ecology — what the new spec asks

WJEC GCE A Level Biology (from 2015) · Unit 3: Energy, Homeostasis & the Environment · Topic 3.4.

Nitrogen fixation

- *Rhizobium* — mutualistic in legume root nodules.
- *Azotobacter* — free-living aerobe in soil.
- Nitrogenase enzyme reduces N_2 to NH_3 (ammonia).

Ammonification

- Saprobiontic bacteria & fungi decompose dead organic matter.
- Proteins & urea broken down to ammonia.
- Ammonia → ammonium ions (NH_4^+) in soil water.

Nitrification

- *Nitrosomonas*: NH_4^+ → nitrite (NO_2^-).
- *Nitrobacter*: nitrite → nitrate (NO_3^-).
- Aerobic process — needs well-drained soil.

Denitrification

- *Pseudomonas* & *Thiobacillus* — anaerobic.
- Convert nitrates back to N_2 gas, returning to the atmosphere.
- Loss of soil fertility — worse in waterlogged soils.

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Crib sheet »

Microbiology — Nitrogen Cycle & Microbial Ecology in one page

Quick-reference notes — revisit before each question.

Fixation

Atmospheric N_2 (78%) is unavailable to most organisms.

Rhizobium in legume nodules (mutualistic).

Azotobacter free-living in soil.

Nitrogenase

Enzyme converts $N_2 \rightarrow NH_3$ (ammonia).

Inhibited by oxygen — nodules contain leghaemoglobin.

High ATP cost ⇒ needs respiring host root.

Ammonification

Saprobionts decompose dead organisms / urea.

Proteins & amino acids → NH_3 / NH_4^+.

Returns N to the soil pool.

Nitrification

Nitrosomonas: $NH_4^+ \rightarrow NO_2^-$.

Nitrobacter: $NO_2^- \rightarrow NO_3^-$.

Aerobic, exergonic — aerate soil to encourage.

Denitrification

Anaerobic bacteria (*Pseudomonas*, *Thiobacillus*).

$NO_3^- \rightarrow N_2$ gas back to atmosphere.

Worst in waterlogged soils — drain to prevent.

Plant uptake

Roots actively absorb NO_3^-.

Reduced to NH_3 then incorporated into amino acids.

Animals get N by eating plants (or other animals).

Examiner only

Answer **all** *questions.*

1. **Nitrogenases** are enzymes used by some organisms to fix atmospheric nitrogen gas (N_2) into a form of nitrogen available to plants.

The **nif gene** is the gene coding for the synthesis of nitrogenases, found in nitrogen fixing bacteria.

Rhizobium is a mutualistic nitrogen fixing bacteria forming a relationship with legume species. In some species of *Rhizobium*, the nif genes are located on plasmids.

(a) Name the *form* of nitrogen produced by *Rhizobium* that is *'available to plants'*. [1]

.....

(b) Name *another* genus of nitrogen fixing bacteria. [1]

.....

(c) State *precisely* where *Rhizobium* would be found in the legume. [1]

.....

(d) Suggest how the relationship between *Rhizobium* and a legume species is beneficial to **both** organisms. [2]

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.....

(e) What are *plasmids*? [1]

.....

6

Examiner only

2. A denitrifying bioreactor is a trench in the ground packed with wood chips. It becomes colonised by soil bacteria that convert nitrate in drainage water to nitrogen gas. Woodchip bioreactors may be a cost-effective, farm-scale practice for nitrate removal from agricultural drainage. When placed strategically, these bioreactors can reduce nitrate levels flowing into streams and help meet environmental demands for the reduction of total nitrogen content in streams and rivers.

Read the passage above and answer the following questions.

(a) (i) What is the correct term for the process where nitrate is washed from the land in the drainage water? [1]

.....

(ii) Name **one** source of the nitrate on the farmland. [1]

.....

(b) Various soil bacteria can change ammonia or ammonium into nitrite, or nitrite into nitrate as part of the nitrogen cycle. Bacteria of the genus **X** are the primary converters of ammonium into nitrite and bacteria of the genus **Y** oxidise the nitrite to form nitrate.

Name the **two** genera **X** and **Y** in the paragraph above and explain why it is important for plants that ammonia is converted to nitrate. [4]

X ..... **Y** .....

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(c) The drainage of land is important for improving crop growth. Explain why farmers want to drain their land. [2]

