

PEARSON EDEXCEL A-LEVEL BIOLOGY A • 9BN0

BIOLOGY



EXAM QUESTION PACK

TOPIC 5: ON THE WILD SIDE

SCORE

/394

PERCENTAGE

%

STEMUP

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Q1.

Ebola haemorrhagic fever is a life-threatening disease caused by the Ebola virus.

(a) Explain why antibiotics are not used to treat Ebola haemorrhagic fever.

(2)

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(b) Some of the blood plasma of individuals who have survived infection with Ebola can be collected. This can be used in the treatment of individuals currently infected with Ebola.

Explain why the blood plasma from survivors can be used to treat new cases of Ebola infection.

(3)

[illegible]

(c) A study of the 2014 Ebola outbreak in Sierra Leone found that the Ebola virus was evolving rapidly.

Explain why the evolution of the virus might reduce the effectiveness of any vaccine being developed.

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(Total for question = 9 marks)

Q2.

The photograph shows heather, *Calluna vulgaris*, a plant that grows on moorland.



© C016/7131/Science Photo Library

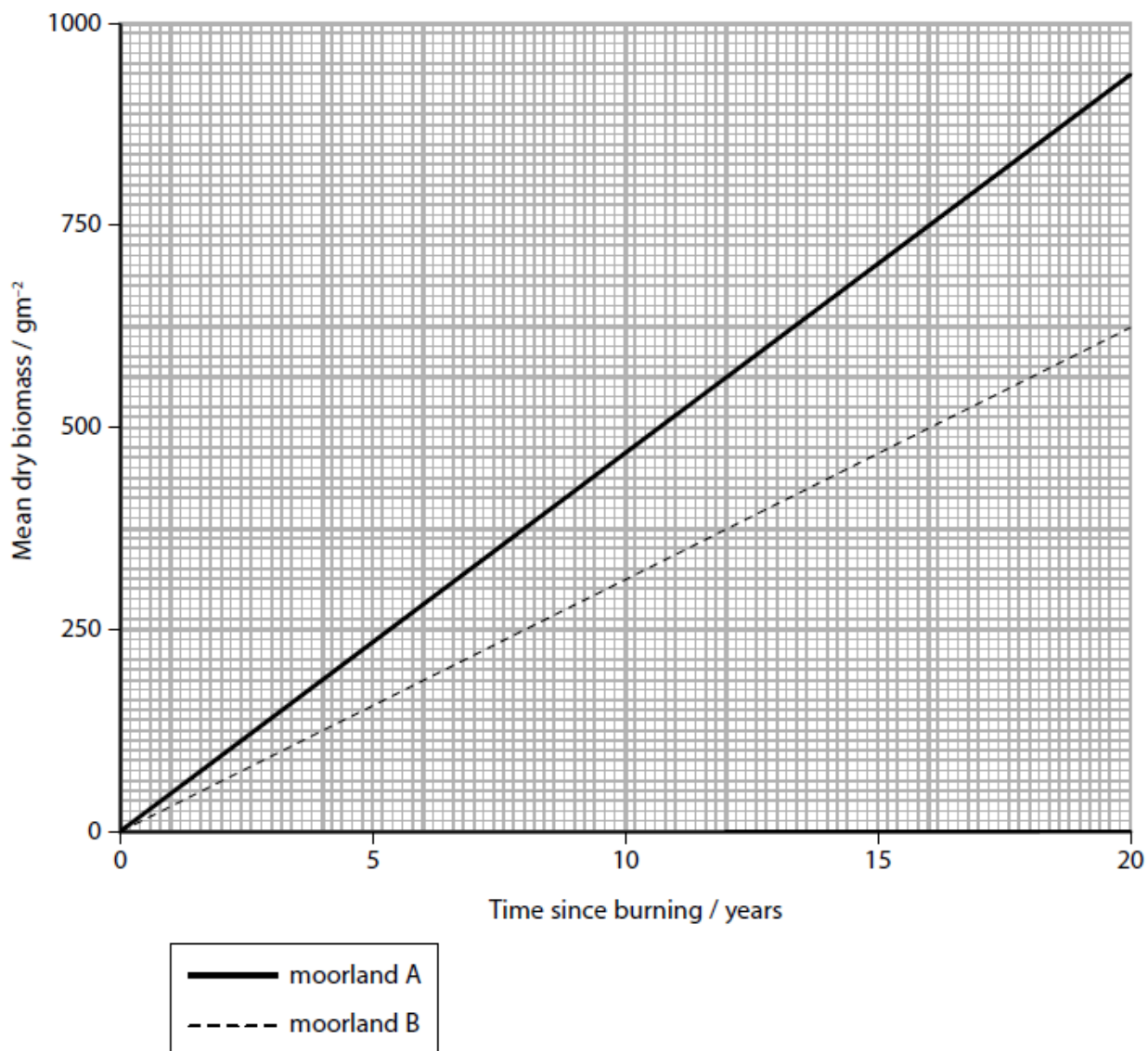
In an investigation into the net primary productivity of heather, all the vegetation on an area of two different moorlands, A and B, was removed by burning. The dry biomass, in g m^{-2} , was then measured each year for a period of 20 years.

(a) Give an equation that shows the relationship between gross primary productivity, net primary productivity and respiration.

(1)

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(b) The graph shows the change in the mean dry biomass of the heather plants during the 20 year period.



(i) Describe a method that could be used to obtain the mean dry biomass of the heather plants in year 20.

(2)

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(ii) The total solar radiation reaching moorland A was $3\,144\,000\text{ kJ m}^{-2}\text{ yr}^{-1}$. Each gram of dry heather contains 22.186 kJ.

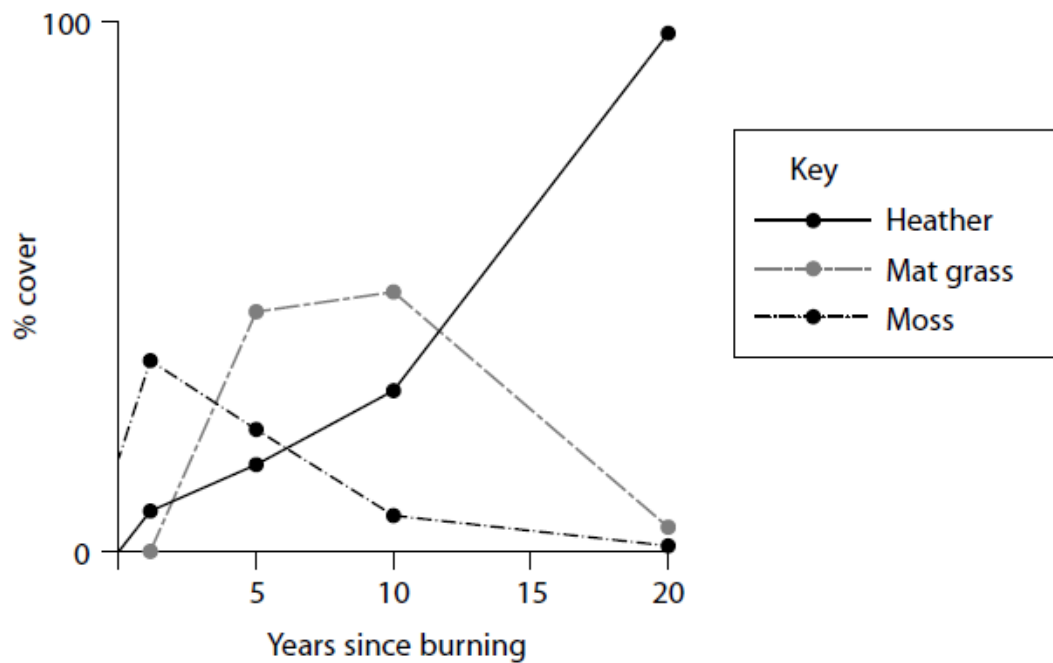
Calculate the percentage efficiency of heather plants from moorland **A** at converting solar radiation into dry biomass.

(2)

Answer

(iii) After the burning of the moorland, a process of succession occurred.

The following information shows some of the changes found over the 20 years.



Analyse the data to explain the changes shown.

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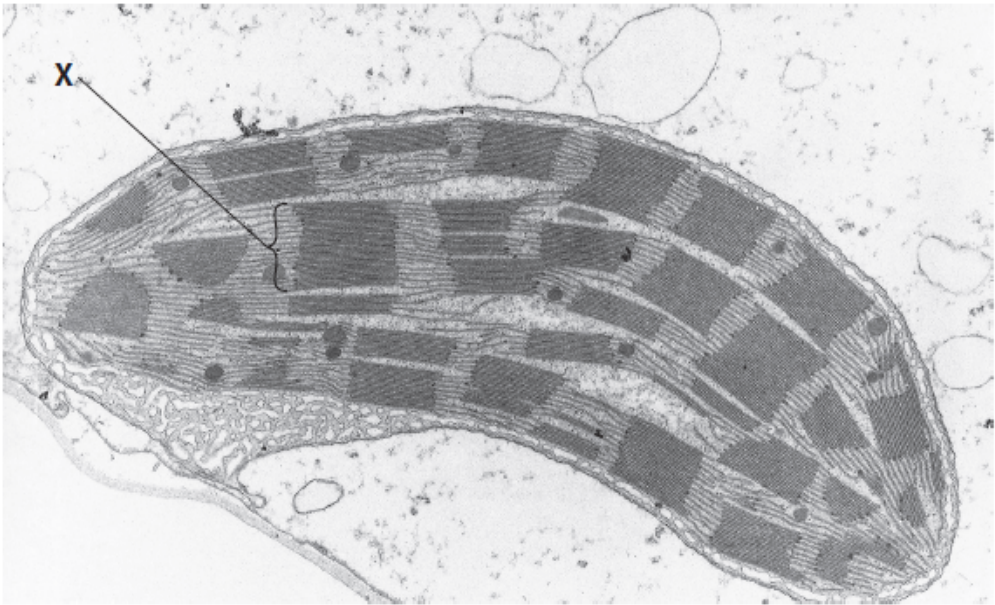
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(Total for question = 8 marks)

Q3.

Eukaryotic cells contain membrane-bound organelles.

The photograph, obtained using an electron microscope, shows an organelle.



(Source: © Science History Images/Alamy Stock Photo)

(i) Label a part of this organelle where carbon fixation occurs. (1)

(ii) Give the name of the component labelled X. (1)

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(iii) Describe how the structure of a membrane in the part labelled X is related to its function. (3)

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(iv) Describe how GP is produced by carbon fixation in this organelle. (2)

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(Total for question = 7 marks)

Q4.

The scientific article you have studied is adapted from an article from '*The Scientist*'.

Use the information from the scientific article and your own knowledge to answer the following questions.

Explain how cyanobacteria evolved to 'handle high temperatures' (paragraphs 14 and 15).

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(Total for question = 5 marks)

Q5.

Scientists have studied behavioural, anatomical and genetic variation in elephants.

The table shows some information about two populations of African elephants.

Population	Location	Feeding behaviour	Anatomical differences
Forest elephant	tropical forest of central and West Africa	feeds on leaves and fruits of high-growing plants such as shrubs and trees	• lower jaw longer and narrower • tusks straighter and downward facing • overall a much smaller size
Savannah elephant	African savannah	feeds on grass and leaves of low-growing shrubs	• lower jaw shorter and wider • tusks more curved and upward facing • overall a larger size

The photographs show elephants from the two populations.



Forest elephant



Savannah elephant

DNA samples were collected from these two populations of elephants.

Scientists have concluded that the forest elephant and the savannah elephant are two different species.

* (i) Analyse the data and the information provided to comment on the validity of this conclusion.

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(ii) Explain how two species of African elephant could evolve from a common ancestor.

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(Total for question = 9 marks)

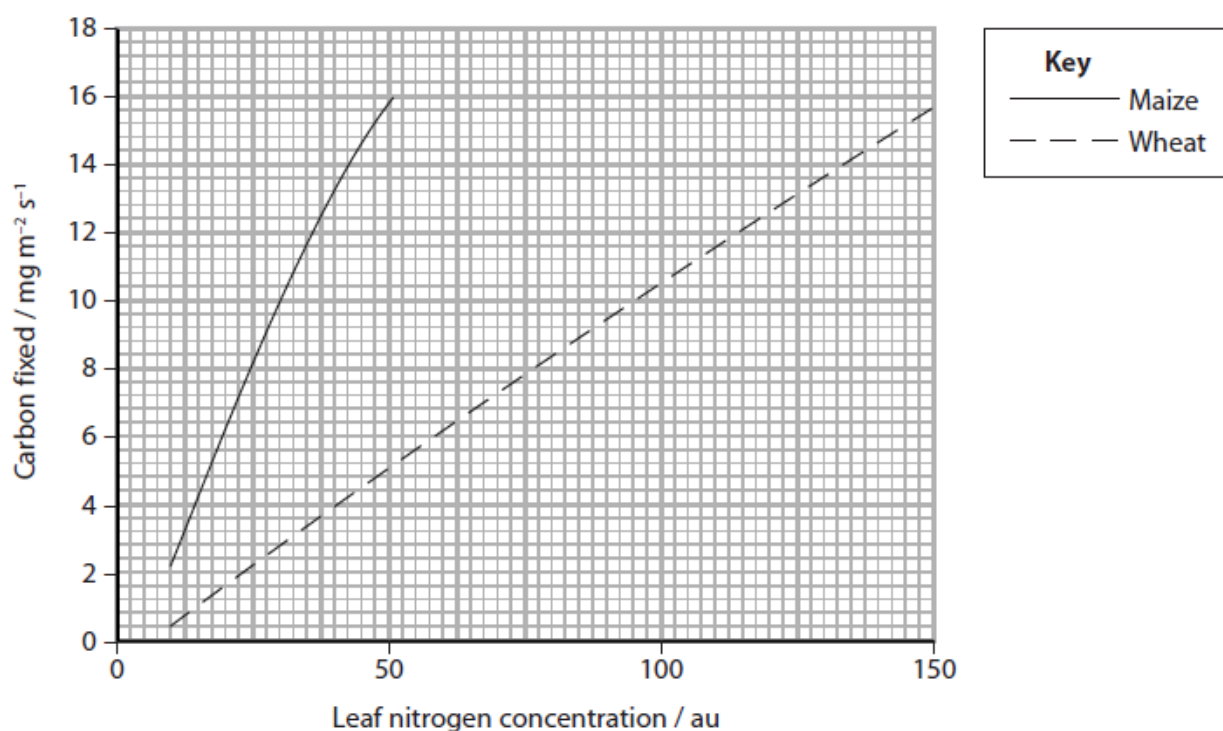
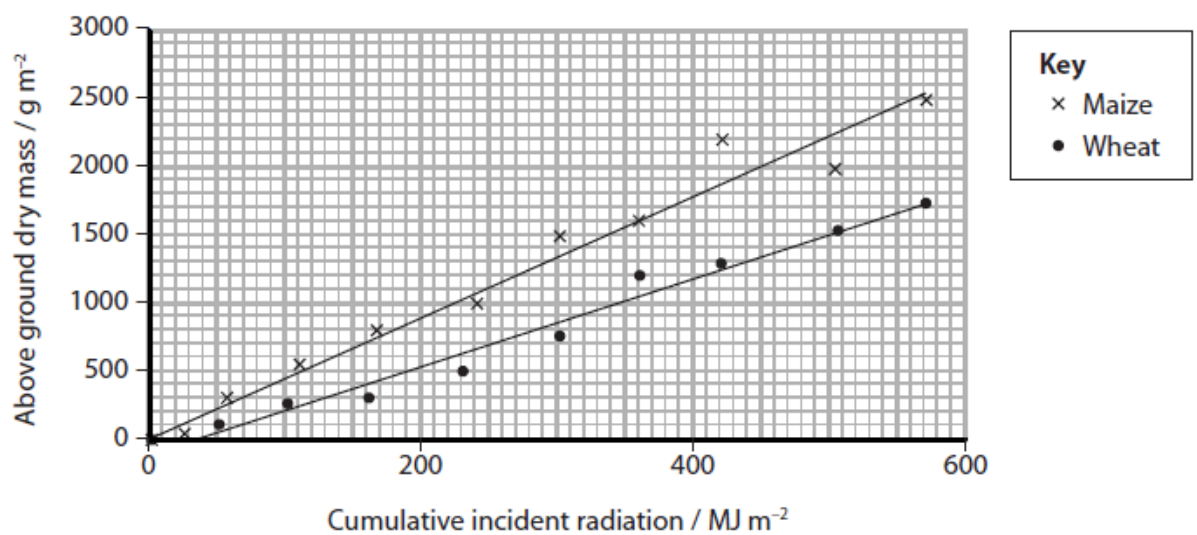
Q6.

