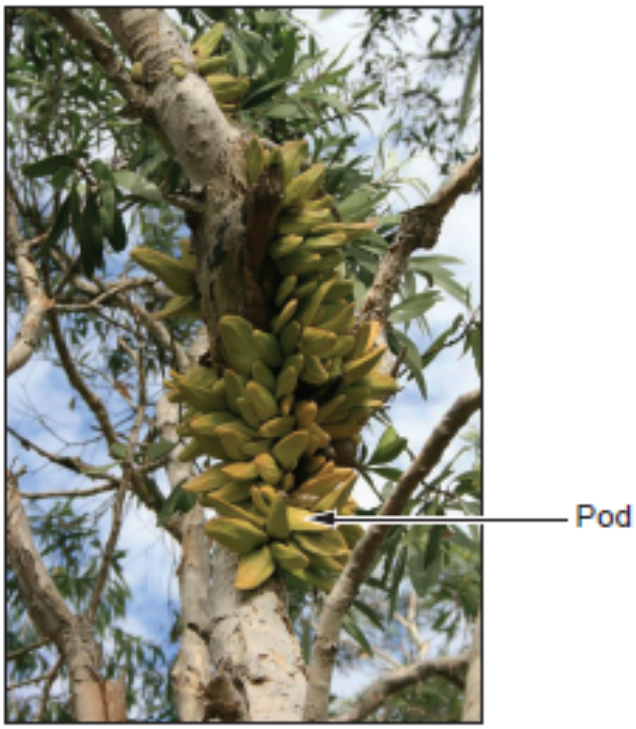
WJEC (Wales) Biology A-level
Topic 3.5: Population Size and Ecosystems
Questions by Topic

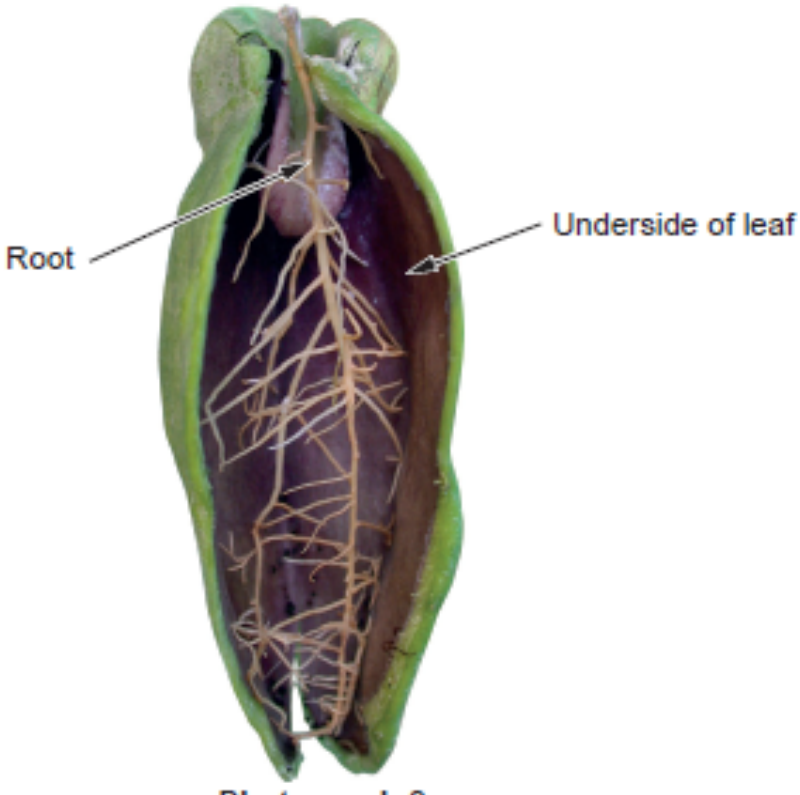
1. *Dischidia major* is a plant found in the rainforests of Malaysia. It is an epiphyte, a non-parasitic plant that grows on other plants.

Some of the leaves of *Dischidia* roll up to form pod-like structures (**photograph 1**).



Photograph 1

The roots of *Dischidia* grow into the pods. **Photograph 2** shows an opened pod to show the underside of the leaf and the roots.



Photograph 2

(a) Ants of the genus *Philidris* live inside these pods. The ants store dead insects and rear their young inside the pods. The ants and dead insects contribute to the nutrients available to these leaves.

(i) The main source of carbon for these leaves is from the air inside the pod, not the atmosphere. Describe how carbon inside the pod is made available for use by these leaves. [4]

(ii) Describe how nitrogen is made available for use by these leaves. [3]

(b) In areas of Malaysia large-scale deforestation is taking place.

(i) Explain how this deforestation could **increase** the concentration of carbon dioxide in the atmosphere in the area. [2]

(ii) Explain how this deforestation could **decrease** the concentration of carbon dioxide in the atmosphere in the area. [1]

2. An investigation was carried out into the productivity of grassland. Ecologists followed the method below.

- Three identical 1 m^2 areas of ungrazed grassland were selected.
- All of the vegetation was removed from Area 1; the roots were washed and the vegetation dried.
- Area 2 was covered with black plastic.
- Area 3 was left undisturbed.
- After two weeks, the vegetation was removed from Areas 2 and 3 and treated in the same way as Area 1.

The results were as follows:

Area	Dry mass / g m^{-2}
1	73
2	61
3	107

(a) Explain why the dry mass was lower in Area **2**. [2]

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(b) Using the information from Areas **1** and 3, calculate the net primary productivity of the grassland.

Give your answer to 2 decimal places. [2]

Net primary productivity ..... g m^{-2} day^{-1}

(c) Suggest why this method cannot be used to calculate the net primary productivity of tropical rainforest. [2]

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(d) To find the dry mass the ecologists dried the grass samples in an oven at 65 °C. Describe how the ecologists would be confident that all the water had been removed but none of the organic matter had been lost. [2]

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3. Natural, species rich, seasonally-flooded grasslands are one of the rarest forms of flower-rich meadows with rare plants such as orchids. These rare plants survive on flooded meadows where levels of nitrates are low.
Many such meadows have been lost through ploughing and the application of fertilisers to increase yields of hay.
Many species-rich meadows in floodplains next to streams and rivers function as seasonal washlands, by temporarily storing flood water during periods of high water flow.

(a) Explain how the low levels of nitrates are brought about in these meadows. [2]

(b) Explain fully how the change in agricultural practices has led to the loss of this type of meadow. [3]

(c) Given that one effect of global warming appears to be more flooding in the UK, discuss why the government is encouraging landowners to preserve and re-instate such meadows in certain areas by compensating them for the loss of productive farm land. [4]

(d) Two species of plantain, greater plantain *(Plantago major)* and ribwort plantain *(Plantago lanceolata)* are very common in grassy areas in Britain. Both plantain species are frequently found on trampled ground.

Greater plantain *(Plantago major)*

Ribwort plantain *(Plantago lanceolata)*

The table shows some characteristics of these two species.

Feature	Greater plantain	Ribwort plantain
Main growth form	rosette	rosette
Drought tolerance	tolerant	not tolerant
Resistance to physical damage	very resistant	moderately resistant
Ability to vary growth form under different conditions	can vary	varies readily
Seed germination	best near soil surface on open ground	best on lightly compacted soil either in open ground or amongst vegetation
Overwintering	as small rosettes or underground	as small rosettes

(i) Describe the technique you would use to carry out an assessment of the abundance of these two species across a moderately trampled footpath. [3]

(ii) Using the information in the table, predict which species would be found mainly in the centre of the trampled path and which species is found mainly at the edges, giving reasons for your choice. [4]

(e) Trophic level transfer efficiency measures the energy that is transferred between trophic levels in ecosystems.
A food chain can usually sustain no more than six energy transfers.
Net Production Efficiency (NPE) measures how efficiently each trophic level uses and incorporates the energy from its food into biomass available to the next trophic level.