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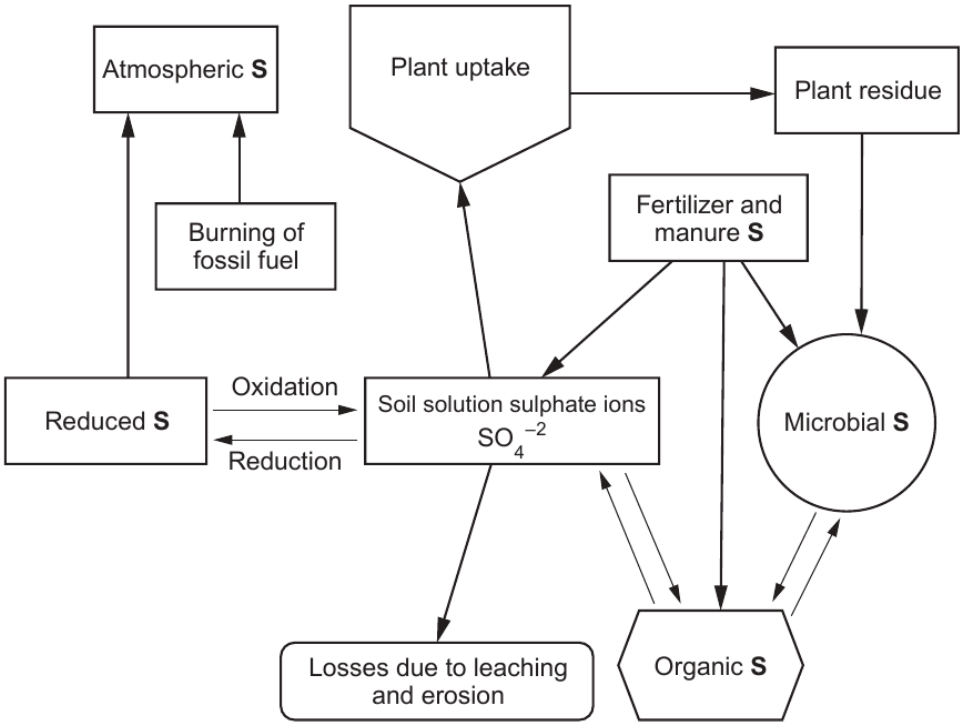
8

Examiner only

4. Organic breakdown and the recycling of mineral nutrients are essential in ecosystems. The diagram below shows the cycling of the mineral sulphur (**S**) in ecosystems, which operates in a similar way to the nitrogen cycle.



(a) (i) State **one** biological molecule which may contain sulphur. [1]

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(ii) Name the mechanism by which the plant takes up sulphate ions. [1]

.....

(b) Explain what is meant by 'losses due to leaching'. [1]

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Examiner only

Although sulphur reduction is shown in the diagram, it is not significant in aerated agricultural soils. In flooded soils, sulphates can be reduced by soil microbes to sulphides with subsequent release of sulphur compounds into the atmosphere.

(c) (i) Using your knowledge of the nitrogen cycle, what steps could farmers take to prevent sulphate loss? [1]

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(ii) Explain how this would affect the conditions in the soil and why this is an advantage to the farmers. [3]

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7

Examiner only

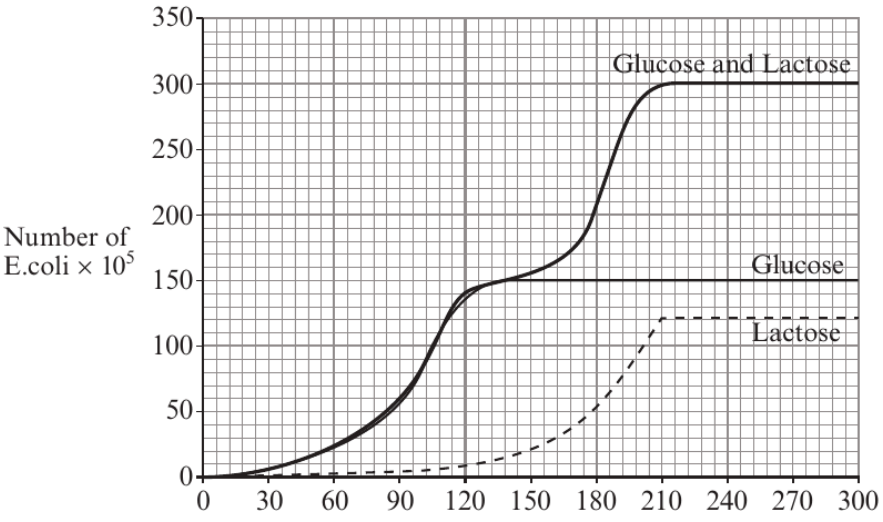
5. Fill in the missing blanks with appropriate scientific terms. [7]

Proteins in dead organisms are decayed by ..... into ..... . The bacterium called ..... converts these into ..... and finally the bacterium ..... converts the waste products of these bacteria into nitrate ions. Bacteria called ..... which live in the root nodules of legumes can fix atmospheric nitrogen.

The bacterium ..... is a free living bacterium in the soil which can also fix nitrogen. It does this by adding atmospheric nitrogen to a carbon source from sugars.

(Total 7 marks)

6. Three fermenters were set up in order to study the population growth of *E. Coli* in different sugar solutions, 0.001 M glucose, 0.001 M lactose and a mixture of glucose and lactose both at 0.001 M. Samples were removed from the fermenter at timed intervals. The population size in each fermenter was estimated. The results are shown in the graph below.



Examiner only

2. The photograph below shows root nodules on a plant.

(a) Name the group of plants which have large numbers of root nodules on their roots. [1]

.....

(b) Explain the advantage to these plants of having root nodules. [3]

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(c) *Nitrosomonas* and *Nitrobacter* are two groups of bacteria which carry out nitrification. Explain this process and why it is so important to soil fertility. [3]

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END OF QUESTION PACK

5 questions · 35 marks · ~56 min
Source: WJEC BY4 + BY5 (2008 modular spec, 2011–2017)
Curated for WJEC Biology 2015 spec A2 Unit 3 — Topic 7 (3.4)

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