Wheat and maize are used as biofuel crops.

Scientists have investigated the effect of incident radiation and leaf nitrogen concentration on the growth of wheat and maize.

Incident radiation is a measure of the useful light energy hitting the plant.
Leaf nitrogen concentration is a measure of the availability of nitrogen in the soil.

The results of these investigations are shown in the graphs.



(i) Scientists calculated the dry mass produced per MJ of incident radiation for wheat. This is shown in the table.

Plant	Above ground dry mass / g MJ ⁻¹
Wheat	3.25

Calculate the above ground dry mass produced per MJ of incident radiation for maize.

(2)

Answer g MJ⁻¹

(ii) Analyse the information provided about maize and wheat to determine which crop should be used for the production of biofuels.

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(iii) Sugar cane crops are also being grown for the production of biofuel.



Devise an experiment to investigate the effect of light intensity on the above ground dry mass of sugar cane crops grown in a field.

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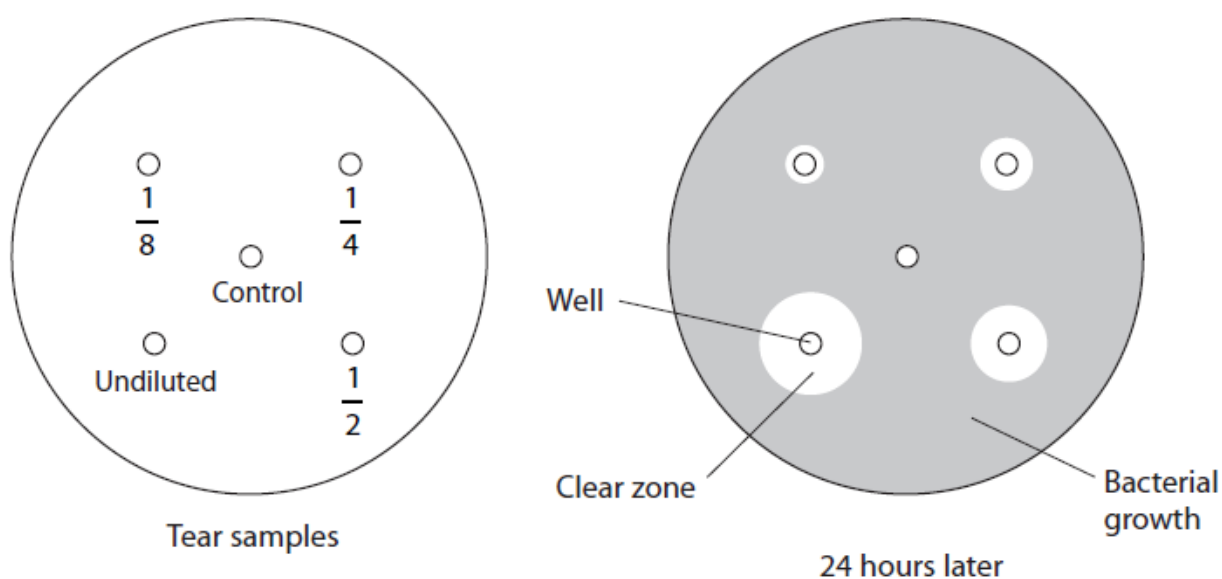
Q7.

Lysozyme is one component of the non-specific response to infection.

A student investigated the activity of lysozyme in tears.

A suspension of bacteria was mixed with molten agar and poured into a Petri dish. After the agar had solidified, wells were cut and different dilutions of tear sample were placed in the wells.

After 24 hours the Petri dish was inspected.



Explain how the student could adapt the investigation to study the effect of pH on the activity of lysozyme.

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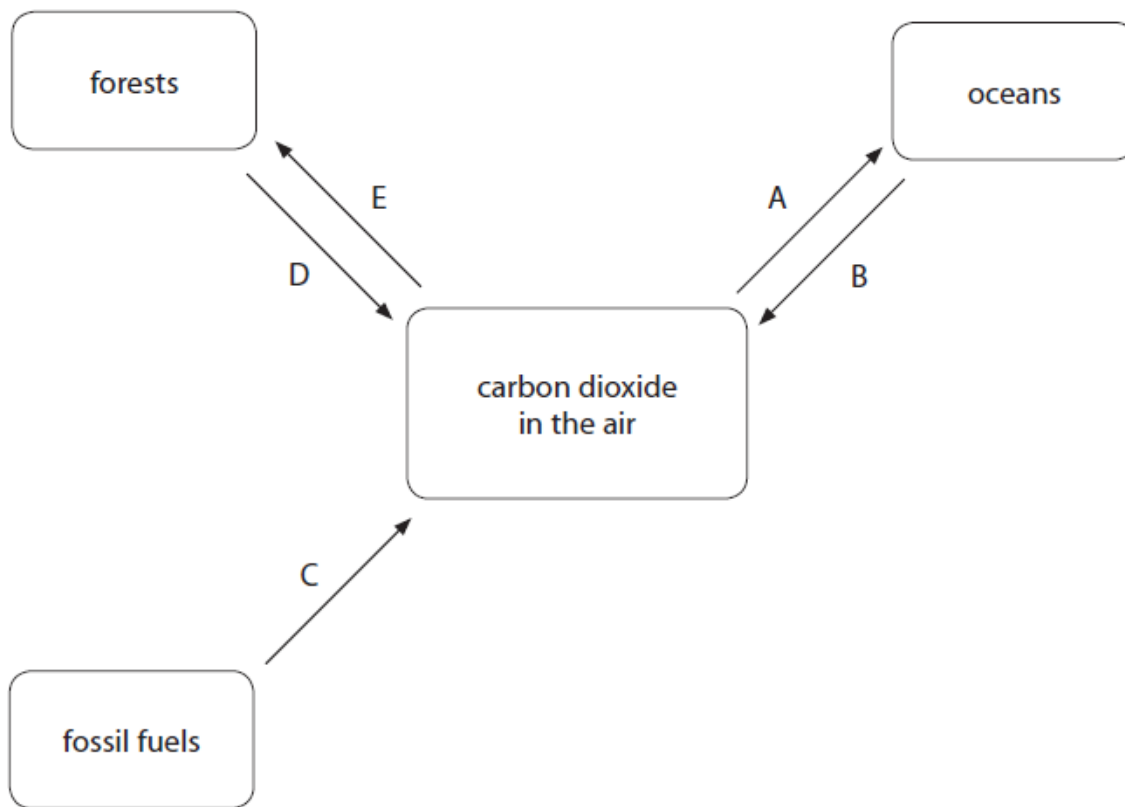
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Q8.

The diagram below shows part of the carbon cycle. The processes A, B, C, D and E, transfer carbon.



Explain how carbon dioxide is removed from the air into the oceans by process A.

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Q9.

The earthworm, (*Lumbricus terrestris*), feeds on dead organic matter found in soil.



Soil pH is one of the abiotic factors that affects the population size of earthworms.

The populations of earthworms in fields with either acidic soil or alkaline soil have been investigated.

The results of this investigation are summarised in the table.

Sample	Earthworms in field with acidic soil		Earthworms in field with alkaline soil	
	Number per square metre	Mass per square metre / g m ⁻²	Number per square metre	Mass per square metre / g m ⁻²
1	80	184	723	1 164
2	59	110	1 613	1 968
3	106	253	354	439
4	31	70	728	961
5	121	238	214	233
6	75	139	874	1 739
7	97	149	668	1 096
8	138	309	121	213
9	63	95	791	1 455
10	63	84	497	736
Total	833	1 631	6 583	10 004

Explain how differences between the mass of earthworms in these two soils could be shown to be statistically significant.

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(Total for question = 3 marks)

Q10.

The scientific article you have studied is adapted from several sources.

Use the information from the scientific article and your own knowledge to answer the following questions.

Probiotics include live bacteria that are ingested for health benefits.

Explain how probiotics may regulate food cravings (paragraphs 18, 19 and 20).

(3)

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(Total for question = 3 marks)

Q11.

Tropical rainforests play a role in maintaining biodiversity and in storing carbon.

Explain how reforestation of tropical rainforests can be used to minimise climate change.

(3)

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(Total for question = 3 marks)

Q12.

Trypsin is an enzyme found in many groups of living organisms.

Trypsin specifically acts on a polypeptide to form amino acids.

Trypsin molecules from vertebrates, but not other animals, have a calcium ion binding site.

Explain how this calcium ion binding site could have evolved in vertebrates.

(3)

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(Total for question = 3 marks)

Q13.

Explain how these two species of snake could have arisen from a common ancestor.

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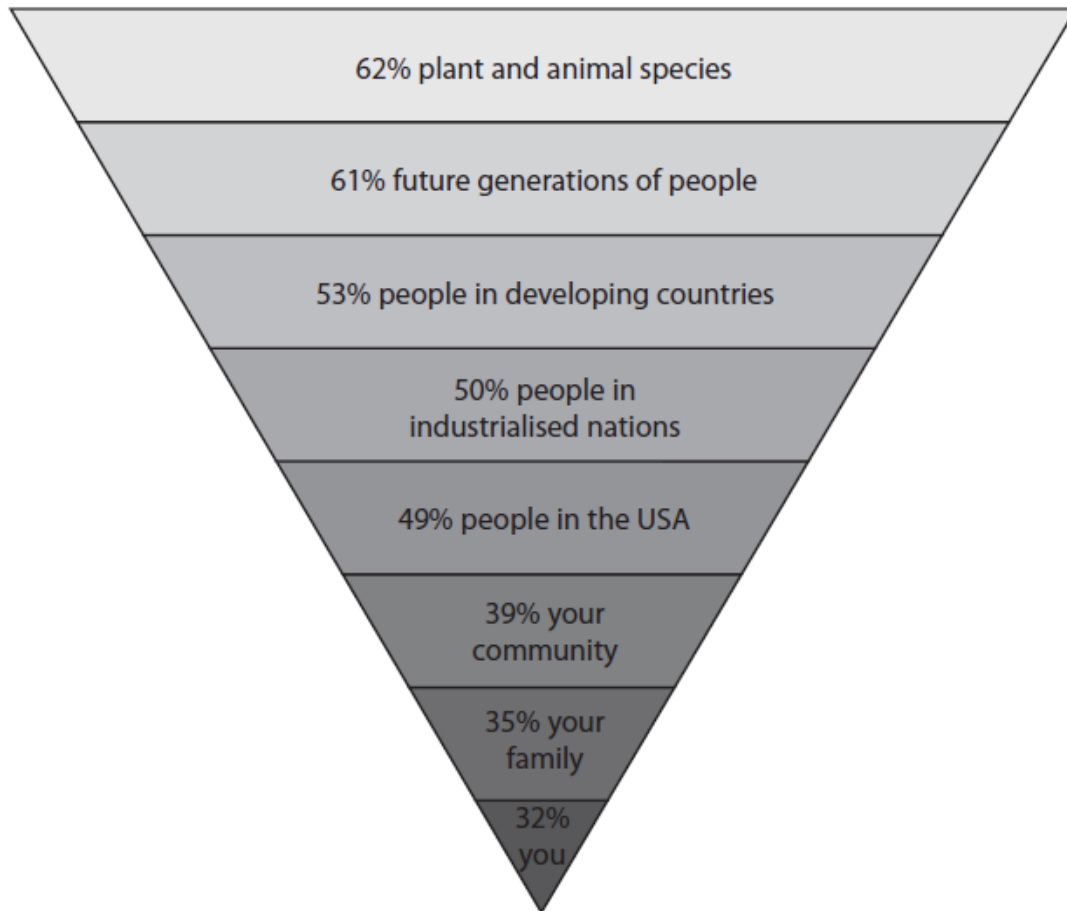
(Total for question = 4 marks)

Q14.

A survey was conducted in the USA to find out what harm people thought global warming could have.

The people were asked if they thought global warming could harm the eight groups shown in the diagram.

The diagram below shows the percentage of people who thought each group would be harmed.



Explain the meaning of the term **global warming**.

(2)

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Q15.

In some commercial glasshouses, the concentration of carbon dioxide in the atmosphere is increased.

Explain why this increase in carbon dioxide concentration affects the growth of plants in glasshouses.

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(Total for question = 3 marks)

Q16.

The Intergovernmental Panel on Climate Change (IPCC) has issued the following statement:

"Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems."

(a) Explain why anthropogenic emissions of greenhouse gases are affecting the climate.

(3)

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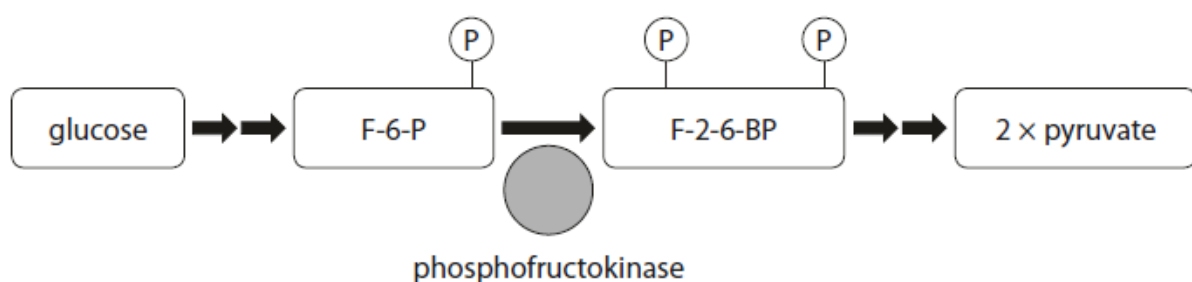
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(Total for question = 3 marks)

Q17.