(i) Why does a food chain usually sustain no more than six energy transfers? Explain why it would be more energy efficient to produce food in the form of corn, soybeans, and other crops rather than as meat and other animal products. [3]

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(ii) Explain why most warm-blooded organisms have to eat more often than cold-blooded organisms to get the energy they need for survival. [2]

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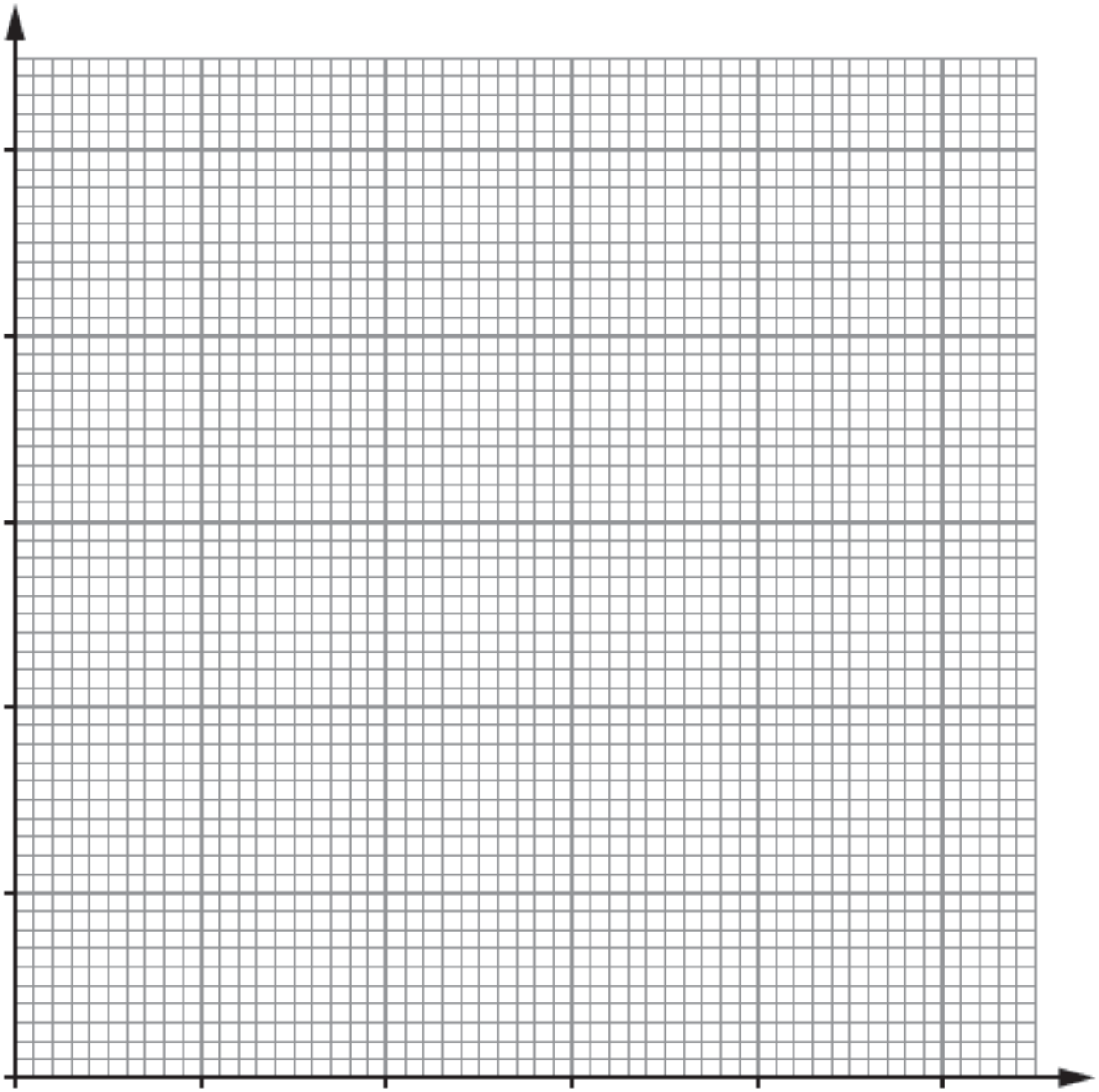
4. The red kite (Milvus milvus) was at one time a common bird of prey in Britain, but by the end of the 19th century it had been driven almost to extinction and just three pairs survived in mid-Wales. As a result of conservation efforts, numbers rose during the 20th century. The table below shows numbers of breeding pairs for years when accurate counts or estimates are available.

Year	Number of breeding pairs
1933	4
1962	15
1976	34
1986	48
1995	100
2009	1000

(a) Use the data to draw a graph to show the increase in the number of breeding pairs of red kites in Wales between 1933 and 2009. [3]



(b) Assuming no net migration, state with a reason whether it was the **birth rate** or the **death rate** which was greater between 1976 and 1986.

[1]

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(c) (i) Suggest **two** density dependent factors, which might prevent numbers of red kite continuing to rise.

[2]

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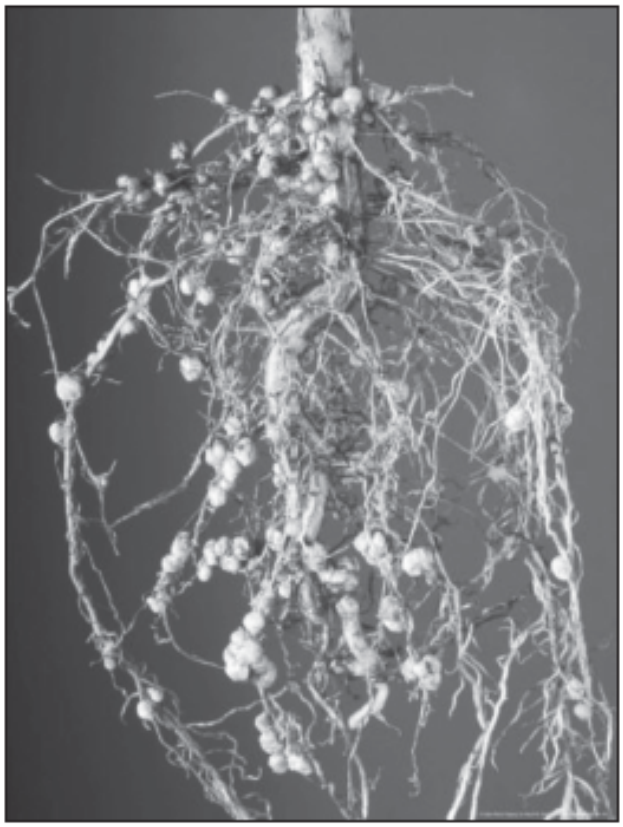
(ii) Suggest **one** density independent factor that might cause the population of red kite in Wales to crash in the future.

[1]

5. 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]

(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.

