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STEM SMART Biology Week 24 - Ecosystems

Ecosystems Overview

Subject & topics

Biology | Ecology | Ecosystems

Status

Not started

Stage & difficulty

A Level Practice 1

Part A

Ecosystem levels

Match the terms to the descriptions below.

[ ]: a group of individuals of one species that live in the same geographical area.

[ ]: the place (or type of place) where an organism lives

[ ]: all the individuals that could potentially interbreed to produce fertile offspring. Usually comprises many populations.

[ ]: all the populations (of different species) that live in the same geographical area.

[ ]: a community plus its physical environment.

Items:

Species **Ecosystem** **Habitat** **Community** **Phylum** **Population** **Kingdom**

Part B

Ecosystem examples

Which of the following could be considered ecosystems? Select all that apply.

- [ ] a rock pool
- [ ] a tree
- [ ] a human
- [ ] a coral reef
- [ ] a forest
- [ ] a city
- [ ] a field

Part C

Ecological niche

Which of the following things are part of the ecological niche of a species? Select all that apply.

- [ ] the biotic and abiotic conditions that the species is best adapted to
- [ ] the types of interactions that species has with other species in the ecosystem
- [ ] the habitat in which that species lives
- [ ] the maximum population size of the species that can be sustained in a given ecosystem
- [ ] the genetic diversity of that species
- [ ] the trophic level of that species

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STEM SMART Biology Week 24 - Ecosystems

Ecological Interactions

Subject & topics

Biology | Ecology | Ecosystems

Status

Not started

Stage & difficulty

A Level Practice 2

Organisms within a species and organisms of different species interact with each other in many different ways within an ecosystem.

Part A

Definitions

Match the interaction types to the definitions in the table below.

Interaction type	Definition
	organisms of **different** species competing for the same resource(s)
	organisms of **the same** species competing for the same resource(s)
	one organism killing and consuming another organism
	an interaction between two organisms that is beneficial for one organism but harmful for the other
	an interaction between two organisms that is beneficial for both organisms
	an interaction between two organisms that is beneficial for one organism and neutral (i.e. neither beneficial nor harmful) for the other

Items:

mutualism **parasitism** **predation** **interspecific competition** **commensalism** **intraspecific competition**

Part B

Examples

Match the interaction type to the example below.

A European garden spider (*Araneus diadematus*) spins a web and waits for an insect to land on it. When this happens, the spider kills and eats the insect. This is an example of [ ].

A male red deer (*Cervus elaphus*) challenges another male red deer, and the two males fight until one concedes defeat. The winner gains the opportunity to mate with the females. This is an example of [ ].

Grey squirrels (*Sciurus carolinensis*) and red squirrels (*Sciurus vulgaris*) eat the same food and occupy the same habitats. The UK population of red squirrels decreased after the introduction of grey squirrels. This is an example of [ ].

Species of the *Plasmodium* genus (single-celled eukaryotes) are transmitted between female *Anopheles* mosquitoes and humans (*Homo sapiens*). Once inside a human's blood, *Plasmodium* cells invade the red blood cells and multiply, using up the nutrients in the red blood cells and eventually causing them to burst - as well as inducing various other symptoms. This is known as malaria. This interaction between *Plasmodium* and humans is an example of [ ].

A honey bee (*Apis mellifera*) lands on a sunflower (*Helianthus annuus*) and drinks nectar from the sunflower, which deposits pollen on the bee. The honey bee then flies to another sunflower to drink nectar from there, transferring pollen to that flower. This interaction is an example of [ ].

A house sparrow (*Passer domesticus*) creates a nest in an oak tree (*Quercus robur*). The sparrow gains shelter and some protection from predators. The oak tree is not affected in any significant way. This is an example of [ ].

Items:

mutualism **inter-specific competition** **commensalism** **predation** **parasitism** **intra-specific competition**

Part C

Extinction consequences

If a population of a particular animal species ("species X") goes extinct in an ecosystem, which of the following species will likely be negatively affected?