Phosphofructokinase is an enzyme that uses ATP to convert fructose-6-phosphate (F-6-P) into fructose-2,6-bisphosphate (F-2,6-BP).

The conversion of F-6-P by this enzyme is a rate-determining step in glycolysis. This is shown in the diagram.



(i) Explain why ATP is required for this reaction.

(3)

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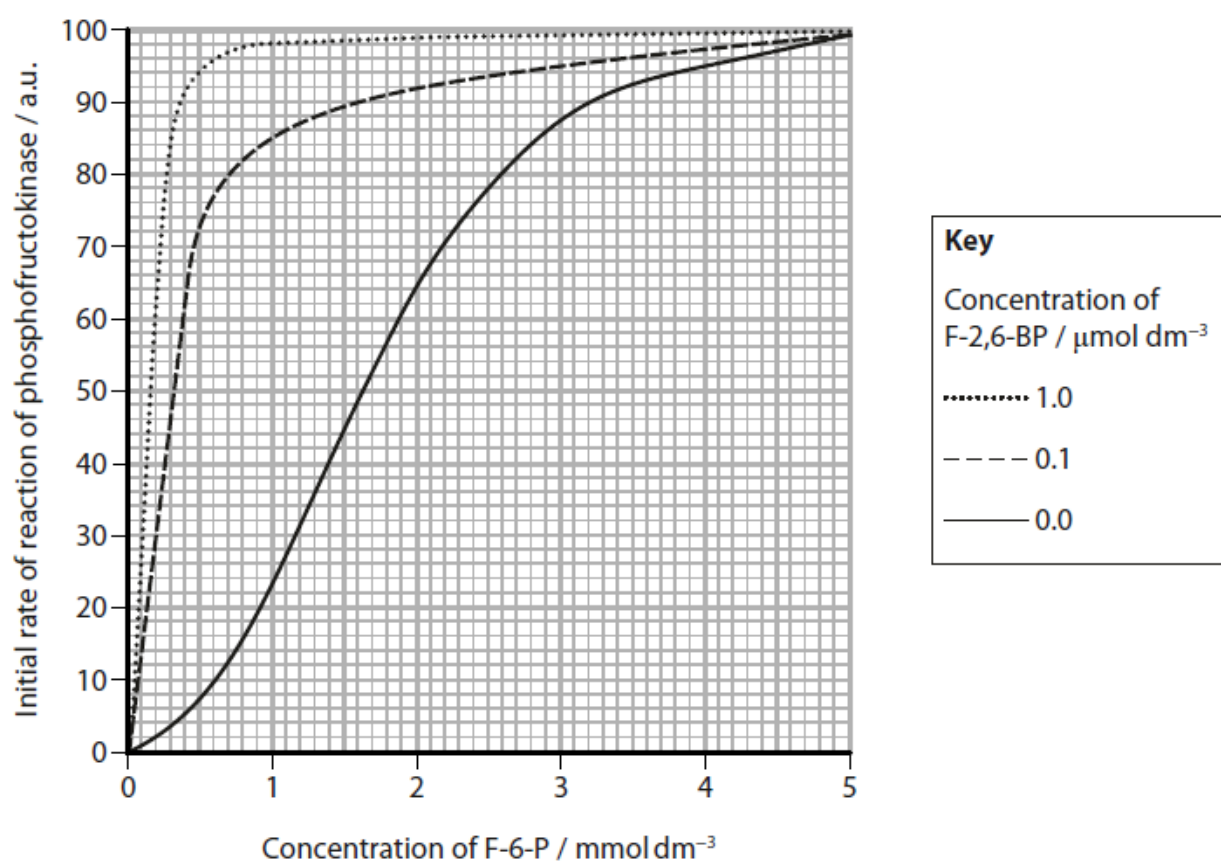
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The effect of substrate concentration on the initial rate of reaction of phosphofructokinase was investigated.

This investigation was repeated with the addition of two concentrations of F-2,6-BP.

The graph shows the results of this investigation.



Comment on the effects of F-6-P and F-2,6-BP concentrations on the rate of glycolysis.

(3)

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(Total for question = 6 marks)

Q18.

Explain why the value for GPP is lower than the light energy available to the ecosystem.

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(Total for question = 3 marks)

Q19.

A new species of mosquito has evolved in the tunnels of the London Underground. These mosquitoes are believed to be the descendants of bird-biting mosquitoes which colonised the tunnels 100 hundred years ago. The mosquitoes now feed on rats, mice and human beings instead of birds.

(a) Place a cross in the box next to the best definition of a species.

(1)

- ☐ **A** individuals can interbreed to produce fertile offspring
- ☐ **B** individuals can interbreed to produce hybrid offspring
- ☐ **C** individuals can interbreed to produce sterile offspring
- ☐ **D** individuals can interbreed to produce offspring

(b) Explain how this species of mosquito may have evolved.

(5)

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(Total for question = 6 marks)

Q20.

DCMU is a herbicide that can disrupt one of the carrier proteins in the electron transport chain of chloroplasts.

A student carried out an investigation to study the effect of DCMU concentration on the Hill reaction.

The student ground up some spinach leaves in an isolation mixture containing sucrose solution at a concentration of 0.4 mol dm^{-3} . The mixture was filtered and then spun in a centrifuge. The chloroplasts were extracted.

These chloroplasts were divided equally into eight different tubes containing a solution of distilled water, DCPIP and a buffer.

A small volume of DCMU was added to each tube and the time taken for the blue DCPIP to decolourise was recorded.

(a) (i) Explain why the isolation mixture contained sucrose at a concentration of 0.4 mol dm^{-3} rather than at a concentration of 0.8 mol dm^{-3} .

(2)

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(ii) The isolation mixture had a temperature of 4°C and pH of 7.

Explain why this temperature and pH are appropriate.

(3)

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(b) The time taken for the DCPIP to decolourise was converted to a rate of colour change. The results are shown in the table.

Concentration of DCMU / $\mu\text{mol dm}^{-3}$	Rate of colour change / $\times 10^{-4} \text{s}^{-1}$
0	23.5
1	12.5
2	6.3
3	4.2
4	3.2
5	2.6
6	2.2
7	2.3

(i) Analyse the data to deduce a null hypothesis for this investigation.

(1)

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(ii) The student started to analyse the data using a statistical test, called the Spearman's rank correlation coefficient (r_s), to see if there was a correlation.

Complete the table by filling in the empty boxes.

(1)

Concentration of DCMU / mol dm^{-3}	Concentration ranked (R_1)	Rate of colour change / 10^{-4} s^{-1}	Rate ranked (R_2)	Difference in ranks d ($R_1 - R_2$)	Difference squared d^2
0	1	23.5	8		
1	2	12.5	7	5	25
2	3	6.3	6	3	9
3	4	4.2	5	1	1
4	5	3.2	4	1	1
5	6	2.6	3	3	9
6	7	2.2	1	6	36
7	8	2.3	2	6	36

(iii) Calculate r_s by using the equation.

$$r_s = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

Where $\sum(d^2)$ is the sum of all the values for d^2 and n is the number of pairs of data.

(3)

$r_s = \dots\dots\dots$

(iv) The table shows some of the critical values for the Spearman's rank correlation coefficient.

Number of pairs of data (n)	p value			
	0.10	0.05	0.02	0.01
6	0.829	0.866	0.943	1.000
8	0.643	0.786	0.833	0.881
10	0.564	0.648	0.746	0.794
12	0.506	0.591	0.712	0.777
14	0.456	0.544	0.645	0.715
16	0.425	0.506	0.601	0.665
18	0.399	0.475	0.564	0.625

Explain the outcome of the statistical test.

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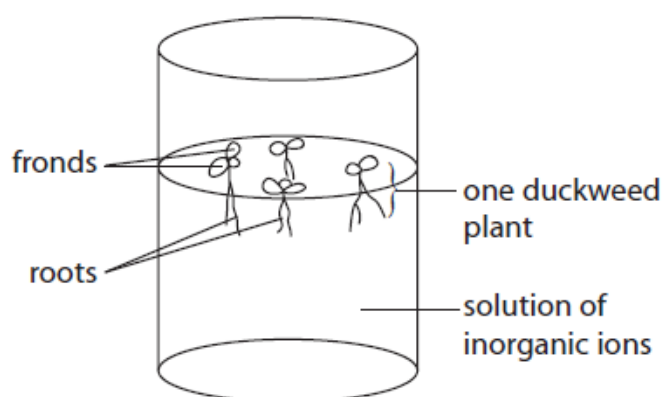
(Total for question = 13 marks)

Q21.

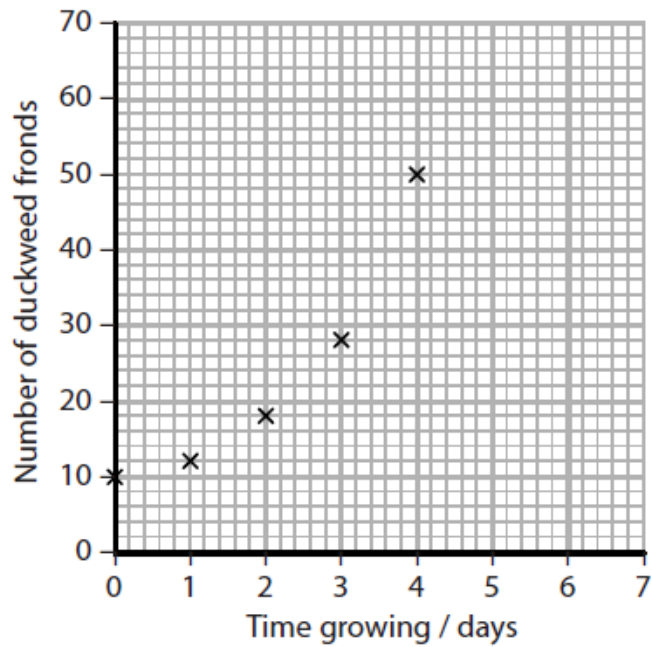
Duckweed is a small plant that floats on the surface of water. It could be a source of animal feed as it grows very quickly. Duckweed absorbs dissolved inorganic ions and this decreases water pollution.

Duckweed grows by producing more fronds, which then separate into new plants.

The diagram below shows some duckweed growing in a beaker containing a solution of inorganic ions.



The graph below shows the growth of duckweed over a four-day period.



(i) Explain what the solution should contain for the optimum growth of duckweed.

(3)

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(ii) Explain how the information in this graph could be used to estimate the increase in growth after a further six days.

(2)

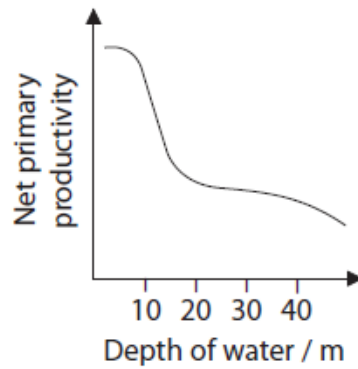
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Q22.

The graph below shows how the depth of water in a freshwater lake affects the net primary productivity (NPP).



Suggest an explanation for the effect of depth of water on the NPP in this freshwater lake.

(4)

These pigments include chlorophyll, found in chloroplasts, and flavonoids that are found in sap vacuoles.

The altitude at which a plant grows on a mountain affects its flavonoid content.

(5)

This image shows a full page of white paper with horizontal dashed lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

(Total for question = 5 marks)

Q24.

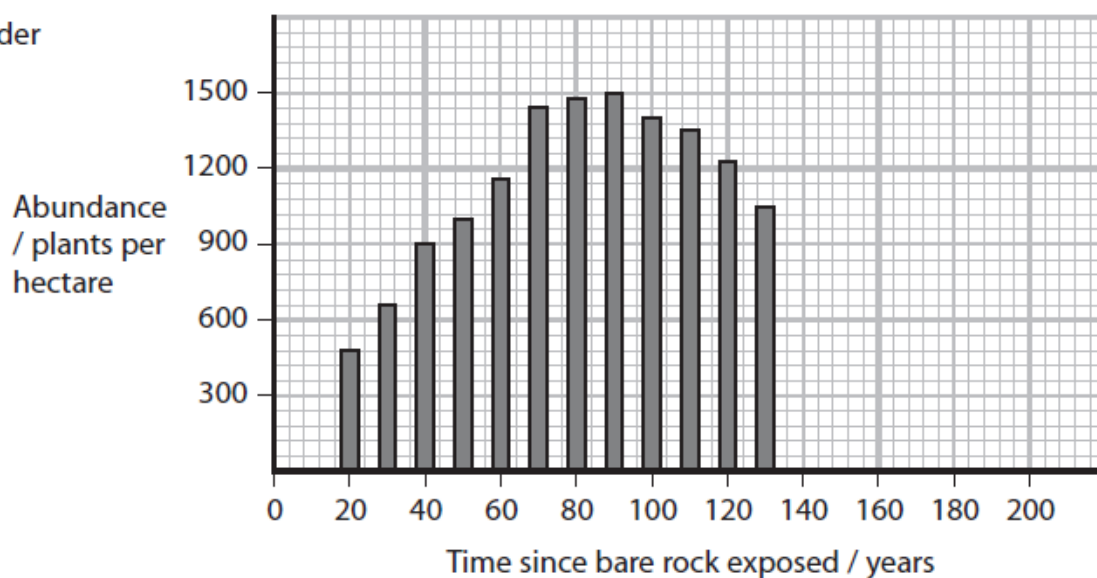
The photograph shows a glacier at the top of a mountain.
Glaciers in many areas of the world are retreating (reducing in size).
The line on the photograph shows the position of the front edge of the glacier in 1985.



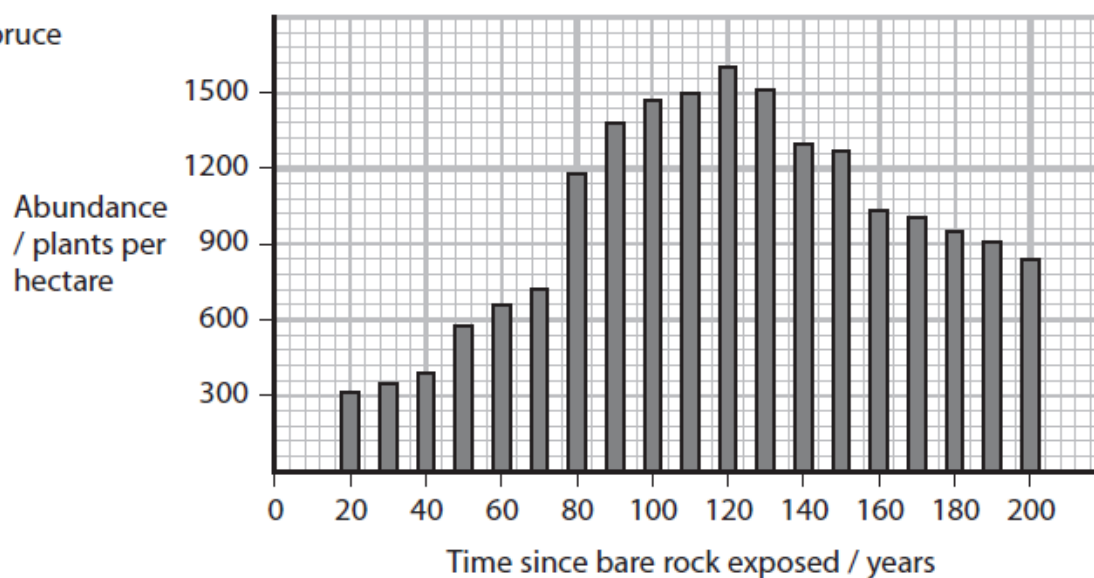
Bare rock is exposed as the glacier retreats. Two hundred years ago, bare rock was exposed after a glacier retreated. A study has been made of the long-term changes in vegetation on that area of rock after the retreat of the glacier.