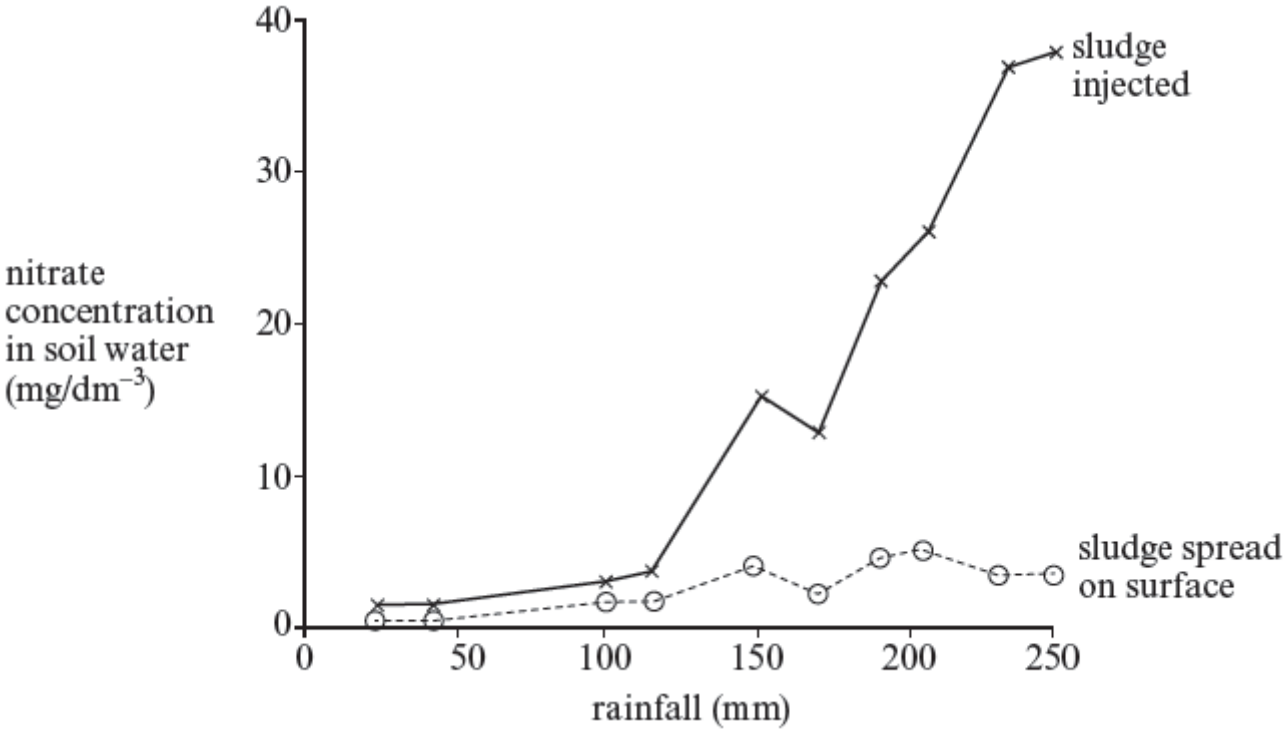
[3]

6. The treatment of sewage produces sludge as a product. This sludge contains high concentrations of nitrogen compounds such as nitrates and ammonia.

Experiments have been carried out into the leaching of nitrate from grassland to which sludge has been applied. The sludge was applied to two areas of grassland. On one area it was spread onto the surface whilst in the other it was injected at various points across the area.

The rate of leaching was measured by taking samples from the water flowing through the soil and measuring the concentration of nitrate in them after different volumes of rainfall had fallen.

The graph below shows the results obtained.



(a) (i) State **two** precautions that should be taken to ensure that the results are reliable.

[2]

(ii) Using the information in the graph describe fully the relationship between the leaching of nitrate and rainfall.

[2]

(iii) Using the data from the graph opposite, what advice would you give to a farmer as to the best time to apply sludge to the farmer's field for maximum benefit?

[1]

(b) The presence of high nitrate levels in rivers can lead to eutrophication. Briefly describe why eutrophication can result in the death of fish and many invertebrates in a river.

[3]

(c) Describe and explain what type of crops a farmer could grow to increase the nitrate level in the soil without using fertilisers, such as sludge.

[3]

7. (a) Explain what is meant by the term *gross primary productivity.*

[1]

(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]

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

[2]

(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]

(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]

8. The following is a quotation from an ecological investigation.

"Lowland heaths are high-profile ecosystems for conservation action in England, but they are under threat from invasion by *Betula spp*., *Pinus sylvestris*, and *Ulex europaeus*."

[R.J. Mitchel et al. Journal of Applied Ecology, 1997, 37, 1426-1444]

(a) Distinguish between primary succession and secondary succession.

[2]

The authors studied a number of heathland sites in Dorset including Arne, Blackhill, and Higher Hyde, where succession to one or another of the three species had taken place. The data below are based on the paper but have been simplified and modified for illustrative purposes. The successional stages in the study were named according to the dominant invasive species; **plus B**, where Betula spp, was the invader, **plus PS**, where Pinus sylvestris was the invader and **plus U**, where Ulex europaeus, was the invader.

(b) The group examined changes in soil chemistry from the original heath stage. Some of their results are summarised in the table below:

soil chemical property	value by succession stage			
	original heath	**plus B**	**plus PS**	**plus U**
pH				
Arne	3.63	4.01	3.60	3.63
Blackhill	3.52	3.66	3.48	3.54
Higher Hyde	3.53	5.06	3.51	3.47
mean	**3.56**	**4.24**	**3.53**	**3.55**
phosphorus μgPg^{-1}				
Arne	2.41	3.85	2.69	3.16
Blackhill	4.15	4.91	3.79	4.55
Higher Hyde	5.08	5.35	3.55	4.76
mean	**3.88**	**4.70**	**3.34**	**4.16**
nitrate/nitrite μgNg^{-1}				
Arne	0.51	0.65	0.59	1.16
Blackhill	0.84	0.88	0.97	2.31
Higher Hyde	0.69	0.98	1.17	3.64
mean	**0.68**	**0.84**	**0.91**	**2.37**

(i) What do the pH values tell us about the soil in all stages in all sites?

[1]

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(ii) Use **mean** values from the table above to compare **three** changes to soil chemistry following invasion by *Betula spp*. with the changes following invasion by *Ulex europaeus*.

[3]

pH . . . . . .

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phosphorus . . . . . .

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nitrate/nitrite . . . . . .

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(c) The table below shows changes to the vegetation in the successional stages:

Species (by successional stage)	% cover of species (by site)		
	Arne	Blackhill	Higher Hyde
original heath			
Calluna vulgaris	62.0	66.1	88.2
Erica cinerea	22.4	25.7	2.6
Erica tetralix	9.9	2.6	9.9
Cladonia portentosa	8.5	0	0.5
plus B			
Betula spp.	18.9	11.7	16.5
Agrostis curtisii	0.0	53.6	0.0
Pteridium aquilinum	25.2	7.5	1.6
Calluna vulgaris	0.0	0.0	0.4
plus PS			
Pinus sylvestris	36.2	38.2	
Pteridium aquilinum	0.3	24.7	
Erica cinerea	0.0	0.0	
Calluna vulgaris	0.0	0.0	
plus U			
Ulex europaeus	87.0	75.3	79.0
Calluna vulgaris	14.7	5.8	7.2
Erica cinerea	1.5	11.3	4.3
Erica tetralix	0.1	0.3	0.3

(i) Which invading species has least impact on the vegetation on the original heathland? [1]

(ii) With reference to the data for **plus B** in both tables suggest a mechanism by which changes to vegetation occur during succession. [2]

(d) Sixteen years later some of these successions have reached their natural conclusions.

(i) What name is given to the group of organisms that inhabit the ecosystem at the end of successional change?