- [ ] an animal species that predates on species X
- [ ] a plant species that is predated on by species X
- [ ] an animal species that competes with species X for food
- [ ] a plant species that is pollinated by species X
- [ ] an animal species that parasitises species X

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STEM SMART Biology Week 24 - Ecosystems

Energy Transfer Efficiency

Subject & topics

Biology | Ecology | Ecosystems

Status

Not started

Stage & difficulty

A Level Practice 2

The diagram in **Figure 1** shows a simple food chain.

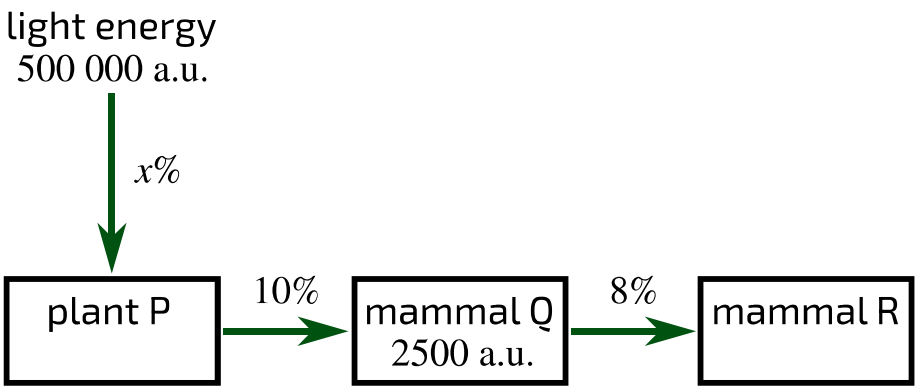

Figure 1: A food chain where energy from light is transferred in turn to P, Q and R. The numbers represent available energy and are in arbitrary units (a.u.), and the percentages represent efficiency of energy transfer.

The energy transfer between trophic levels is not 100% efficient.

Part A

Efficiency

For the food chain in **Figure 1**, calculate the efficiency of energy transfer x.

Give your answer as a percentage.

Part B

Energy transfer P to Q

Which of the following could explain the inefficiency of energy transfer from P to Q? Select all that apply.

- [ ] CO_2 levels are limiting the rate of photosynthesis
- [ ] energy is lost as heat
- [ ] some wavelengths of light are not used
- [ ] some of the light is reflected by the leaves rather than absorbed
- [ ] cellulose is not digested and is lost in faeces
- [ ] bones are either not consumed or not digested

Part C

Energy transfer Q to R

Which of the following could explain the inefficiency of energy transfer from Q to R? Select all that apply.

- [ ] CO_2 levels are limiting the rate of photosynthesis
- [ ] energy is lost as heat
- [ ] some wavelengths of light are not used
- [ ] some of the light is reflected by the leaves rather than absorbed
- [ ] cellulose is not digested and is lost in faeces
- [ ] bones are either not consumed or not digested

Part D

Available energy in mammal R

Calculate the available energy in mammal R.

What percentage of the initial available light energy in the ecosystem is available in mammal R?

Adapted with permission from NSAA 2021 Section 2 Q42

Question deck:

STEM SMART Biology Week 24 - Ecosystems

STEM SMART Biology Week 24 - Ecosystems

Energy Transfer and Productivity

Subject & topics

Biology | Ecology | Ecosystems

Status

Not started

Stage & difficulty

A Level Practice 2

Energy transfer between trophic levels is not 100% efficient - only some of the energy stored within one trophic level will be transferred to the trophic level above. This is because energy is lost from the food chain as heat (during respiration) and through material that is excreted (e.g. in faeces and urine).

The quantity of energy stored within the **producers** in an ecosystem over a given time period is called the gross primary productivity (GPP). This is usually expressed in units of energy per unit area per unit time e.g. $\mathrm{kJ\ m^{-2}\ yr^{-1}}$. The net primary productivity (NPP) refers to how much of this energy during this time period is available to consumers, taking into account the energy lost by the producers as heat during respiration (R) during this time period. This can be represented by the following equation:

$$\mathrm{NPP} = \mathrm{GPP} - \mathrm{R}$$

We can also quantify the net productivity of **consumers** (N), which is the amount of energy stored within consumers that is available to higher trophic levels. We do this by calculating the energy stored within ingested material (I) and subtracting the energy lost through undigested material in faeces and urine (F) and the energy lost as heat during respiration (R). This can be represented by the following equation:

$$\mathrm{N} = \mathrm{I} - (\mathrm{F} + \mathrm{R})$$

The energy flow in one ecosystem is shown below in **Figure 1**.