The graphs show the abundance of three species of tree since the bare rock was exposed as the glacier retreated. The abundance of each species was measured every ten years for 200 years.

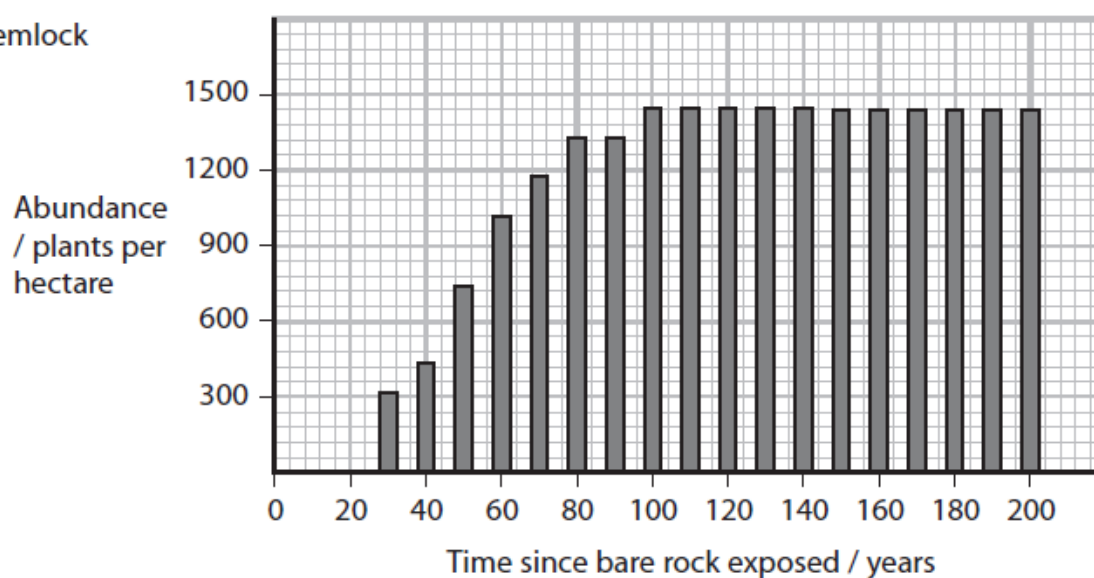
Alder



Spruce



Hemlock



Comment on the changes in the abundance of these three species over 200 years.

(4)

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(Total for question = 4 marks)

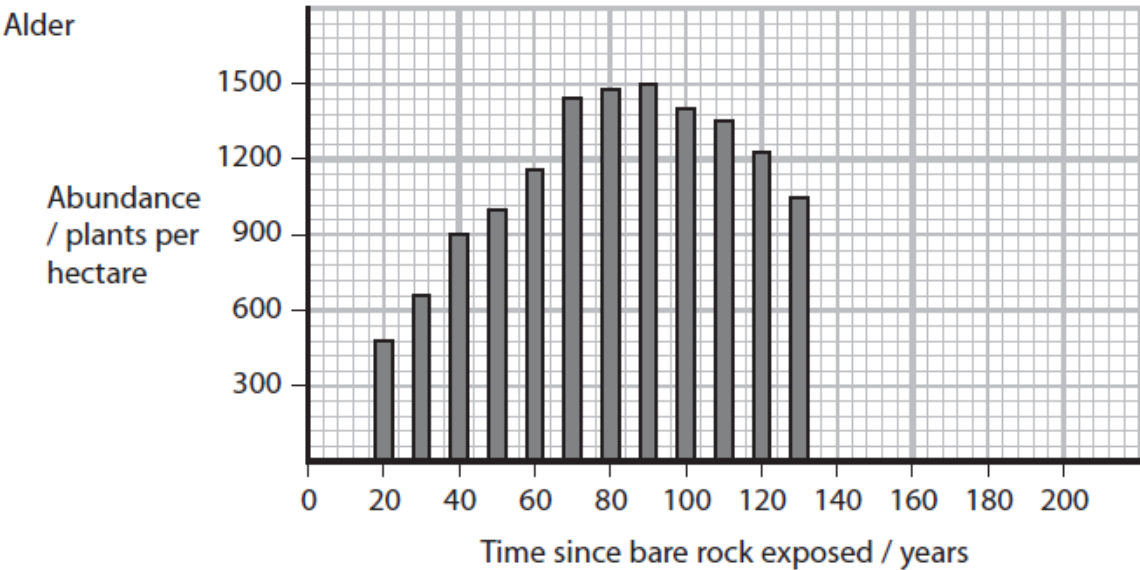
Q25.

The photograph shows a glacier at the top of a mountain.
Glaciers in many areas of the world are retreating (reducing in size).
The line on the photograph shows the position of the front edge of the glacier in 1985.

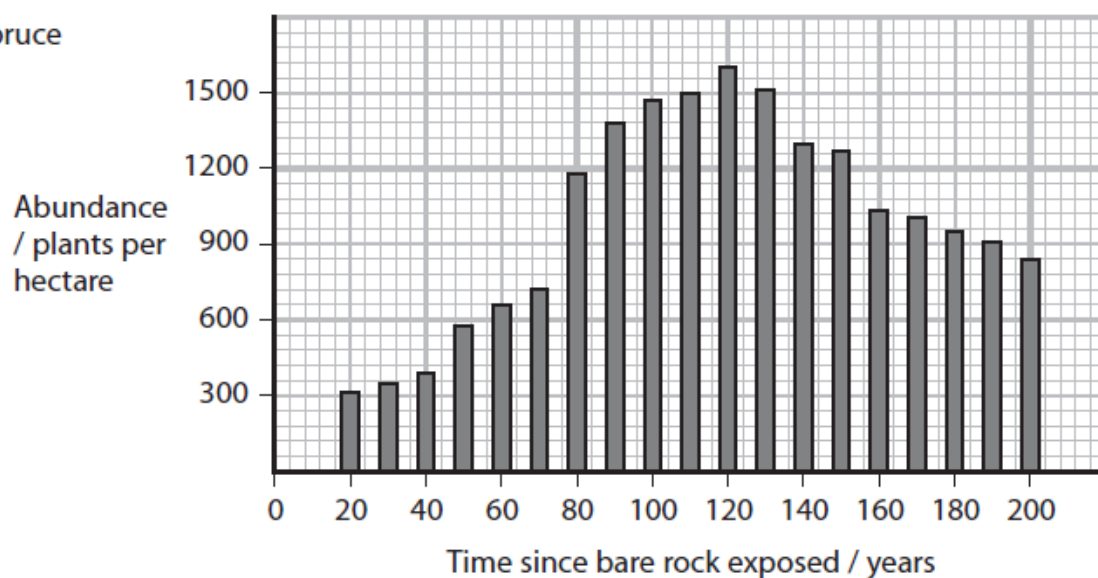


Bare rock is exposed as the glacier retreats. Two hundred years ago, bare rock was exposed after a glacier retreated. A study has been made of the long-term changes in vegetation on that area of rock after the retreat of the glacier.

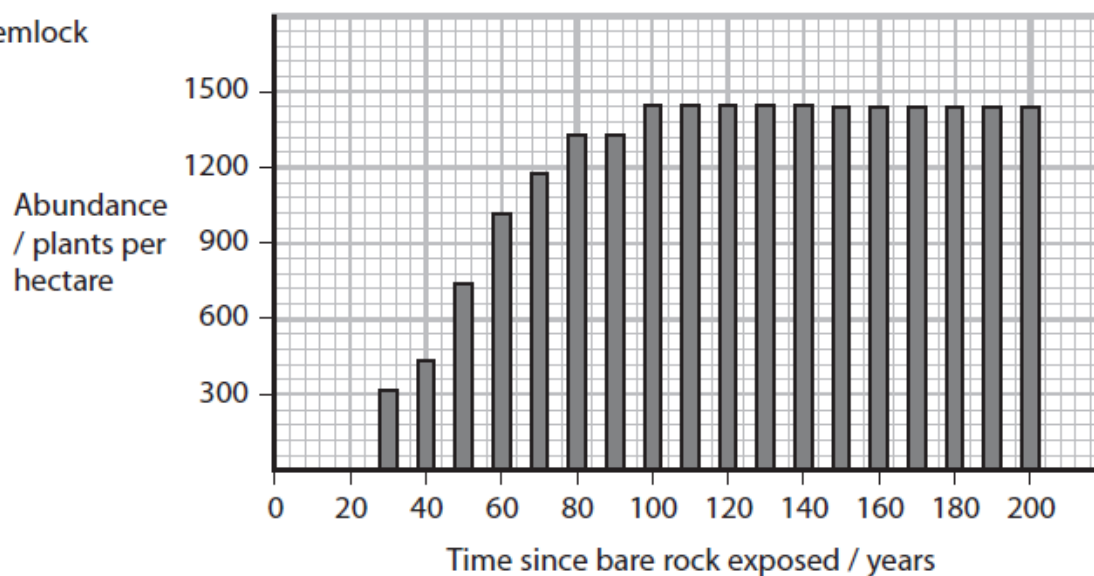
The graphs show the abundance of three species of tree since the bare rock was exposed as the glacier retreated. The abundance of each species was measured every ten years for 200 years.



Spruce



Hemlock



Explain what happened to the bare rock to allow the growth of these trees.

(3)

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Mark Scheme

Q1.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	An explanation that makes reference to the following: - antibiotics target { organelles / structures / processes } found in bacteria (1) - viruses therefore unaffected by antibiotics (1)		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	An explanation that makes reference to the following: - survivors will have antibodies specific to the virus in their plasma (1) - antibodies given to individuals infected with Ebola will provide passive immunity (1) - the antibodies provided will		(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
	therefore (1) { agglutinate / opsonise } the virus particles		

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	An explanation that makes reference to the following: • vaccine stimulates immune response to make antibodies specific to viral proteins (1) • mutations in the virus nucleic acid (1) • results in a change in the shape of the viral proteins (1) • therefore antibodies can no longer bind to the virus (1)	Accept reference to antigens Ebola is an RNA virus but allow reference to mutations in DNA	(4)

Q2.

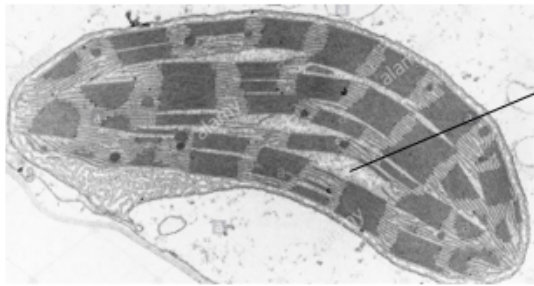
Question Number	Acceptable Answer	Additional guidance	Mark
(a)	$\text{NPP} = \text{GPP} - \text{R}$ (1)		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(i)	A description that makes reference to the following: • use of several quadrats of stated area placed at random (1) • heather placed in drying oven until constant mass (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(ii)	• (gradient) $46.875 \text{ (g m}^{-2} \text{ yr}^{-1}) \times 22.186 \text{ (kJ)} = 1039.97 \text{ (g kJ m}^{-2} \text{ yr}^{-1})$ (1) • $(1039.97 \div 3\,144\,000) \times 100 =$	Example $750 \text{ g m}^{-2} \div 16 \text{ years} = 46.875 \text{ g m}^{-2} \text{ yr}^{-1}$	(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(iii)	An explanation that makes reference to the following: • moss not all removed by burning so quickly re-grows (1) • mat grass colonises after 1 year and outcompetes moss for {light / minerals / water} so is the dominant plant after 5 years (1) • both decrease as heather colonises and becomes dominant as the heather outcompetes them both for {light / minerals / water} (1)		(3)

Q3.

Question number	Answer	Additional guidance	Mark
(i)		ALLOW location of carbon fixation IGNORE unqualified letters	Expert (1)

Question number	Answer	Additional guidance	Mark
(ii)	• granum	ALLOW stack of thylakoids / thylakoid / grana	Graduate (1)

Question number	Answer	Additional guidance	Mark
(iii)	A description that makes reference to three of the following: • large surface area (1) • containing {chlorophyll / photosystems / photosynthetic pigments} (1) • to absorb as much light as possible (1) • the membrane (contains) electron transport chain / (contains) ATP synthase for the synthesis of ATP (1)	ALLOW PSII IGNORE to absorb light unqualified ALLOW ATP-ase	Expert (3)

Question number	Answer	Additional guidance	Mark
(iv)	A description that makes reference to the following: • (the enzyme) RUBISCO (1) • combines carbon dioxide with RuBP (1) • unstable {6 carbon / 6C} molecule breaks down into (two) GP (1)	ALLOW five carbon molecule / 5C molecule / ribulose biphosphate ALLOW glycerate phosphate	Expert (2)

Q4.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to five of the following: - as a result of a mutation (1) (cyanobacteria) produce proteins containing the amino acid cysteine (1) (cysteine rich proteins) produce {heat stable enzymes / proteins resistant to unfolding} (1) - other adaptations such as {enzymes with large hydrophobic cores / simpler protein folds / amino acids that do not bond to metal ions } (1) - high temperatures act as a selection pressure (1) - allowing them to {survive / replicate} and pass advantageous allele to next generation (1)	ALLOW 'pass alleles for heat tolerance to next generation'	(5)

Q5.

Question Number	Answer
* (i)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. - feeding behaviours - anatomy - genetic differences - no information on whether they can interbreed to produce fertile offspring - different locations do not indicate that they are different species - no information on number of elephants used for DNA analysis - GBA alleles K and L are exclusive to one type of elephant / genetic isolation

Level	Mark	Descriptor	
Level 0	Marks	No awardable content	
Level 1	1-2	An answer may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The answer will contain basic information with some attempt made to link knowledge and understanding to the given context.	Makes reference to one of behavioural, phenotypic, anatomical or genetic differences
Level 2	3-4	An answer will be given with occasional evidence of analysis, interpretation and/or evaluation of more than one pieces of scientific information. The answer shows some linkages and lines of scientific reasoning with some structure.	Makes reference to more than one of behavioural, phenotypic, anatomical or genetic differences Also includes an interpretation of allele data or considers reasons why may not be different species
Level 3	5-6	An answer is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of all pieces of scientific information. The answer shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Also includes an interpretation of allele data and considers reasons why may not be different species

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: - two populations are geographically isolated from each other (1) - therefore reduced gene flow between the two populations (1) - which leads to allopatric speciation (1) - different selection pressures leading to natural selection (1)	ALLOW description of populations separated by a geographical feature ALLOW description of natural selection in context of selection pressures	3

Q6.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	- appropriate x and y axis values identified (1) - correct answer 4.5 (1)	<u>Example of Calculation:</u> $(1800 - 900) \div 200$ $= 4.5$ Allow full marks for correct answer with no working	(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to two of the following: - maize produce more above ground dry mass for a particular amount of incident radiation (1) - maize fix more carbon for a particular leaf nitrogen concentration (1) - maize will grow in less optimum conditions so better for biofuel production (1)		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following: • { select / plant } a field of sugar cane (1) • sample, at suitable time intervals, using randomly placed quadrats (1) • measure light intensity (1) • harvest, dry and weigh sugar cane (1) • { monitor / record } other abiotic factors (1)		(5)

Q7.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • use of buffers of different pH (1) • control other variables e.g. temperature (1) • { compare / measure } diameter of clear zone (1)		(3)

Q8.