[1]

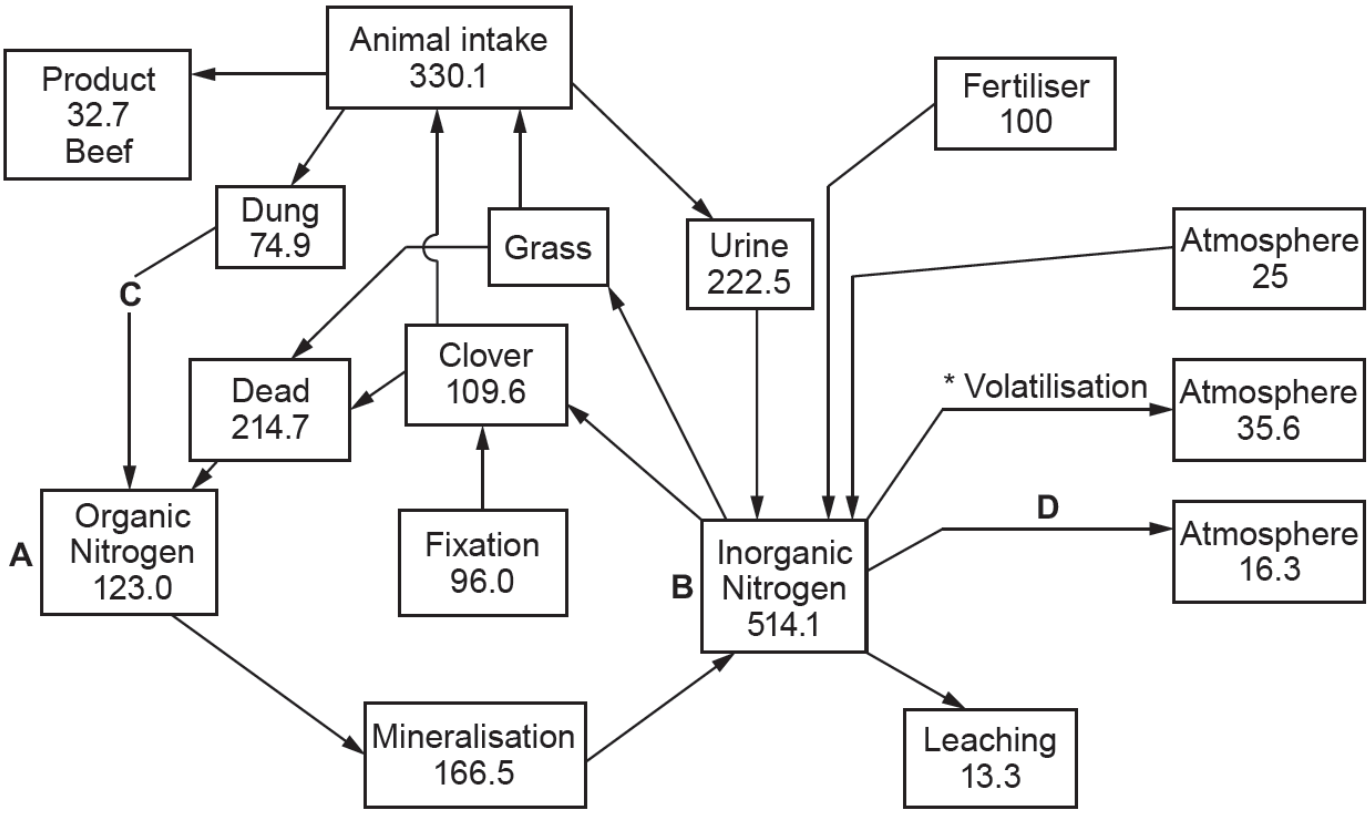
(ii) What usually happens to species diversity as succession proceeds?

[1]

(iii) Using **named** species from the table in part (c) explain why conservationists in Dorset are taking steps to prevent **plus B** and **plus PS** succession in heathland, but are less worried about type **plus U** succession.

[2]

9. Computer modelling is being used increasingly to represent aspects of the nitrogen cycle. One programme describes the annual flow of nitrogen in grazed grassland.



Annual flow of nitrogen through the nitrogen cycle (kg/ha)

* The term volatilisation is the natural loss of ammonia gas derived from faeces and urine to the atmosphere.

(a) (i) Give **one** example of an organic nitrogen compound and **one** example of an inorganic form of nitrogen which could be referred to in boxes **A** and **B**.

[1]

Organic . . . . . .

Inorganic . . . . . .

(ii) Name the process referred to by arrows **C** and **D**.

[2]

C . . . . . .

D . . . . . .

(iii) Explain **one** way by which the farmer could decrease the effect of process **D**.

[2]

(iv) Clover has bacteria living in root nodules.

I. Name the genus of these bacteria.

[1]

II. State how these bacteria increase the availability of compounds of nitrogen in the soil.

[3]

(b) Calculate the annual mass of nitrogen flowing into clover from inorganic nitrogen.

[1]

Answer = ... kg/ha

(c) The average application of nitrogen to fields growing wheat in the UK is 190kg/ha. Dairy grassland farmers need to add less (about 170kg/ha). Suggest **two** reasons to account for the difference.

[2]

1. . . . . .

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2. . . . . .

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10. 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]

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

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(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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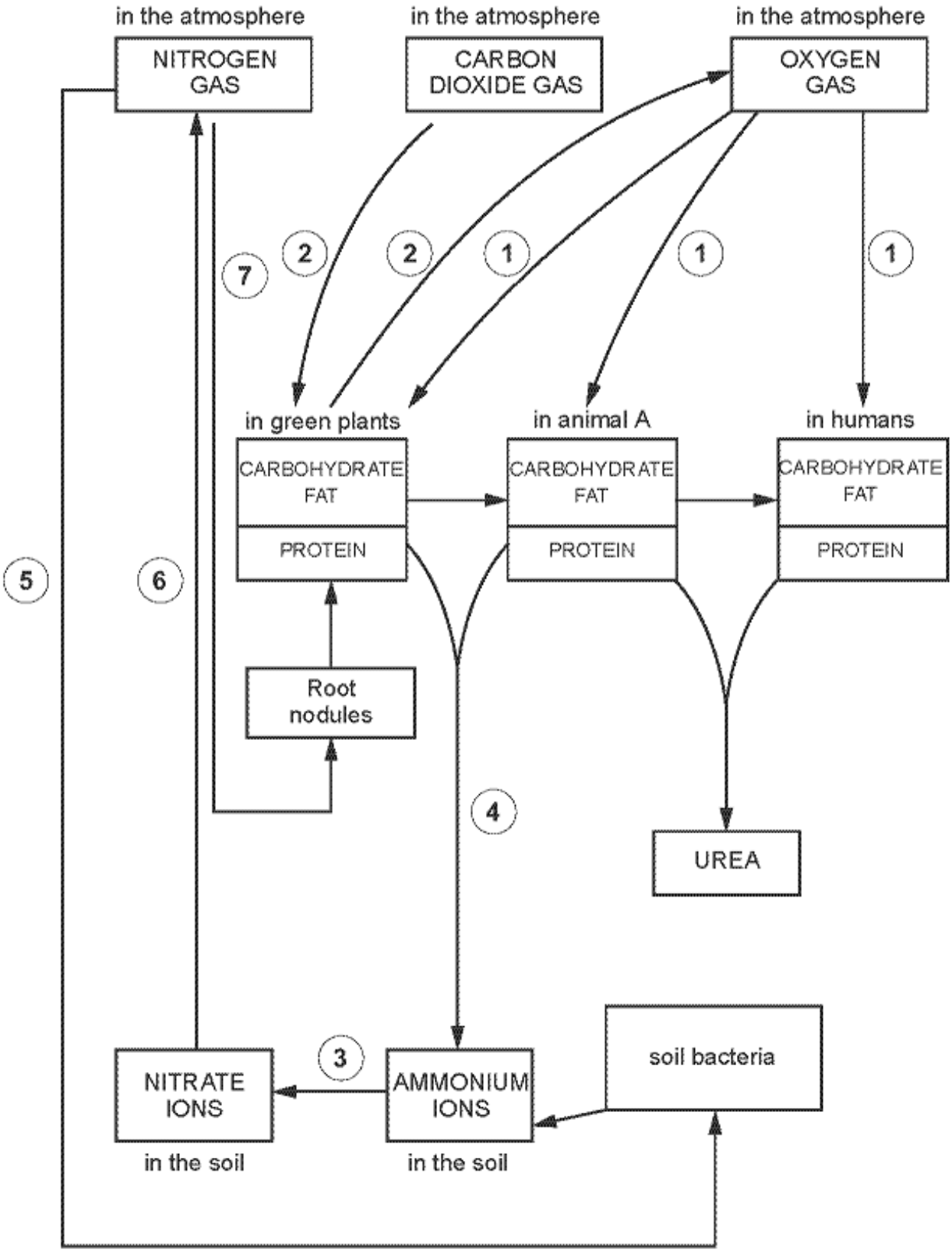
11.