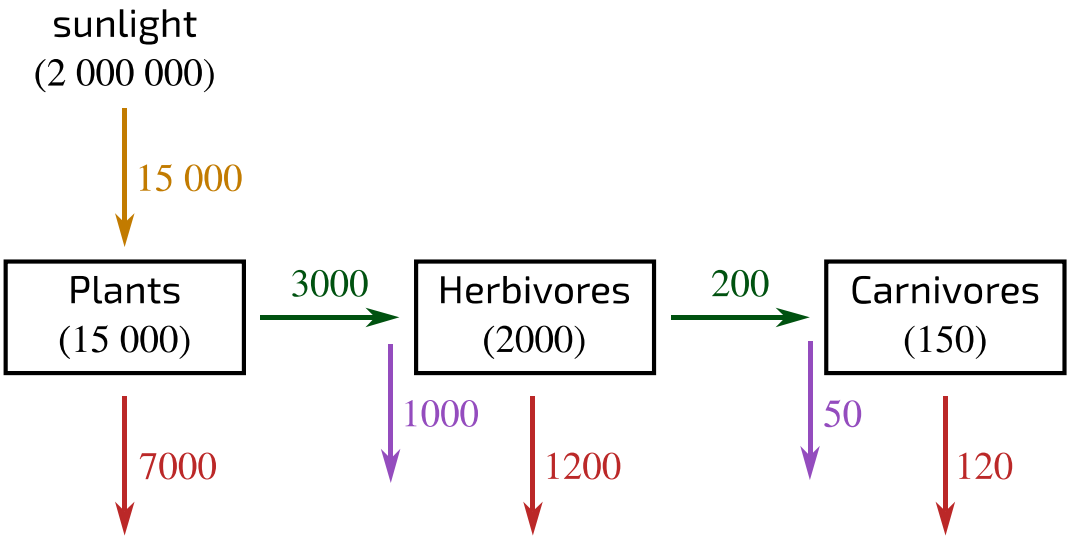

Figure 1: Energy flow in an ecosystem. Numbers represent energy values in $\mathrm{kJ\ m^{-2}\ yr^{-1}}$. Numbers in boxes represent the energy stored within the bodies of those organisms. The yellow arrow represents sunlight energy fixed by plants, whereas green arrows represent energy ingested by consumers. Red arrows represent energy lost as heat during respiration, whereas purple arrows represent energy lost through undigested material in faeces and urine.

Part A

Plants

Identify/calculate the following values for the producers in this ecosystem.

$\mathrm{GPP} =$

$\mathrm{NPP} =$

$\mathrm{R} =$

Part B

Herbivores

Identify/calculate the following values for the herbivores in this ecosystem.

$\mathrm{N} =$

$\mathrm{I} =$

$\mathrm{F} =$

$\mathrm{R} =$

Part C

Carnivores

Identify/calculate the following values for the carnivores in this ecosystem.

$\mathrm{N} =$

$\mathrm{I} =$

$\mathrm{F} =$

$\mathrm{R} =$

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Question deck:

STEM SMART Biology Week 24 - Ecosystems

STEM SMART Biology Week 24 - Ecosystems

Carbon Cycle Diagrams

Subject & topics

Biology | Ecology | Nutrient Cycles

Status

Not started

Stage & difficulty

A Level Practice 2

Part A

Digestive and respiratory enzymes

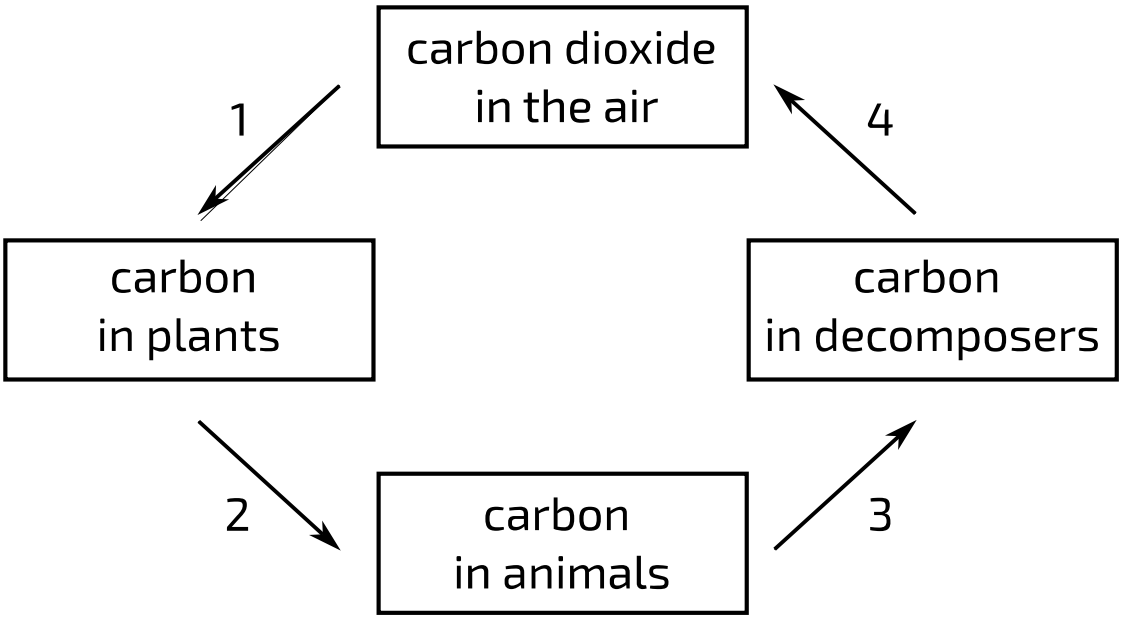

Figure 1: Part of the carbon cycle. Four processes are labelled 1-4.

Which processes involve digestive enzymes? Select all that apply.

- [ ] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [ ] none of the above

Which processes involve respiratory enzymes? Select all that apply.

- [ ] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [ ] none of the above

Part B

Chemical processes

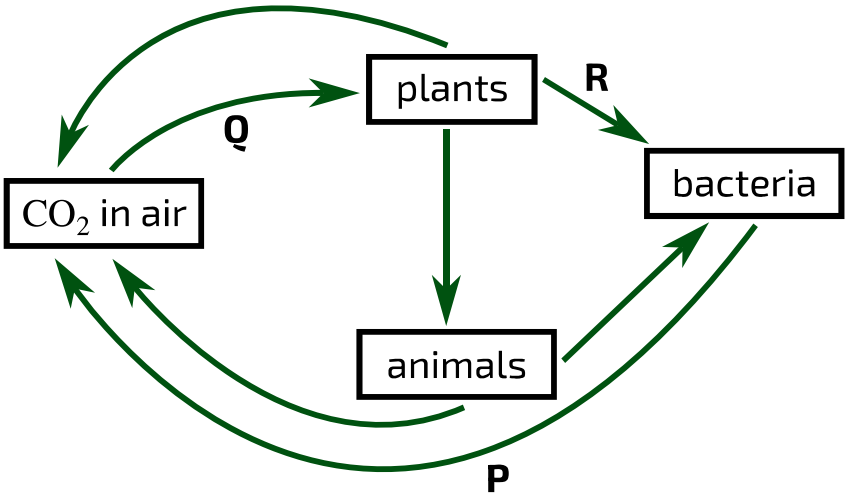

Figure 2: Part of the carbon cycle. Three processes are labelled **P**, **Q** and **R**.

Which of the following statements is/are correct?

- [ ] **P** requires the presence of mitochondria.
- [ ] Overall, **Q** releases heat.
- [ ] **R** is sensitive to changes in pH and temperature.