Question Number	Answer	Additional Guidance	Mark
	1. idea that carbon dioxide dissolves (in the water / in the oceans) ; 2. for {carbon fixation / light-independent reaction / eq} ; 3. by {photosynthesis / eq} of {seaweed / algae / (phyto) plankton / autotrophs / eq} ;	1 ACCEPT absorbed / reacts with /diffuses into / becomes carbonic acid 3 ACCEPT plants (that live in the sea) IGNORE organisms	(2)

Q9.

Question Number	Answer	Additional guidance	Mark
	A description that makes reference to three of the following: • find mean values (1) • use a t-test/ calculate a t-value (1) • (calculated) t-value needs to be greater than the critical value (1) • (compared to cv for) probability of { 0.05 / 5% } (1)	ALLOW use of mean values IGNORE chi-squared test ALLOW compare the t-value to the critical value	(3)

Q10.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: • (addition of bacteria) changes the { gut flora / gut microbes / microbiome } (1) • resulting in a change in taste perception (1) • resulting in a change to { cravings / food preferences } (1) • preventing one type of bacterium controlling { food preferences / taste perception / cravings } (1)	ALLOW (probiotics) outcompete other gut microbes ALLOW affects taste receptors	(3)

Q11.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following • {new / young / growing} trees • resulting in net uptake of carbon dioxide / more carbon dioxide taken in by photosynthesis than released by respiration • therefore reducing carbon dioxide in the atmosphere • which slows the rate of global warming	ALLOW plant more trees ALLOW trees acting as a carbon sink/store ALLOW reduces greenhouse effect	(3)

Q12.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: - variation in the trypsin gene (some variations / mutations) result in production of a calcium (ion) binding site - a calcium (ion) binding site confers a (selective) advantage (vertebrates) survive, reproduce and pass on this (trypsin) allele / the frequency of this (trypsin) allele increases	ALLOW (random) mutations in the trypsin gene ALLOW makes the enzyme more effective	(3)

Q13.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to four of the following: - mutation leads to { variation within the population of grass snakes / (snakes with) different colour or markings } (1) (natural selection led to) those snakes which were better camouflaged surviving to reproduce (1) (therefore) giving rise to two populations with differing allele frequency (1) (as the result of natural selection) the two populations became reproductively isolated (1) - sympatric speciation (in the context of new species developing in the same habitat) (1)	ALLOW separate gene pools develop or a change in allele frequency ALLOW can no longer breed with each other	(4)

Q14.

Question Number	Answer	Additional Guidance	Mark
	1. (gradual) increase in {average / eq } temperature ; 2. (of earth's) {surface / atmosphere} (and oceans) ;	NB IGNORE any explanations as to the cause 1 IGNORE warming	(2)

Q15.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following points • description of carbon dioxide as a limiting factor (1) • carbon dioxide is fixed to produce { GP / GALP } (1) • (therefore increased carbon dioxide) results in more { carbohydrate / polysaccharides / glucose } being produced (1) • which would lead to a greater rate of { growth / cell division } (1)	ALLOW other relevant biological molecule e.g. amino acids, lipids, nucleic acids ALLOW faster growth	(3)

Q16.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: • relevant example of human activity (1) • increasing a named greenhouse gas (1) • therefore more {heat energy / infrared radiation} is trapped in the atmosphere (1) • causing a mean increase in the {surface / atmospheric} temperature (1)	e.g. burning fossil fuels / landfill / cattle ranching / deforestation e.g. carbon dioxide / methane ALLOW more heat trapped in the atmosphere	(3)

Q17.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference the following: • hydrolysis of ATP (1) • provides energy for the reaction (1) • provides phosphate group for phosphorylation of F-6-P (1)	ALLOW as the reaction requires energy ALLOW provides {phosphate / Pi} that is added to F-6-P	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to three of the following: - as concentration of { F-6-P / F-2,6-BP } increases so does the (initial) rate of reaction of the phosphofructokinase (1) - an increasing in the concentration of { F-6-P / F-2,6BP } will increase the rate of glycolysis (1) - up to a maximum (rate) (1) - increasing the concentration of F-2,6-BP reduces the concentration of F-6-P required to achieve the maximum rate of glycolysis (1)	ALLOW 'enzyme' for 'phosphofructokinase' ALLOW F-2,6-BP provides positive feedback to the enzyme activity	(3)

Q18.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following - not all of the light falls on the { leaves / plants / producers } (1) - some of the light is reflected (from the surface of the leaf) (1) - some of the light misses the chloroplasts (and passes through leaf) (1) - some of the light is { the wrong wavelength / not absorbed by the chlorophyll } (1)	ALLOW energy instead of light ALLOW some of the light falls on { bark/parts of the plant that do not photosynthesise } ALLOW chlorophyll / photosystem ALLOW description of not all light wavelengths being absorbed	(3)

Q19.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	A		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	An explanation that makes reference to the following: • mosquitoes are geographically isolated in the tunnels (1) • random genetic mutations cause variation in the population which allows some individuals to feed on rats, mice and humans (1) • these individuals {will be selected for / are more likely to survive and reproduce} (1) • the proportion of individuals in the population with this mutation will change over time (1) • over many generations these populations become genetically distinct from the above ground population (1)		(5)

Q20.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(i)	An explanation that makes reference to the following: - there is no concentration gradient present between the chloroplast and the isolation solution (1) - no net loss of water from the chloroplast from osmosis (1)		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(ii)	An explanation that makes reference to the following: - low temperature to (temporarily) slow enzyme activity (1) - pH 7.0 so enzymes not denatured (1) - so RUBISCO remains active (1)		(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	There is no correlation between the concentration of DCMU and the rate of DCPIP colour change		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(ii)	7 and 49		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(iii)	- Correct calculation of numerator (1) - Correct calculation of denominator (1) - Correct calculation of correlation coefficient (1)	<u>Example of calculation:</u> $(\sum d^2 = 996) \div (n(n^2-1) = 504)$ $= (-) 0.976$ Allow all marks for correct answer with no working	(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(iv)	An explanation that makes reference to the following: - Selection of appropriate critical value from the table (1) - calculated value is greater (than critical value) (1) - Can reject the null hypothesis / correlation is significant (1)	0.786 , 0.833 , 0.881	(3)

Q21.

Question Number	Answer	Additional Guidance	Mark
(i)	1. solution should contain (all) the {mineral / ions} that duckweed needs ; 2. at the minimum concentration / eq ; Any two correctly named ion and its corresponding function : e.g. {nitrate (ions) / NO_3^{2-}} for {amino acids / protein / nucleic acid / ATP /chlorophyll / eq} {magnesium ions / Mg^{++}} for chlorophyll {calcium ions / Ca^{++}} for {cell wall / pectate / middle lamella / eq } {phosphate (ions) / PO_4^{3-}} for { nucleic acid /ADP / ATP / NAD /phospholipid / eq} ; ;	1 IGNORE nutrients 2 ACCEPT in excess IGNORE carbon dioxide and wrong formulae NOT nitrogen NOT magnesium NOT calcium ACCEPT membrane NOT phosphorous	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	1. idea of {extrapolation / drawing a line of best fit / eq} (to estimate number of fronds after 10 days) ; 2. read value from graph / eq ; 3. idea of subtracting { 50 / 10} from the number of fronds after 10 days ;	NB Apply this mark scheme even if they describe weighing the fronds and calculating the mass increase 2 IGNORE time refs.	(2)

Q22.

Question Number	Answer	Additional Guidance	Mark
	1. idea that light is reduced by the deeper water ; 2. idea that carbon dioxide levels might be lower deeper down ; 3. idea that temperature might be lower deeper down ; 4. idea that {photosynthesis / eq} will be reduced ; 5. idea that less {glucose / hexose / GALP / GP / eq } produced to convert into {biomass / NPP / eq} ; 6. idea that GPP goes down but respiration {stays the same / increases} ;	NB ACCEPT converse of mp 1 - 5 if in context of shallow water 5 IGNORE energy	

Q23.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to five of the following: - variable {heights / altitude} (1) {collecting / growing} plants for each sample (1) - standardising plant material to be analysed (1) - other abiotic factors taken into account (1) - method of extraction of pigment (1) - method to measure pigment (1)	ALLOW reference to plant material in place of plants e.g. same mass / same part of plant e.g. humidity, wind speed, soil moisture, soil pH e.g. use of solvent e.g. use of colorimeter	(5)

Q24.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to four of the following - succession has occurred (1) - alder and spruce were the first species of tree to colonise (1) - slowest increase in abundance was spruce (1) (interspecific) competition occurs between the three species (1) - example of resources competed for (1)	IGNORE primary or secondary ALLOW either alder or spruce ALLOW description of increase and decrease of abundance of each species over time ALLOW spruce and hemlock compete with alder / hemlock competes with spruce and alder e.g. water, mineral ions, light, etc.	(4)

Q25.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following • the bare rock was colonised by pioneer species (1) • (these pioneer species) break up the rock (1) • dead plants add {humus / organic matter} (as they decompose) (1) • (eventually trees will be able to grow) as the soil { becomes deeper / can retain more water } (1)	ALLOW algae or lichen	(3)

Q1.

Global warming can affect abiotic factors that determine the distribution of organisms.

The presence of sodium chloride in soil is an abiotic factor that affects the germination of seeds.

The effects of sodium chloride solution and gibberellin on the germination of rice seeds have been investigated.

Gibberellin regulates developmental processes in plants.

Fifty seeds were placed in each of three Petri dishes containing different solutions.

The seeds were incubated for 96 hours and the number that germinated in each Petri dish was counted.

Treatment	Solution	Number of seeds germinating
Control	Distilled water	48
Sodium chloride	120 mmol dm ⁻³ of sodium chloride	33
Sodium chloride and gibberellin	120 mmol dm ⁻³ sodium chloride and 50 µmol dm ⁻³ gibberellin	45

(i) Give a null hypothesis for this experiment.

(1)

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(ii) Calculate the chi-squared (χ^2) value for these results, using the formula provided.

(3)

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Answer

(iii) In a second experiment, using the same three treatments, the chi-squared (χ^2) value was found to be 6.635.

The table gives the critical values for the chi-squared (χ^2) test at different probability levels.

Degrees of freedom	Probability level		
	0.05	0.01	0.001
1	3.841	6.635	10.83
2	5.991	9.210	13.82
3	7.815	11.34	16.27
4	9.488	13.28	18.47

Deduce the statistical significance of the results of the second experiment.

(2)

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(Total for question = 6 marks)

Q2. The Sylt-Rømø Wadden Sea, shown in the diagram below, has a high gross primary productivity (GPP) which is monitored constantly.

The Sylt-Rømø Wadden Sea is protected from the North Sea by an island.

There are no large rivers flowing into the Sylt-Rømø Wadden Sea.



(a) Explain the meaning of the term **gross primary productivity (GPP)**.

(2)

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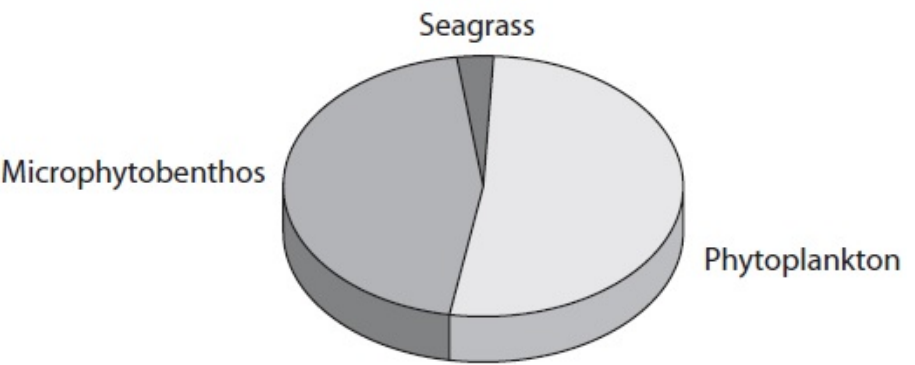
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(b) Seagrass, microphytobenthos and phytoplankton are the producers found in the Sylt-Rømø Wadden Sea.

The chart below shows the distribution of GPP between these producers.



(i) Using the chart, describe the distribution of GPP in this sea.

(2)

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(ii) The total GPP for this sea is $840 \times 10^6 \text{ kJ m}^{-2} \text{ y}^{-1}$.

Explain how GPP for the phytoplankton could be calculated.

(2)

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(iii) Suggest why GPP for this sea is very high.

(2)

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(c) Explain why net primary productivity (NPP) is lower than GPP.

(2)

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(Total for Question = 10 marks)

Q3.

Anthropogenic activities are contributing to global warming.

Scientists from the IPCC (Intergovernmental Panel on Climate Change) say that changes to diet can have a major impact on greenhouse gas emissions. The method of farming affects the level of impact.

The Paris Agreement of 2015 committed countries to reduce carbon emissions.

The table shows the mass of greenhouse gas released in the production of one serving of a variety of sources of protein.

Source of protein	Mass of greenhouse gas released in the production of one serving of the protein / kg
Beef	7.0
Lamb	5.0
Chicken	2.5
Cheese	2.0
Tofu (from soya beans)	1.0
Nuts	0.5

(i) Explain why a diet based on plant protein produces lower greenhouse gas emissions than a

diet based on animal protein.

(3)

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(ii) Beef cattle are traditionally reared by grazing on natural pastures (grassland).

In recent years, large areas of rainforest have been cleared to produce beef.

Explain why the farming of beef cattle on deforested land produces more greenhouse gas emissions than from those reared on natural pastures.

(3)

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(Total for question = 6 marks)

Q4.

The scientific article you have studied is adapted from *Scientific American*.

Use the information from the scientific article and your own knowledge to answer the following question.

Describe how the effects of 'competitive release' could be demonstrated (paragraphs 18 and 19).