The diagram below represents some of the more important inter-relationships between living organisms and the occurrence of nitrogen, carbon and oxygen in the environment.
Study the diagram and answer the questions that follow.



(a) What is the name of the processes represented by the arrows labelled **1** and **2**? [1]

1. .....

2. .....

(b) Why does ploughing and drainage of the soil encourage the process represented by arrow **3**? [1]

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(c) What general name is given to all the organisms responsible for the process represented by arrow **4**? [1]

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(d) Name the term which describes the biochemical process represented by arrow **5**. [1]

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(e) What is the general name given to the organisms carrying out the process shown by arrow **3**? [1]

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(f) What process is indicated by arrow **6**? [1]

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(g) Give the name of the genus of bacteria that could carry out the process represented by arrow **7**. [1]

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7

12.

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

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

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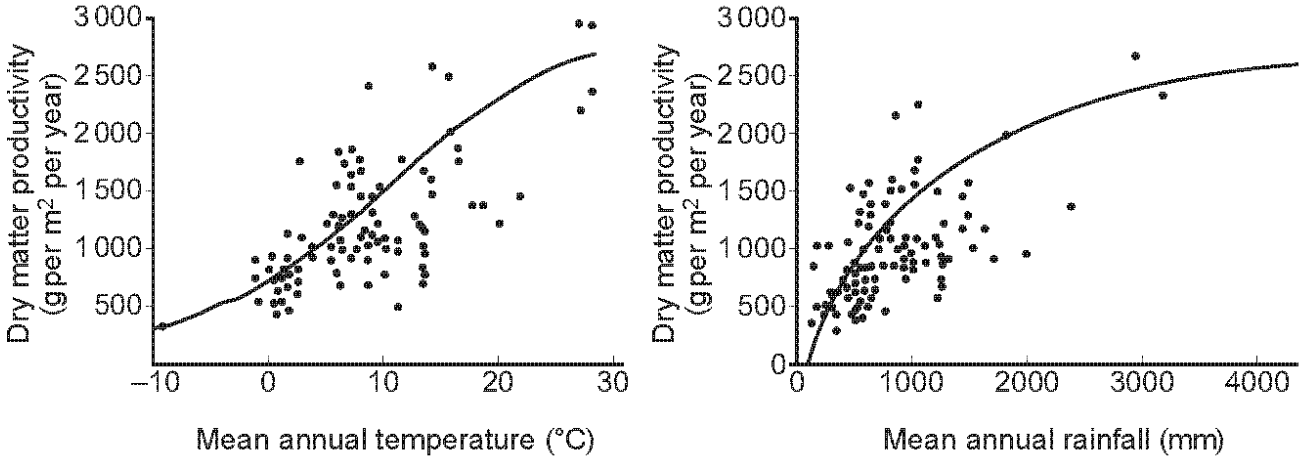
(b) The rate of Primary Production is called Primary Productivity. The graphs below show the effect of two environmental factors on Primary Productivity.



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

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(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.

Type of Ecosystem	Average NPP ($kJ/m^2/yr$)
Tropical rain forest	35280
Temperate forest	24360
Northern coniferous forest	15120
Woodland and shrubs	10920
Lakes and streams	9240
Agricultural crops	8820
Desert	840

The average value for the solar energy striking the Earth's atmosphere is estimated at 4.41×10^7 $kJ/m^2/yr$.

The ecological efficiency of tropical rain forest is $(35280 \div 4.41 \times 10^7) \times 100 = 0.08$

(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 (21785 km^2) was cleared and used to grow sugar cane (an agricultural crop). [2]

Answer .....

(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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13

13. The following list of terms refers to the nitrogen cycle.

A	legume
B	nitrogen fixation
C	denitrification
D	*Nitrobacter*
E	nitrification
F	putrefaction
G	*Nitrosomonas*
H	ploughing
I	*Rhizobium*

Below are five statements. Select from the above list the **letter** for the appropriate term that matches the statement. [5]

(i) The conversion of ammonium ions to nitrate ions. ☐

(ii) A means of improving the aeration of the soil. ☐

(iii) The decomposition of dead plants and animals. ☐

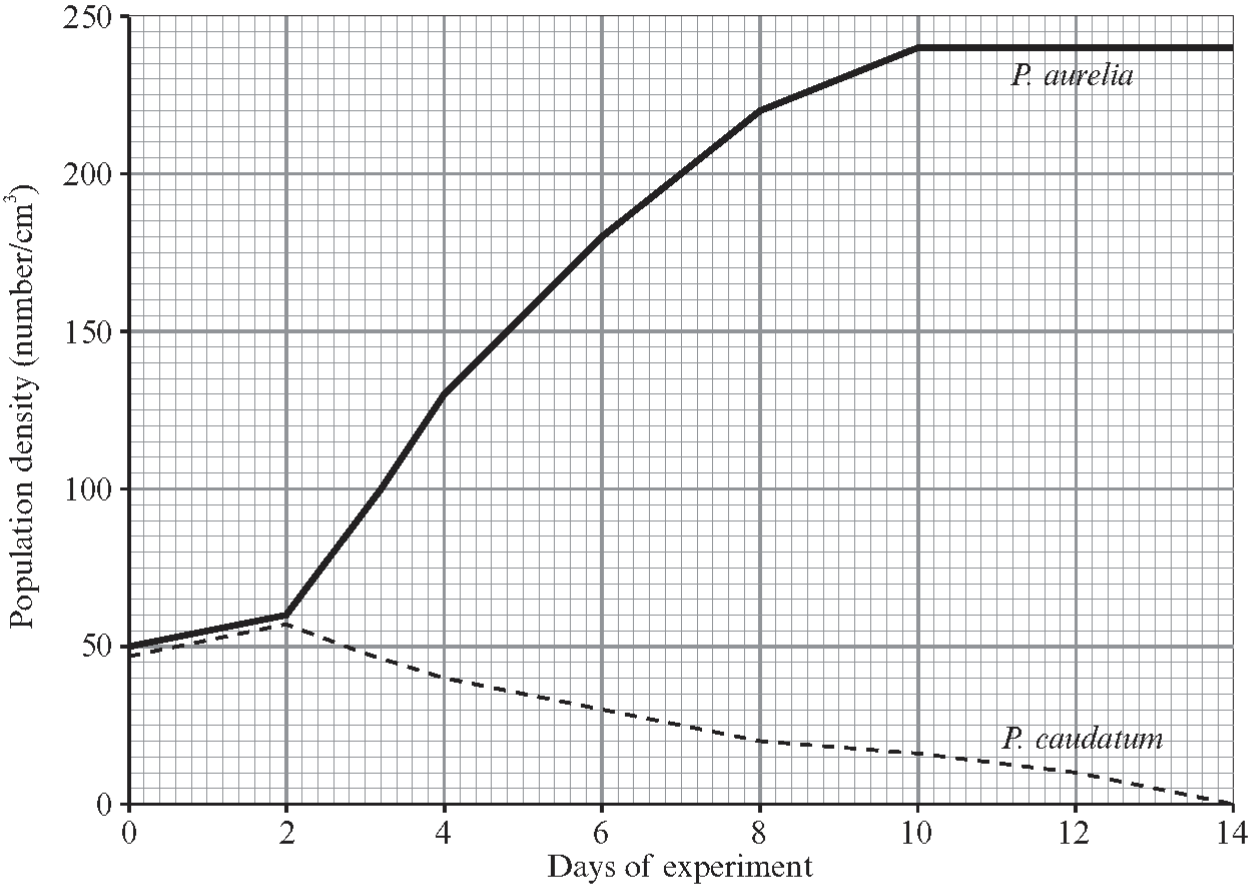
(iv) The conversion of atmospheric nitrogen into nitrogen compounds. ☐