Part C

Sources of carbon

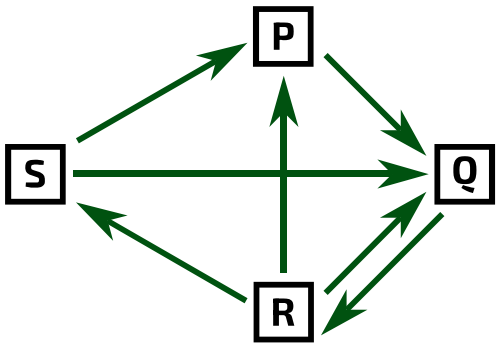

Figure 3: Part of the carbon cycle. Four parts are labelled **P**, **Q**, **R** and **S**. Arrows represent processes.

Drag and drop the correct descriptions for the boxes in **Figure 3**.

Description	Box
CO_2 in atmosphere	
carbon-rich compounds in animals	
carbon-rich compounds in decomposers	
carbon-rich compounds in plants	

Items:

P Q R S

Question elements adapted with permission from NSAA 2022 Specimen Paper Section 1 Q74, NSAA 2021 Section 1 Q72, NSAA 2020 Section 1 Q64

Question deck:
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Nitrogen Cycle Processes

Subject & topics

Biology | Ecology | Nutrient Cycles

Status

Not started

Stage & difficulty

A Level Practice 2

Nitrogen is an important component of many biological molecules. However, plants and animals cannot directly utilise atmospheric nitrogen. Most plants obtain nitrogen from nitrates, which they absorb from the soil. Animals obtain nitrogen from plants either directly (by consuming plants) or indirectly (by consuming other animals that obtained nitrogen from plants).

The conversion of atmospheric nitrogen to nitrates (and back) involves many processes. The main processes involved are nitrogen fixation, nitrification, denitrification, and ammonification. Together, these processes make up the nitrogen cycle.