(4)

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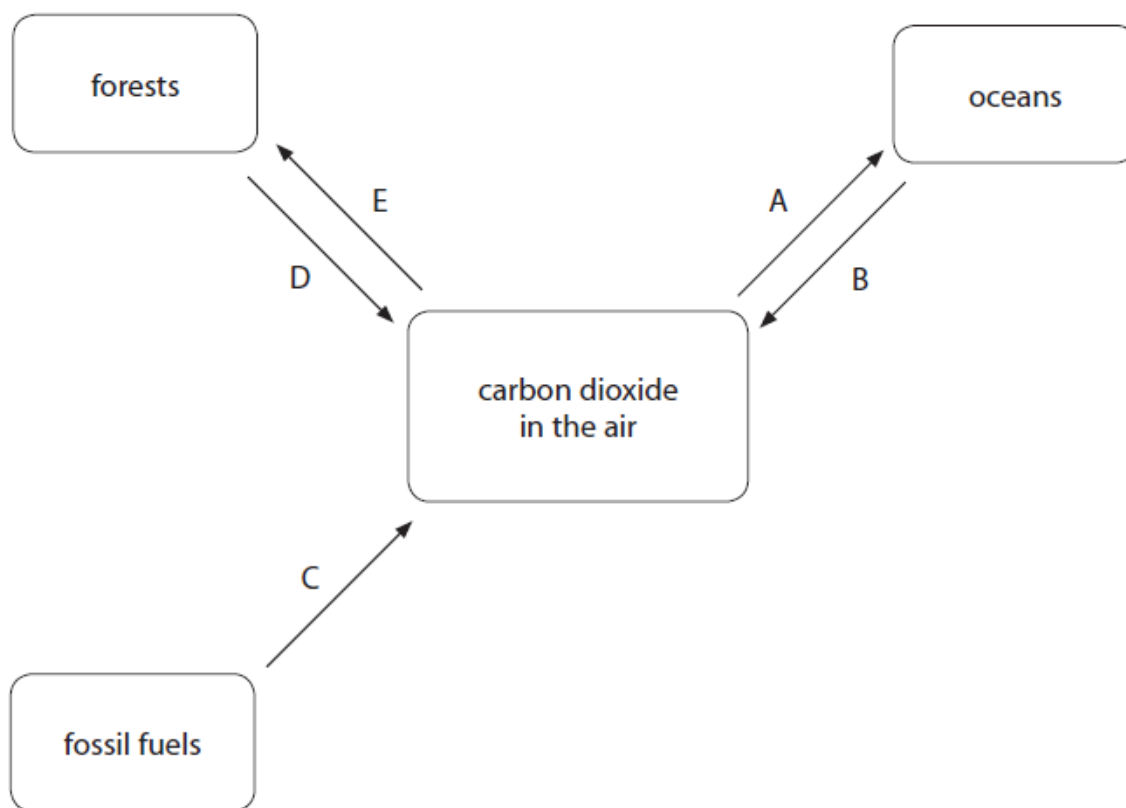
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(Total for question = 4 marks)

Q5.

The diagram below shows part of the carbon cycle. The processes A, B, C, D and E, transfer carbon.



Place a cross ☒ in the box next to the reaction in process E that uses carbon dioxide.

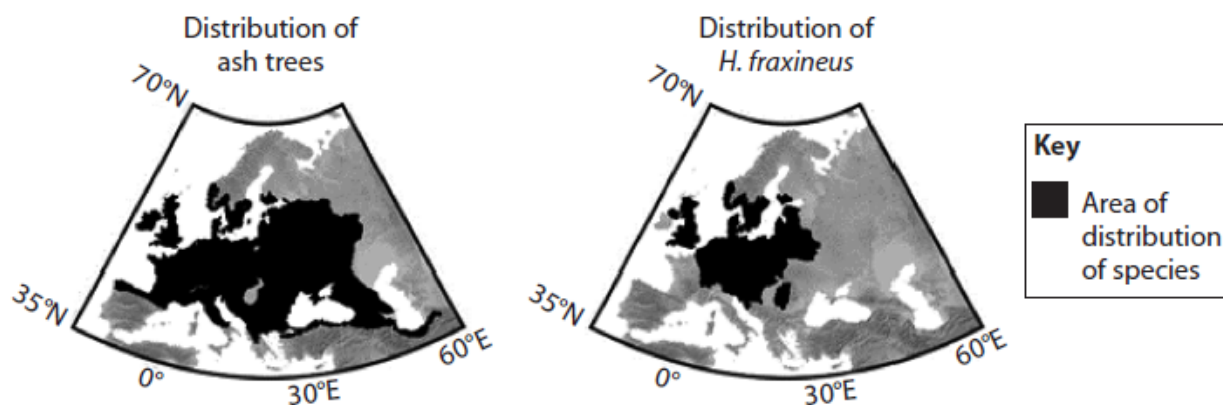
(1)

- ☒ **A** light-dependent reaction
- ☒ **B** light-independent reaction
- ☒ **C** photolysis
- ☒ **D** photophosphorylation

Q6.

Hymenoscyphus fraxineus (*H. fraxineus*) is the fungus that causes ash dieback. This disease usually kills all the ash trees that it infects.

The diagrams show the distribution of ash trees and *H. fraxineus* in 2007.



In 2007 the mean atmospheric carbon dioxide concentration was 398 ppm.

Models have been used to predict the effect of increasing atmospheric carbon dioxide concentration on the distribution of ash trees and *H. fraxineus*.

The table shows these predictions.

Concentration CO ₂ / ppm	Predicted region suitable for ash trees	Predicted region suitable for <i>H. fraxineus</i>	Predicted distribution of ash trees
430			
1080			

(i) Which of the following is an abiotic factor that should be considered in the model?

(1)

- ☐ A ash tree resistance to *H. fraxineus*
- ☐ B *H. fraxineus* pathogens
- ☐ C humidity
- ☐ D ocean pH

(ii) Which of the following could be caused by an increase in atmospheric carbon dioxide from 398 ppm to 1080 ppm?

(1)

- ☐ A decreased photosynthesis
- ☐ B global warming

☐ **C** increased plant respiration

☐ **D** ozone depletion

(iii) Analyse the data to explain the predicted effect of climate change on the distribution of ash trees.

(5)

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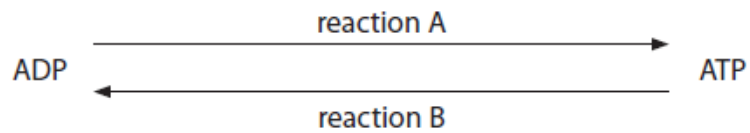
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(Total for question = 7 marks)

Q7.

Phagocytosis requires a source of energy in the form of ATP.

The diagram below shows the relationship between ATP and ADP.



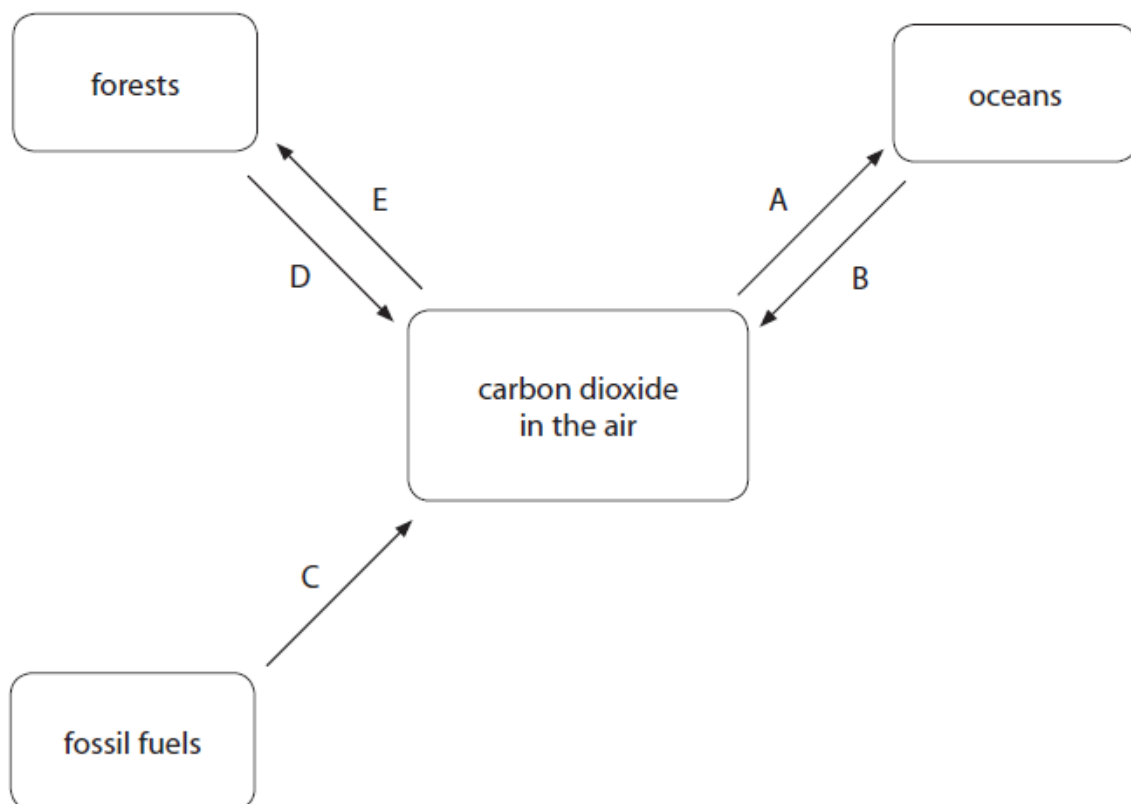
Place a cross ☒ in the box next to the name of reaction A and reaction B.

(2)

Reaction	Name of reaction				
	autolysis	decarboxylation	hydrolysis	phosphorylation	polymerisation
A	☐	☐	☐	☐	☐
B	☐	☐	☐	☐	☐

Q8.

The diagram below shows part of the carbon cycle. The processes A, B, C, D and E, transfer carbon.



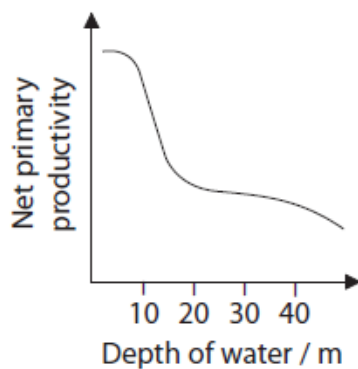
Place a cross ☒ in the box next to the gases produced by process C.

(1)

- ☐ **A** carbon dioxide and methane
- ☐ **B** carbon dioxide and water vapour
- ☐ **C** carbon dioxide, methane and water vapour
- ☐ **D** carbon dioxide, oxygen and water vapour

Q9.

The graph below shows how the depth of water in a freshwater lake affects the net primary productivity (NPP).



Place a cross ☐ in the box next to the units that should appear on the y-axis of this graph.

(1)

- ☐ **A** kg
- ☐ **B** kJ m^{-1}
- ☐ **C** $\text{kJ m}^{-2} \text{year}^{-1}$
- ☐ **D** $\text{kg m}^{-1} \text{year}^{-1}$

Q10.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☐.

Photosynthetic plants use light as a source of energy for the synthesis of organic molecules. Photosynthesis is a two-stage process.

The light-dependent reactions take place in the chloroplast.

(i) Which of the following describes where, in the chloroplast, the light-dependent reactions take place?

(1)

- ☐ **A** cristae
- ☐ **B** matrix
- ☐ **C** stroma
- ☐ **D** thylakoids

(ii) Which of the following are the products of the light-dependent reactions?

(1)

- ☐ **A** carbon dioxide and reduced NADP
- ☐ **B** glucose and oxygen
- ☐ **C** reduced NAD, ATP and oxygen
- ☐ **D** reduced NADP, ATP and oxygen

(iii) Which of the following is the source of the hydrogen produced by the light-dependent reactions?

(1)

- ☐ **A** glucose
- ☐ **B** reduced NAD
- ☐ **C** reduced NADP
- ☐ **D** water

(Total for question = 3 marks)

Q11.

The golden snub-nosed monkey (*Rhinopithecus roxellana*) is endemic to high mountainous

regions of China.

This endangered species of monkey feeds on seeds.

Golden snub-nosed monkeys live in areas with very cold winters.

The seeds in their diet contain lipids and carbohydrates.

Climate change is reducing seed production by plants in their habitat.

Discuss the impact of climate change on the monkey population.

(4)

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(Total for question = 4 marks)

The coffee husks, shown in the photograph, are a waste product of coffee plantations.

Composting has been suggested as an environmentally friendly way of decomposing these coffee husks.



The effect of adding cow dung to coffee husks, before they are composted, has been investigated.

The table shows the percentages of organic carbon and nitrogen in two compost heaps at the start of composting and after 90 days.

	Husks alone		Husks with added cow dung	
Days composting	0	90	0	90
Organic carbon (%)	54.50	41.70	48.10	35.40
Nitrogen (%)	1.84	2.31	2.76	3.19

* The changes in the compost heaps are due to the activity of decomposers and other organisms.

Devise an investigation to determine the effect of the carbon to nitrogen ratio on the succession of species in these compost heaps.

(6)

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(Total for question = 6 marks)

Q13.

Glycolysis is inhibited by acidic conditions.

Devise an investigation to determine the effect of acidic conditions on the initial rate of reaction of phosphofructokinase.

(4)

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The scientific article you have studied is adapted from *The Biologist*.

Human cells can be grown in monolayers using tissue culture (Figure 1).

(5)

[illegible]

(Total for question = 5 marks)

Q15.

A student investigated the light-dependent reactions of photosynthesis in spinach leaves.

The leaves were cut into pieces and ground in a cold solution of sucrose and a buffer.

The mixture was filtered and centrifuged. The liquid in the tube was poured off and kept in an ice water bath.

The pellet at the bottom of the tube was suspended by mixing with fresh sucrose and buffer and stored in an ice water bath.

Four tubes were then set up as follows:

Tube	Liquid poured off after centrifuging / cm ³	Resuspended pellet / cm ³	Sucrose and buffer solution / cm ³
1	–	0.5	–
2	–	–	0.5
3	–	0.5	–
4	0.5	–	–

The tubes had 5 cm³ of DCPIP added to them. Tube 3 was kept in the dark and the others kept in the light.

After twenty minutes, the colour in each tube was recorded. The results are shown in the table below.

Tube	Colour in tube
1	pale green
2	blue
3	blue
4	blue

(a) (i) Give **two** reasons why a cold solution containing sucrose and a buffer was used in this investigation.