(v) A bacterium found in the root nodules of clover. ☐

(Total 5 marks)

14.

(a) Two species of a single celled organism called *Paramecium*, *P. aurelia* and *P. caudatum* were grown together in a single culture of the bacterium *Bacillus pyocyaneus*, on which they both feed. Their population densities were measured every two days and the results are shown in the graph below.



(i) For *P. aurelia* on which day of the experiment did the population growth enter the stationary phase? [1]

day .....

(ii) On which days of the experiment is the population growth of *P. caudatum* in the death phase? [1]

days ..... to .....

(b) The experiment shows both interspecific and intraspecific competition.

(i) Which type of competition is most likely to have caused the population of *P. caudatum* to decrease after day 2? [1]

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(ii) What was the carrying capacity for *P. aurelia* in this experiment? [1]

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(iii) How might the carrying capacity have been increased in this experiment? [1]

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(iv) Suggest, with an explanation, what would happen to the numbers of *P. caudatum* if *P. aurelia* became infected with a parasitic microorganism at day eight. [2]

Suggestion .....

Explanation .....

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(c) (i) Distinguish between the terms *density dependent* and *density independent* factors. [2]

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(ii) Name **one** density independent factor that could have changed in the experiment. [1]

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(Total 10 marks)

15. State the term which applies to the following ecological definitions.

(a) (i) The recolonisation by living organisms of a woodland following its destruction by fire. [1]

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(ii) The first organisms which colonise a bare rock surface. [1]

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(iii) The stable stage of a succession which undergoes no further change. [1]

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(iv) The different stages in a succession. [1]

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(b) (i) The rate at which products such as glucose are produced by a plant. [1]

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(ii) A diagram to represent the quantity of energy passing from one trophic level to the next. [1]

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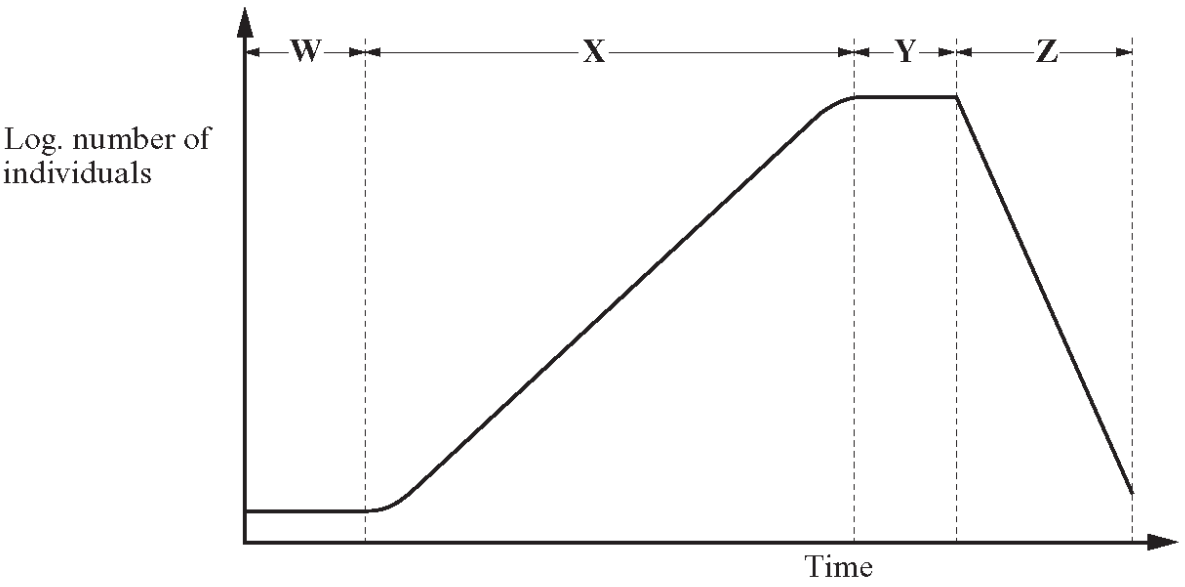
16. The diagram below shows the growth curve for a population of a simple organism such as yeast.



(a) Name the phases of growth **W-Z**. [2]

W .....

X .....

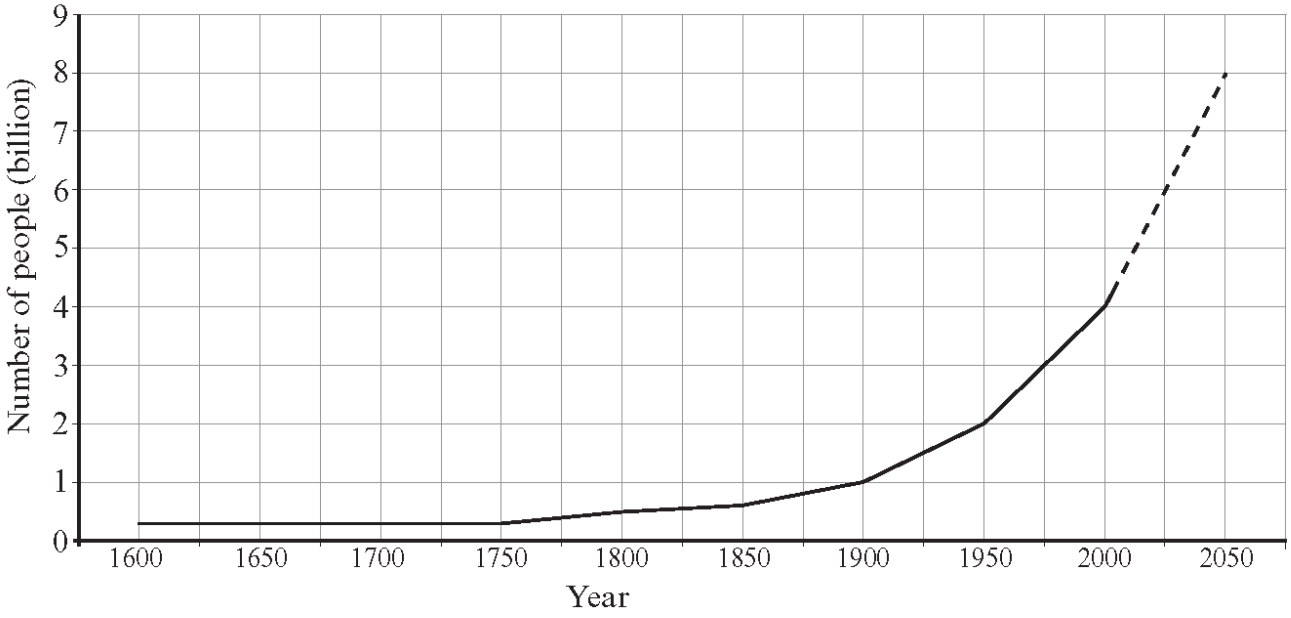
Y .....