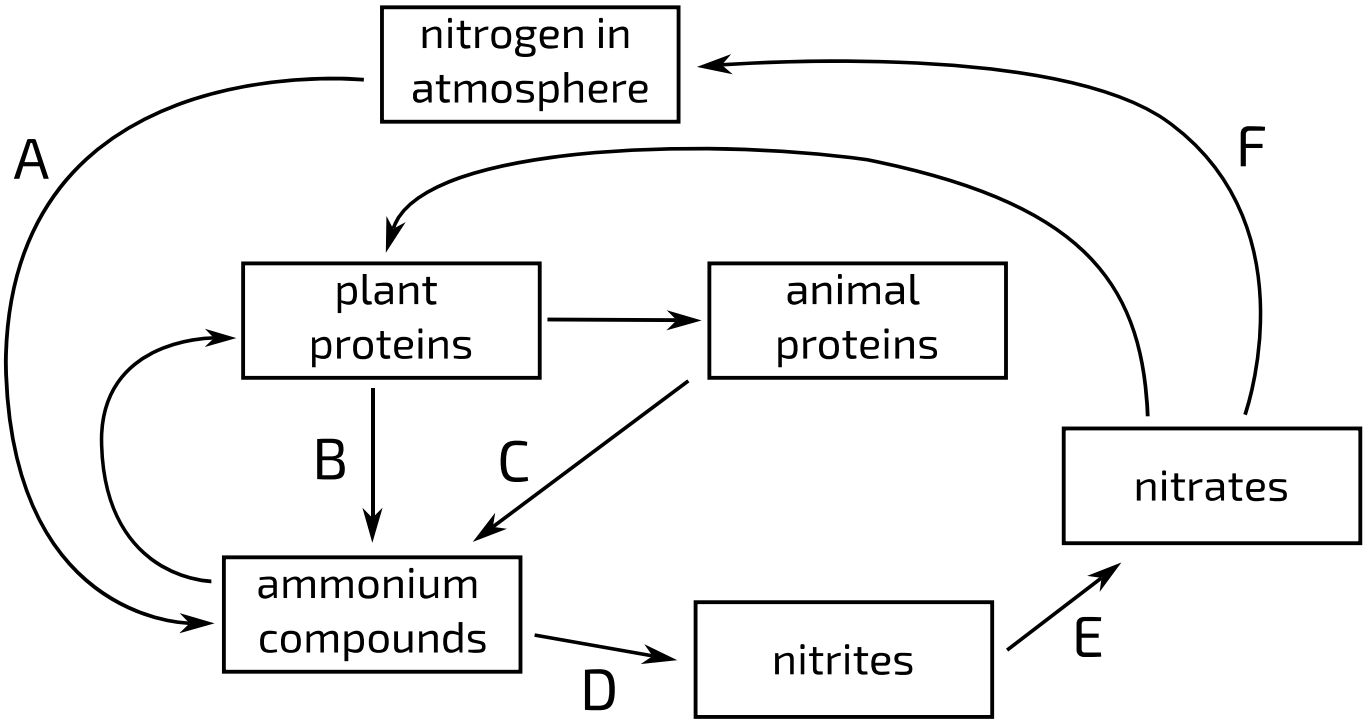

Figure 1: Part of the nitrogen cycle. Arrows represent processes within the nitrogen cycle, some of which are labelled (A-F).

Part A

Nitrogen Fixation

Which letter(s) in **Figure 1** represent(s) nitrogen fixation? Select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E
- [ ] F

Part B

Nitrification

Which letter(s) in **Figure 1** represent(s) nitrification? Select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E
- [ ] F

Part C

Denitrification

Which letter(s) in **Figure 1** represent(s) denitrification? Select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E
- [ ] F

Part D

Ammonification

Which letter(s) in **Figure 1** represent(s) ammonification? Select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E
- [ ] F

Adapted with permission from CIE AS Level November 2001, Biology Paper 1, Question 40

Question deck:

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Nitrogen Cycle Compounds

Subject & topics

Biology | Ecology | Nutrient Cycles

Status

Not started

Stage & difficulty

A Level Practice 2

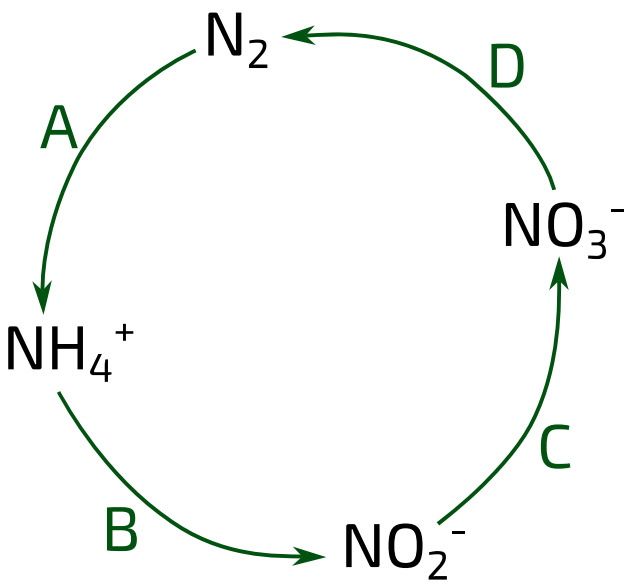

Figure 1: A part of a the nitrogen cycle. Arrows (A-D) represent processes within the nitrogen cycle.

Part A

Name the molecule/ion

Match the name to the molecule/ion in the table below.

Formula	Name
N_2	
NH_4^+	
NO_2^-	
NO_3^-	

Items:

nitrite ions | (atmospheric) nitrogen | nitrate ions | ammonium ions

Part B

Identify the process

Match the figure label to the process in the table below.

Label	Process
A	
B	
C	
D	

Items:

nitrification | denitrification | ammonification | nitrogen fixation

Part C

Nitrogen necessity

Which of the following biological compounds contain nitrogen?

- [ ] DNA
- [ ] starch
- [ ] RNA
- [ ] amino acids
- [ ] triglycerides
- [ ] glucose
- [ ] cholesterol
- [ ] ATP

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Ecosystem Bacteria

Subject & topics

Biology | Ecology | Nutrient Cycles

Status

Not started

Stage & difficulty

A Level Challenge 2

Part A

Bacterial species

Fill in the table below to show the locations of each type of bacterium in the nitrogen cycle and the reactions they perform.