(2)

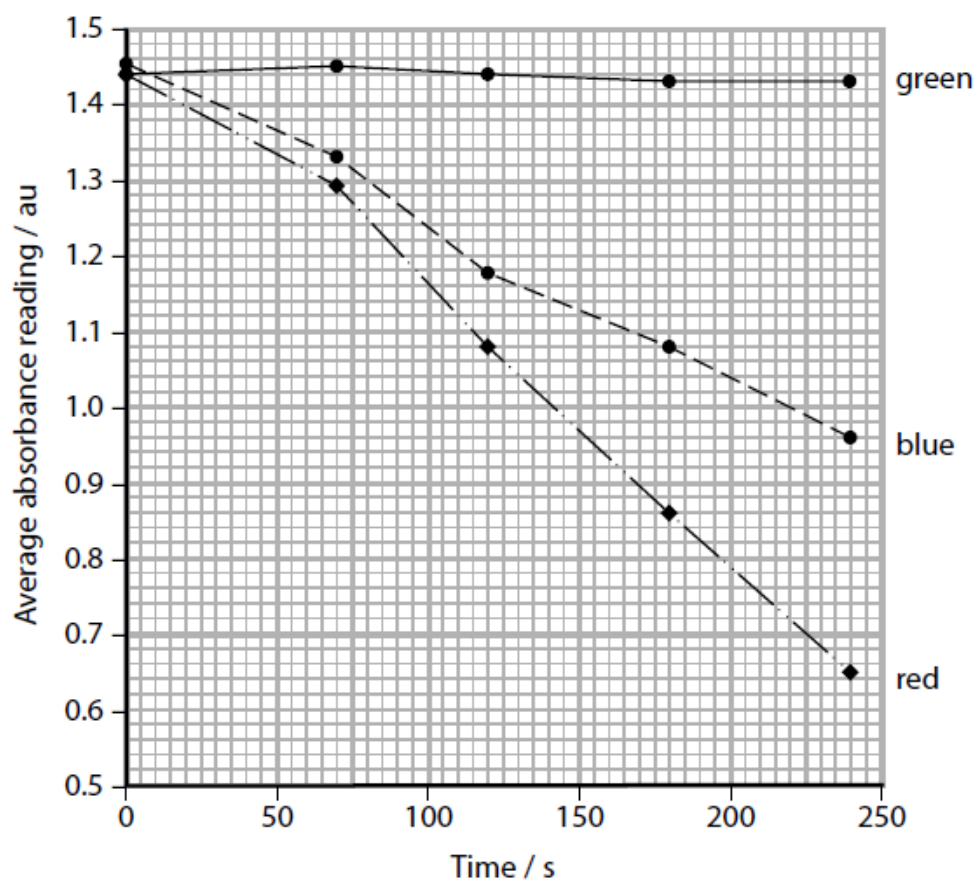
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(ii) Give a reason why tube 3 was used in this investigation.

(1)

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(iii) In another investigation, the student wanted to determine the effect of different wavelengths of light on the light-dependent stage of photosynthesis.

The student modified her first investigation to obtain results.

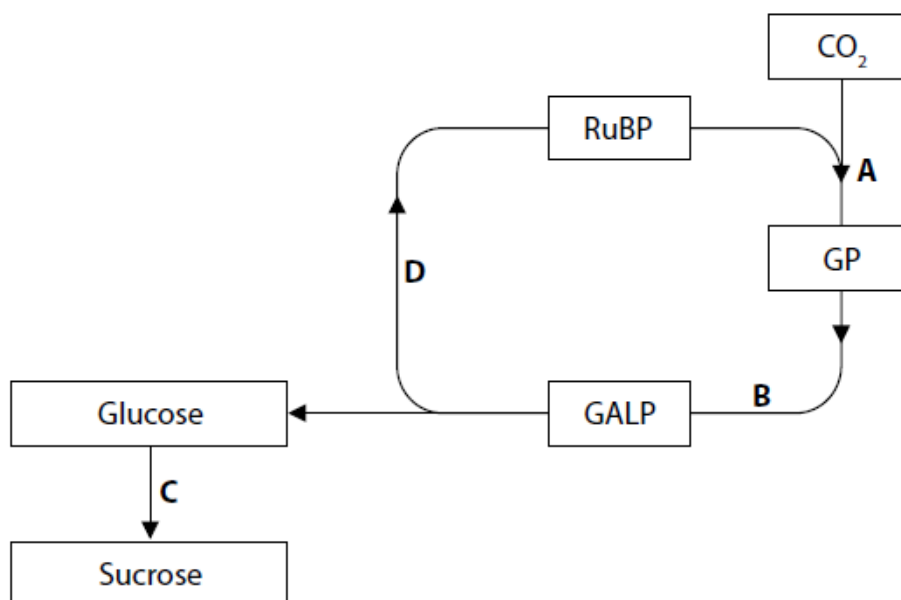
The graph shows the results of her modified investigation.



Explain how the student modified the practical procedure of the first investigation to enable these results to be obtained.

(4)

(b) The diagram shows part of the Calvin cycle (light-independent reactions) of photosynthesis.



Place a cross in the box which indicates the correct stage (A – D) for the following statements.

(i) The stage which involves a condensation reaction and fructose.

(1)

☒ A

☒ B

☒ C

☒ D

(ii) The stage where the enzyme RUBISCO is involved.

(1)

☒ A

☒ B

☒ C

☒ D

Q16.

A student investigated the effect of salt concentration on the growth of one species of brine shrimp.

The student placed 100 shrimp eggs in a beaker containing 1dm^3 of 3% salt solution. Three days after the eggs hatched, 10 shrimps were collected and their lengths measured. Seven days after hatching, another 10 shrimps were collected and their lengths measured.

The procedure was repeated using a 5% salt solution. All other variables were kept constant.

The results are shown in the table.

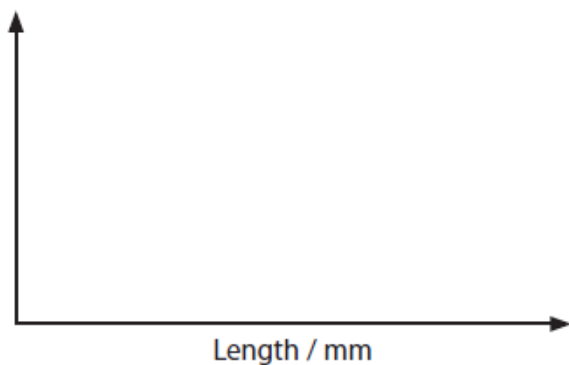
Specimen number	Length of specimen in 3% salt solution / mm		Length of specimen in 5% salt solution / mm	
	3 days after hatching	7 days after hatching	3 days after hatching	7 days after hatching
1	0.75	1.00	0.75	0.98
2	0.78	1.25	0.73	0.95
3	0.66	1.10	0.61	0.93
4	0.73	1.03	0.63	0.83
5	0.85	1.15	0.53	0.98
6	0.78	1.08	0.60	1.08
7	0.90	1.13	0.52	0.95
8	0.90	1.05	0.81	1.03
9	0.80	1.18	0.58	0.88
10	0.85	1.05	0.68	0.88
Mean	0.800	1.102		0.949

The student carried out a statistical test to see if there was a significant difference between the mean lengths of brine shrimps in these two salt solutions. The student used the 7 days after hatching data.

The student selected the *t*-test because the data are normally distributed.

(i) Draw a line on the graph to show a normal distribution for a population of brine shrimp.

(1)



(ii) Complete the table by filling in the missing value for specimen 7 and then calculate the value for Σx_1^2 .

(1)

Specimen number (n)	3% salt solution		5% salt solution	
	Length of specimen (x_1)	Square of length of specimen (x_1^2)	Length of specimen (x_2)	Square of length of specimen (x_2^2)
1	1.00	1.000	0.98	0.960
2	1.25	1.563	0.95	0.903
3	1.10	1.210	0.93	0.865
4	1.03	1.061	0.83	0.689
5	1.15	1.323	0.98	0.960
6	1.08	1.166	1.08	1.166
7	1.13		0.95	0.903
8	1.05	1.103	1.03	1.061
9	1.18	1.392	0.88	0.774
10	1.05	1.103	0.88	0.774
Sum (Σ)	$\Sigma x_1 = 11.020$	$\Sigma x_1^2 =$	$\Sigma x_2 = 9.490$	$\Sigma x_2^2 = 9.055$
Mean	$\bar{x}_1 = 1.102$		$\bar{x}_2 = 0.949$	

(iii) The variances are used in the calculation of a t -value.

The variance for the 3% salt solution $S_1^2 = 0.0059$.

Calculate the variance for the 5% salt solution (S_2^2) using the formula

$$S_2^2 = \frac{\Sigma x_2^2 - \frac{(\Sigma x_2)^2}{n}}{n-1}$$

n = the number of specimens

(2)

s_2^2

(iv) Calculate the t -value using the formula.

Give your answer to an appropriate number of significant figures.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

(3)

$t =$

(v) The calculated t -value is greater than the critical value at $p = 0.05$.

Describe what this result indicates about the effect of salt concentration on the length of brine shrimp.

(2)

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(Total for question = 9 marks)

Q17.

The pigment content of mountain plants can be affected by various environmental factors. These factors include altitude (height up a mountain), exposure to ultraviolet radiation (UV-B) and temperature.

These pigments include chlorophyll, found in chloroplasts, and flavonoids that are found in sap

vacuoles.

Flavonoids can protect plants from ultraviolet radiation (UV-B) that can damage DNA.

State the location of chlorophyll in a chloroplast.

(1)

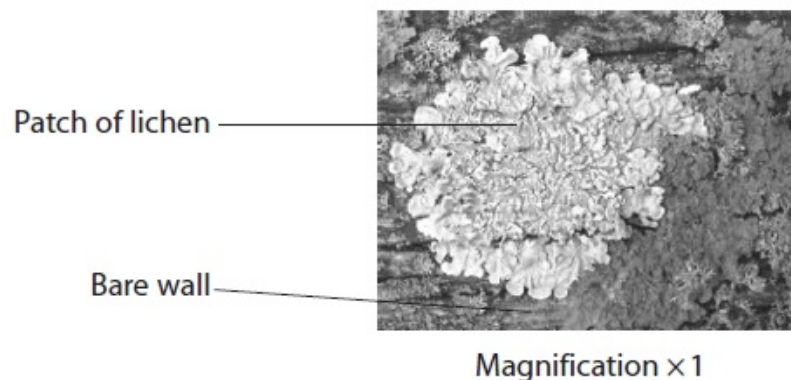
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(Total for question = 1 mark)

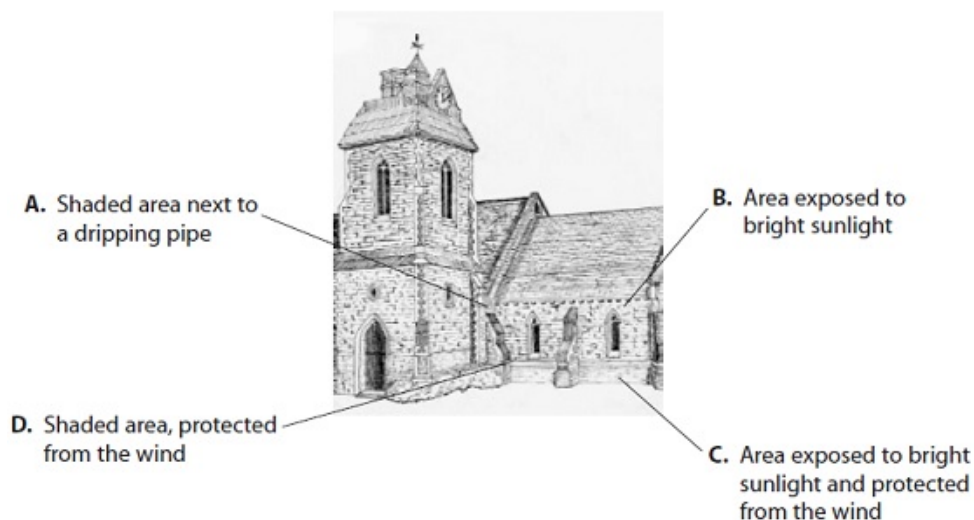
Q18. Lichen consists of two organisms, an alga and a fungus, growing together. The alga photosynthesises producing carbohydrate for the two organisms and the fungus absorbs and retains water so that the lichen does not dry out.

The photograph below shows a patch of lichen growing on a wall.



Algae and fungi are eukaryotic organisms.

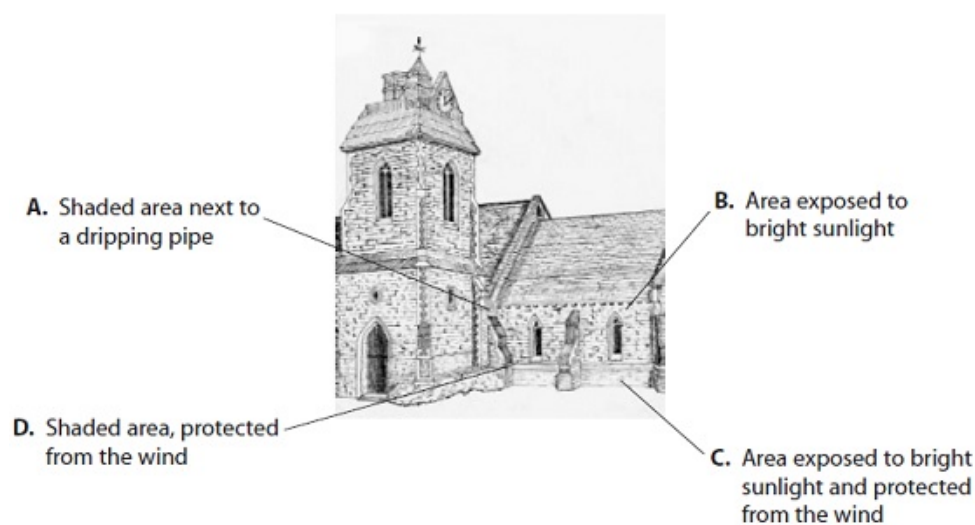
(a) Place a cross



in the box

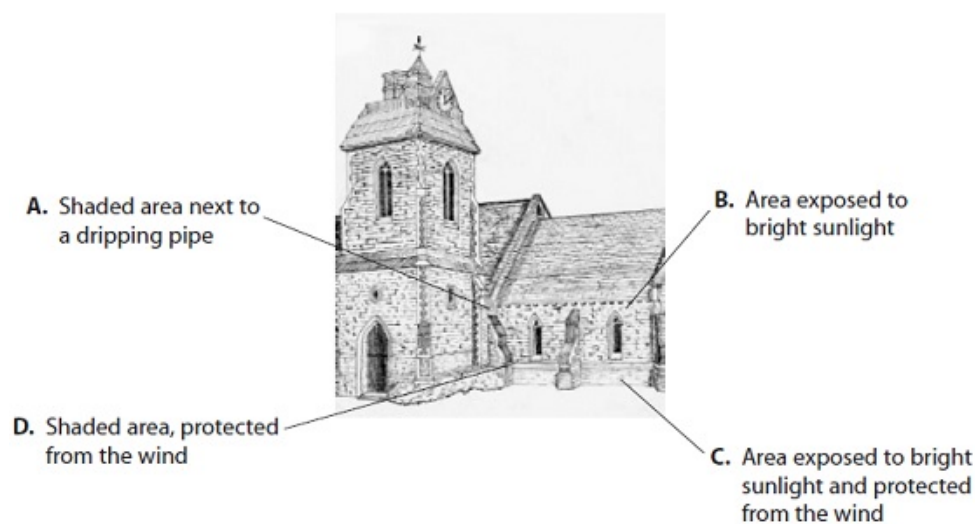
next to the names of cell structures that would be used to classify algae and fungi as eukaryotic organisms.