Z .....

(b) The growth for world human populations may be given by the formula;

Population growth = Birth – Deaths

A growth curve for world human population is shown with a solid line below.



(i) How did birth rate compare with death rate over the following periods?

(I) 1600 to 1750 [1]

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(II) 1700 to 1900 [1]

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(ii) Describe **one** difference between the population growth phases in humans and yeast cells. [1]

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(iii) Describe **two** human activities that have allowed human population to increase so rapidly after 1900. [2]

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(iv) Give **two** reasons why the growth curve for human population might not continue as shown by the broken line. [2]

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(Total 9 marks)

17. *(a)* Name **two** nitrogen containing molecules found in living organisms. [2]

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(b) What is the role of the following bacteria in the nitrogen cycle? [2]

Nitrobacter .....

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Nitrosomonas .....

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(c) What is the importance of ploughing and drainage of agricultural land? [2]

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(d) Explain why farmers need to apply fertiliser to farmland to maintain nitrate levels in the soil after harvesting. [2]

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(e) Explain how certain crops increase the amount of nitrate in the soil. [3]

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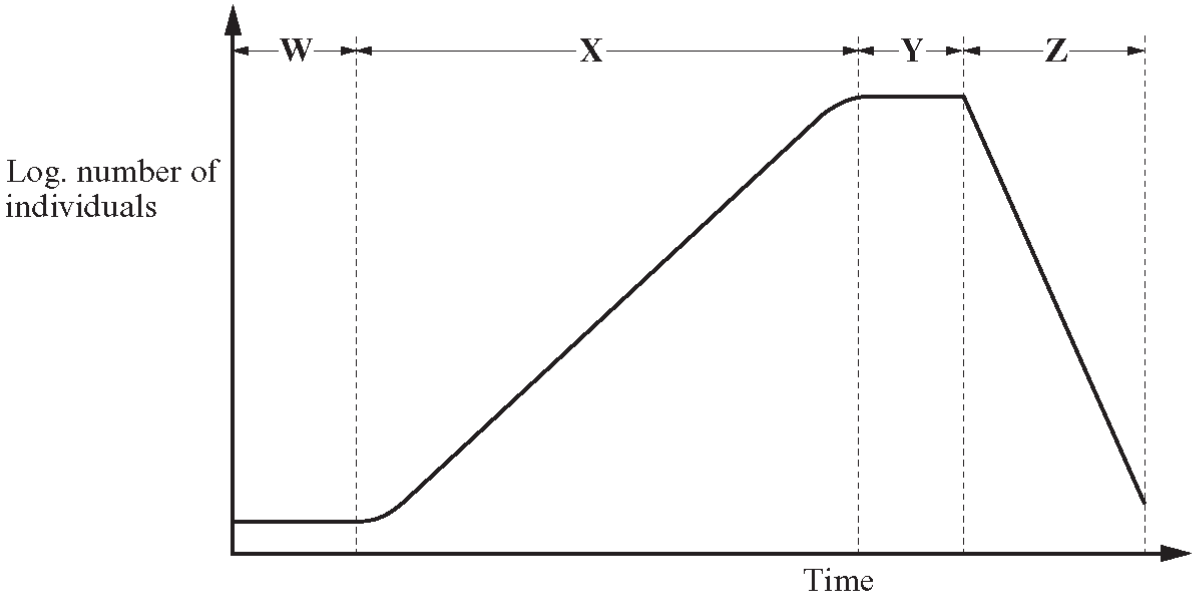
18. The diagram below shows the growth curve for a population of a simple organism such as yeast.



(a) Name the phases of growth **W-Z**. [2]

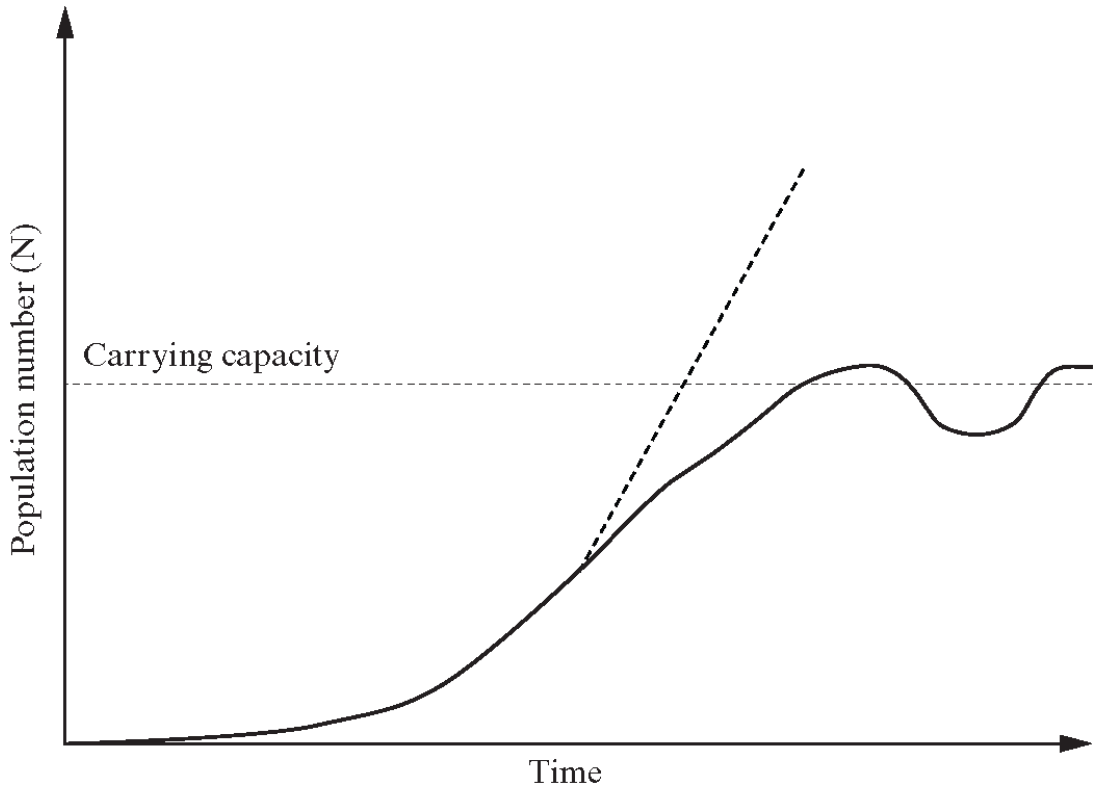
W .....

X .....

Y .....

Z .....