Type of bacterium	Location	Reactant(s)	Product	Nitrogen is...
Rhizobium		N_2 and H^+ ions	NH_3	reduced
Nitrosomonas	soil			oxidised
Nitrobacter	soil		NO_3^-	
Denitrifying bacteria		NO_3^-		

Items:

soil | root nodules of legumes | N_2 (nitrogen gas) | NO_2^- (nitrites) | NH_4^+ (ammonium ions) | oxidised | reduced

Part B

Nitrogenase

Nitrogen fixation is an important part of the nitrogen cycle.

The rate of nitrogen fixation is reduced by the presence of oxygen.

Rhizobium uses the enzyme nitrogenase to fix atmospheric nitrogen. H_2 can bind instead of N_2 to the binding site shown for N_2.

Figure 1 shows a simplified representation of the structure of nitrogenase.

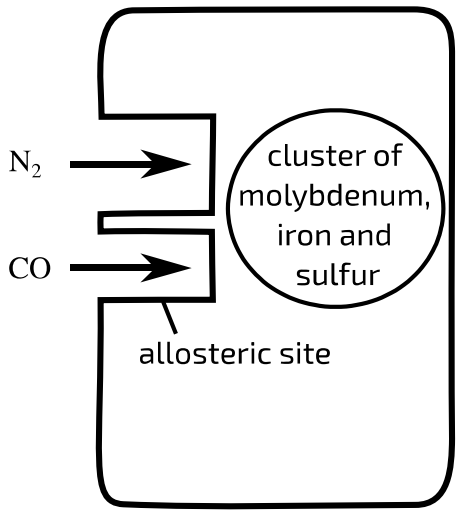

Figure 1: Nitrogenase enzyme structure.

The reaction that nitrogenase catalyses is:

$$N_2 + 8\,H^+ + 8\,e^- + 16\ \text{ATP} \rightarrow 2\,NH_3 + H_2 + 16\ \text{ADP} + 16\,P_i$$

Based on the information above, which of the following statements about nitrogenase are correct? Select all that apply.

- [ ] H_2 may act as a **competitive** inhibitor
- [ ] H_2 may act as a **non-competitive** inhibitor
- [ ] CO may act as a **competitive** inhibitor
- [ ] CO may act as a **non-competitive** inhibitor
- [ ] the cluster of molybdenum, iron and sulfur is a prosthetic group
- [ ] the cluster of molybdenum, iron and sulfur is part of the nitrogenase enzyme's primary structure

Part C

Leghaemoglobin

Leghaemoglobin is a molecule, found in leguminous plants, that improves the performance of nitrogenase. It has very similar properties to mammalian haemoglobin.

Which of the following statements could explain how leghaemoglobin improves the performance of the nitrogenase enzyme? Select all that apply.

- [ ] leghaemoglobin acts as an enzyme to convert ammonium to nitrates
- [ ] leghaemoglobin acts as an enzyme to convert nitrates to nitrogen
- [ ] leghaemoglobin stops carbon monoxide from binding to the allosteric site of nitrogenase
- [ ] leghaemoglobin increases the efficiency of aerobic respiration in the plant cells
- [ ] leghaemoglobin stops oxygen from reacting with nitrogenase
- [ ] leghaemoglobin stops hydrogen from binding to the active site of nitrogenase

Part D

Decomposition

Many species of bacteria act as decomposers within ecosystems by breaking down organic material.

Scientists analysed the energy flow within a grassland ecosystem.

They estimated that the energy in the decomposers' trophic level was $950\,000\ \mathrm{J\ m^{-2}\ yr^{-1}}$.

The energy within the producers' trophic level was $800\ \%$ greater than that of the decomposers.

Calculate the energy in the producers' trophic level in $\mathrm{kJ\ m^{-2}\ yr^{-1}}$. Give your answer to 3 significant figures.

Calculate the percentage efficiency of the energy transfer from producers to decomposers. Give your answer to 2 significant figures.

Adapted with permission from OCR A Level Biology A, June 2017, Unified Biology, Question 4