(b) The growth for more complex organisms may be given by the formula;
Population growth = (Births + Immigrations) – (Deaths + Emigrations)
A growth curve for such a population is shown with a solid line below.



(i) Draw an arrow labelled D on the solid line to show **one** phase where (Deaths + Emigrations) exceeds (Births + Immigrations). [1]

(ii) Explain the term *carrying capacity*. [2]

.....

.....

.....

(iii) State **two** examples of **density dependent** factors that can affect the carrying capacity of an ecosystem. [2]

.....

.....

(iv) State **one** example of a density independent factor. [1]

.....

(v) On the graph, extend the dashed line to show what is likely to happen to a population whose size substantially exceeds the carrying capacity. [1]

(Total 9 marks)

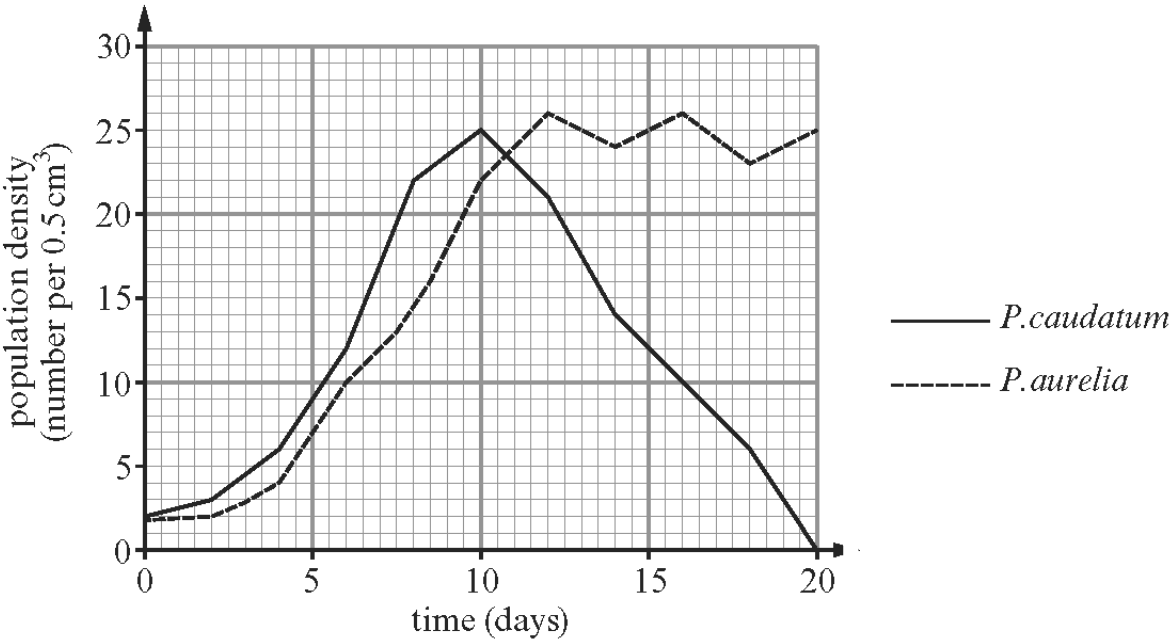
19.

In the 1930s G.F.Gause investigated the population dynam cs of different species of a protoctistan of the genus *Paramecium*. These single-celled org nisms live in ponds and feed mainly on yeast. Two species, *P.aurelia* and *P.caudatum* swim f eely and feed in all parts of a pond while another species, *P.bursaria* feeds mostly at the bott m of the habitat.

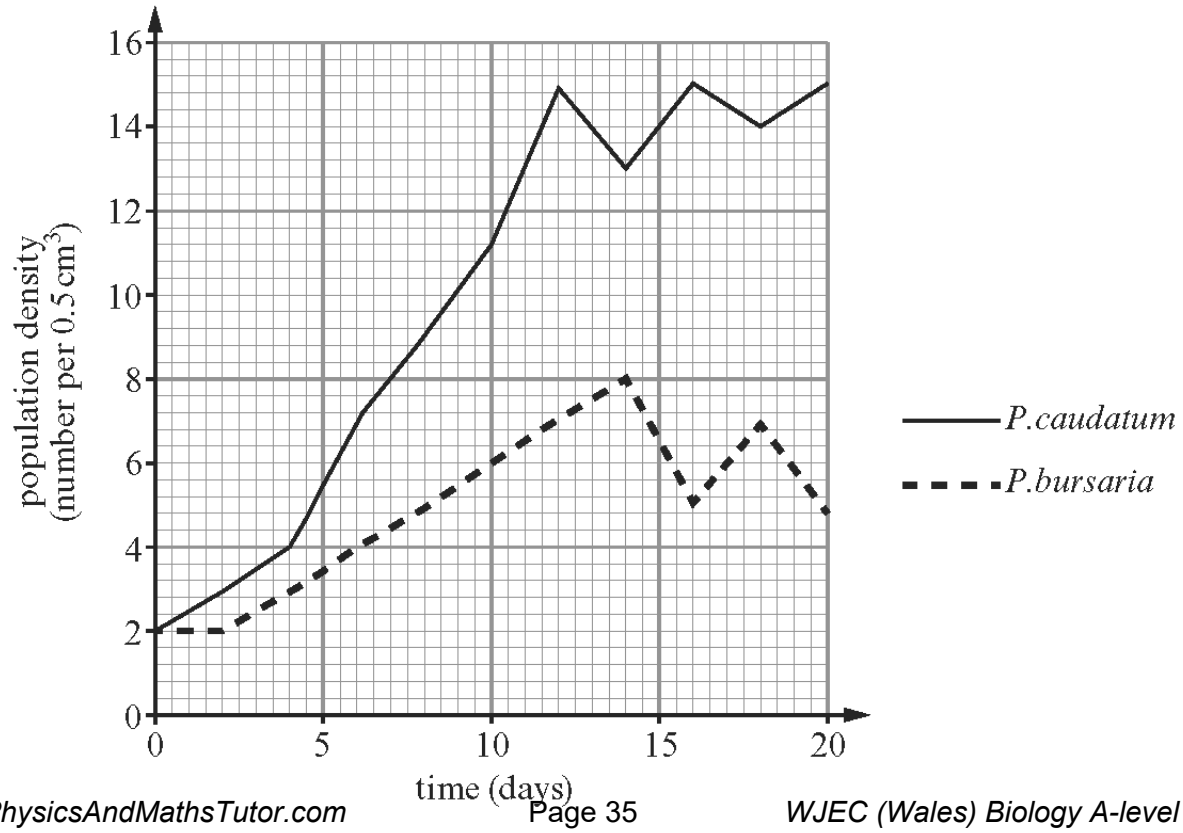
In a series of experiments Gause grew different species of *Par mecium* together in the same container, under the same conditions, to investigate interspecif c competition.

The graphs below show results from two of his experiments.

Graph 1 shows the change in population densities of *P.caudat m* and *P.aurelia* when grown together.



Graph 2 shows the change in population densities of *P.caudatu n* and *P.bursaria* when grown together.



(a) (i) Explain what is meant by the term **carrying capacity** [2]

.....

.....

.....

(ii) From **Graph 1** opposite estimate the carrying capacity for *P.aurelia* in this experiment. [1]

.....

(iii) Describe **TWO** density dependent factors and **ONE** density independent factor that could have prevented the population of *P.aurelia* from exceeding its carrying capacity.

I. **Density Dependent** [2]

.....

.....

.....

.....

II. **Density Independent** [1]

.....

.....

20 **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]