(1)



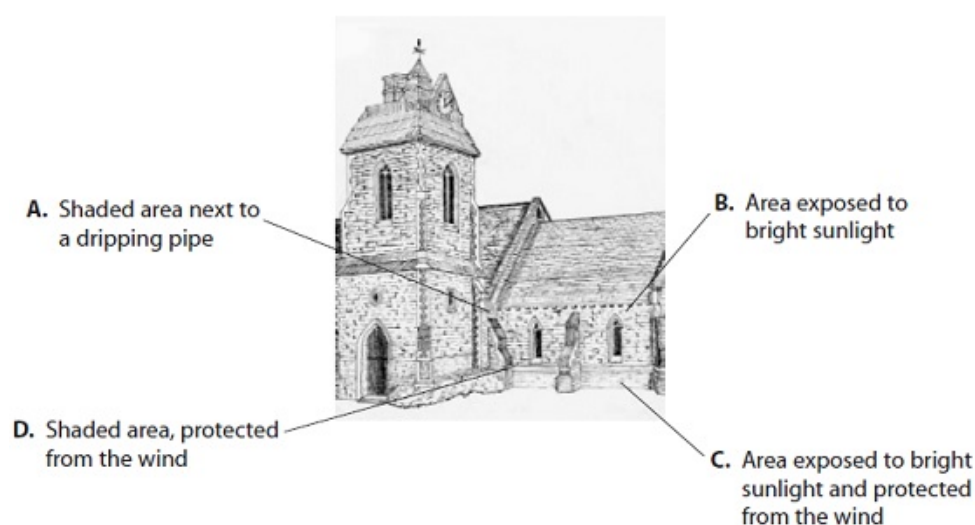
A cytoplasm and large

(80S) ribosomes



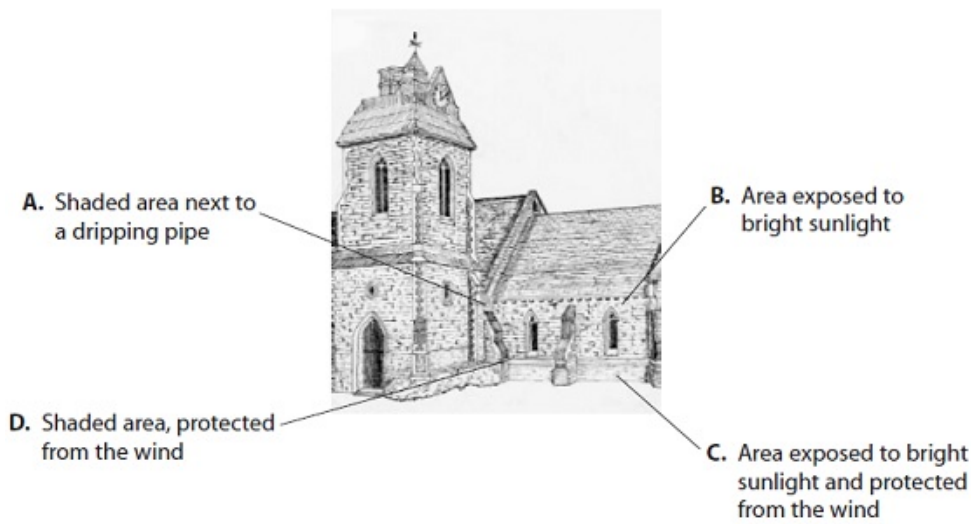
B cytoplasm and small

(70S) ribosomes



C nucleus and large (80S)

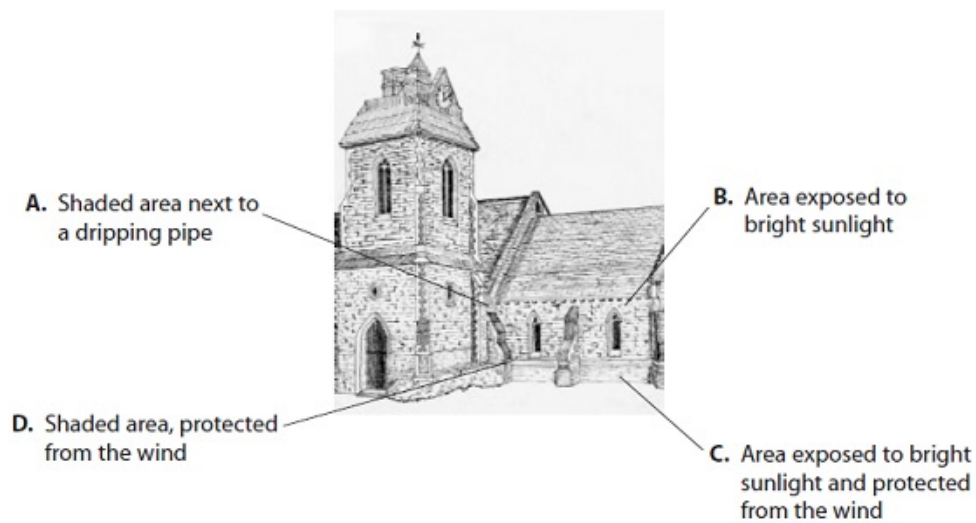
ribosomes



D nucleus and small (70S)

ribosomes

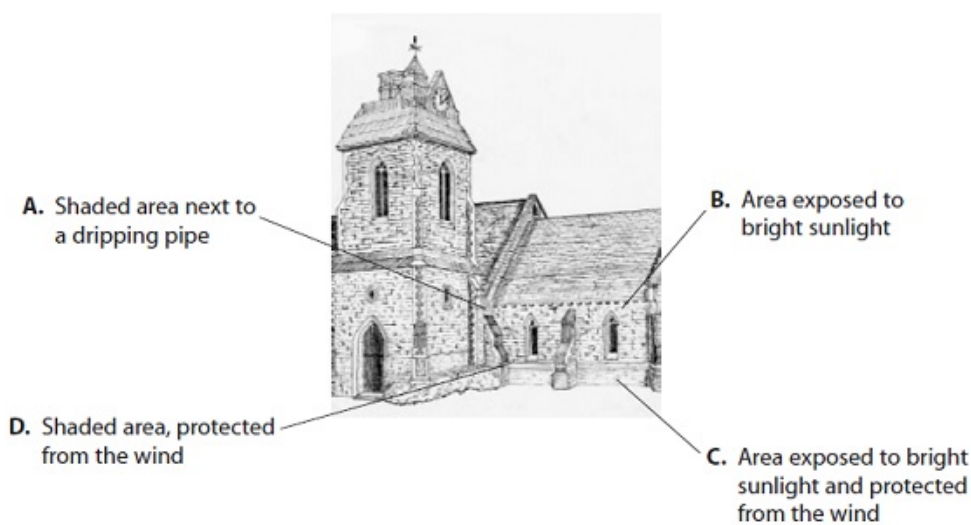
(b) Place a cross



in the box

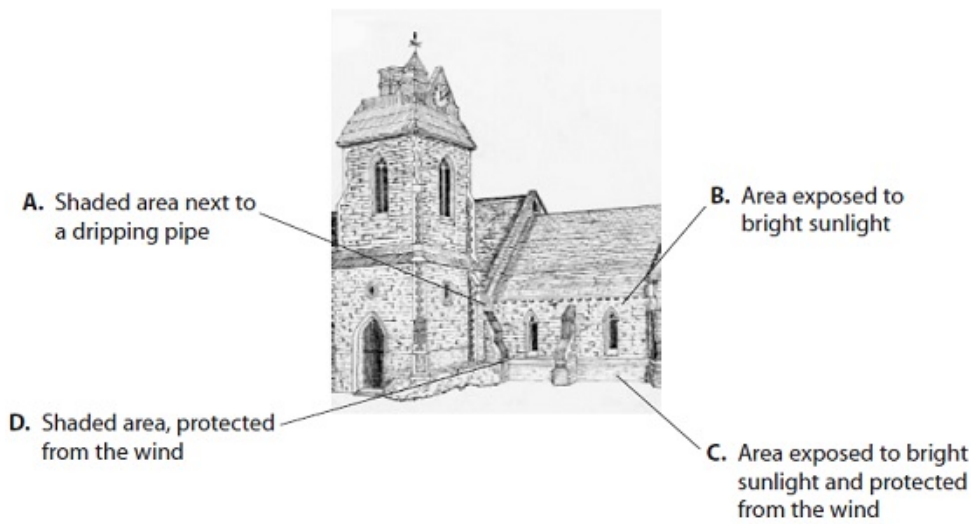
next to one difference in cell structure between these two eukaryotic organisms.

(1)



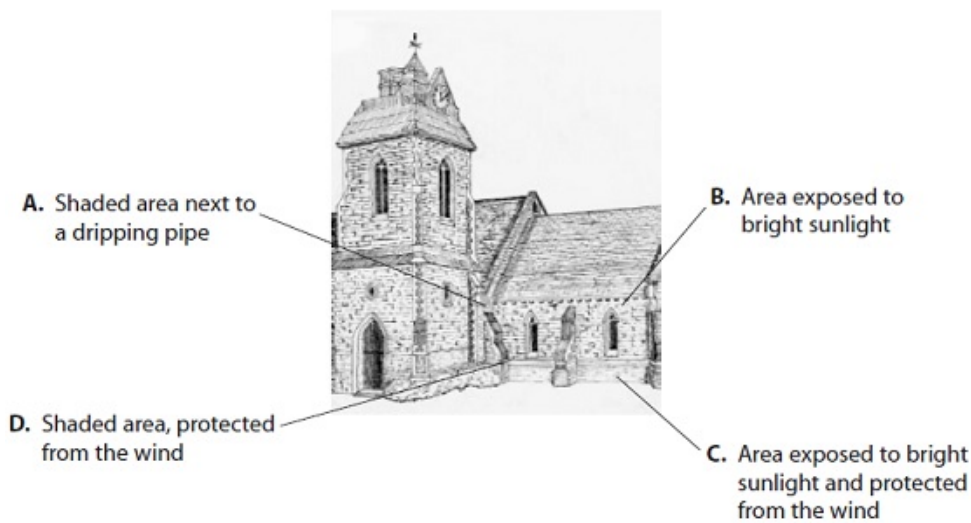
A algae have chloroplasts,

fungi do not



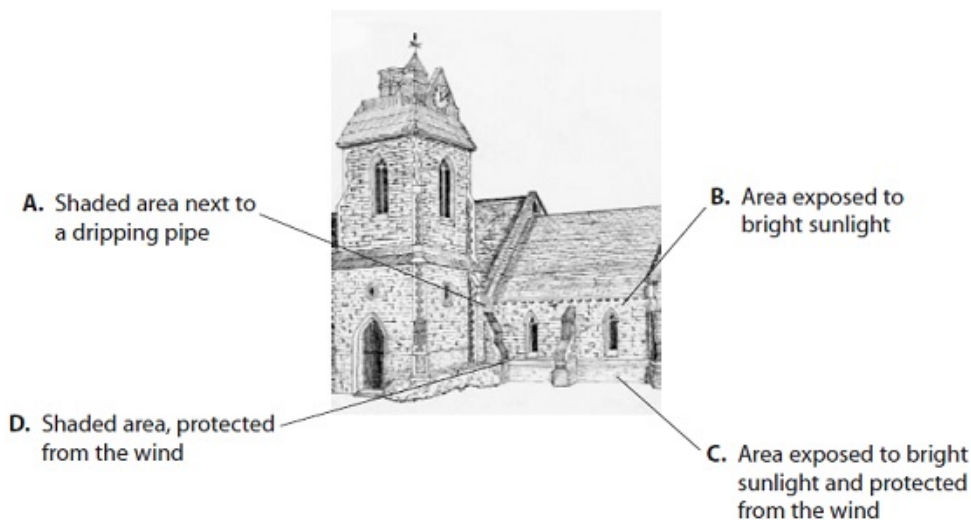
fungi have linear DNA

B algae have circular DNA,



algae do not

C fungi have chloroplasts,



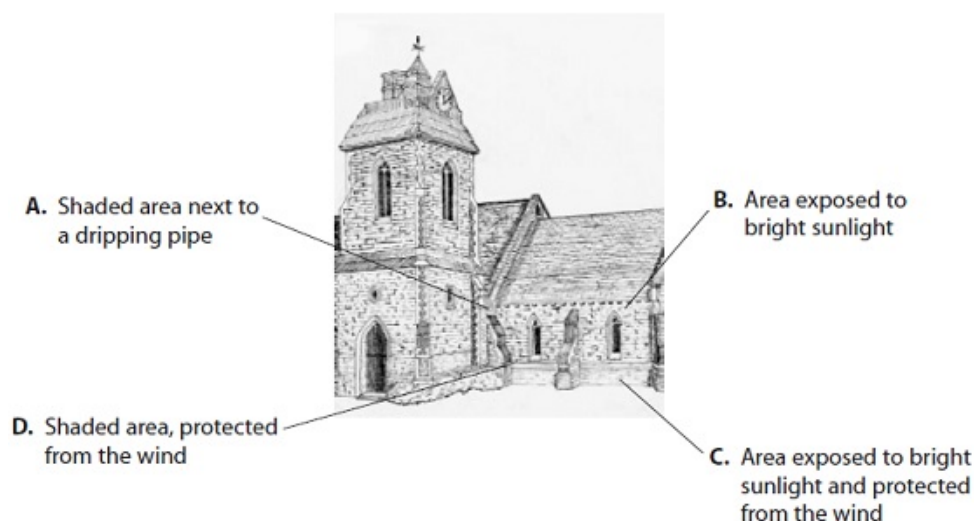
algae have linear DNA

D fungi have circular DNA,

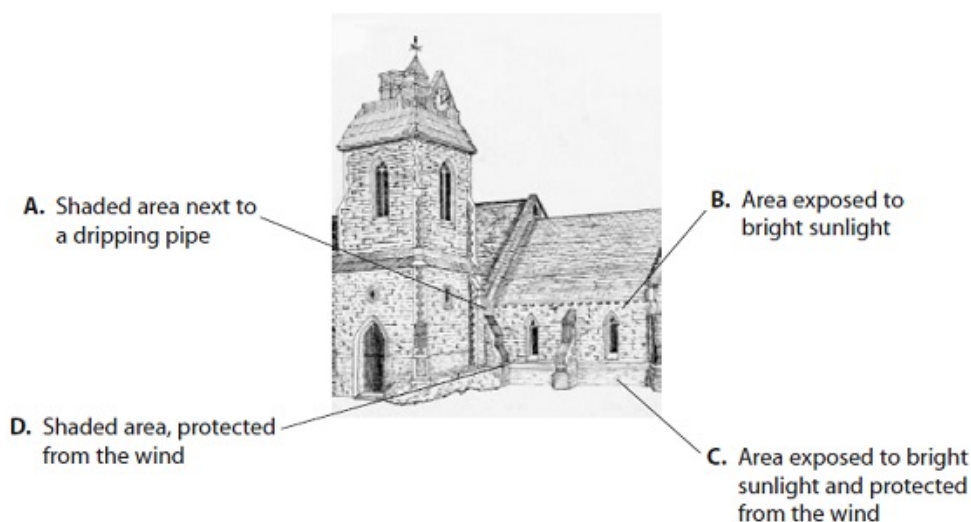
(c) Lichens can reproduce sexually and asexually. Sexual reproduction involves meiosis and asexual reproduction involves mitosis.

Suggest advantages to lichens of being able to reproduce both sexually and asexually.

(d) The diagram below shows the conditions at four positions, A, B, C and D, on a building.



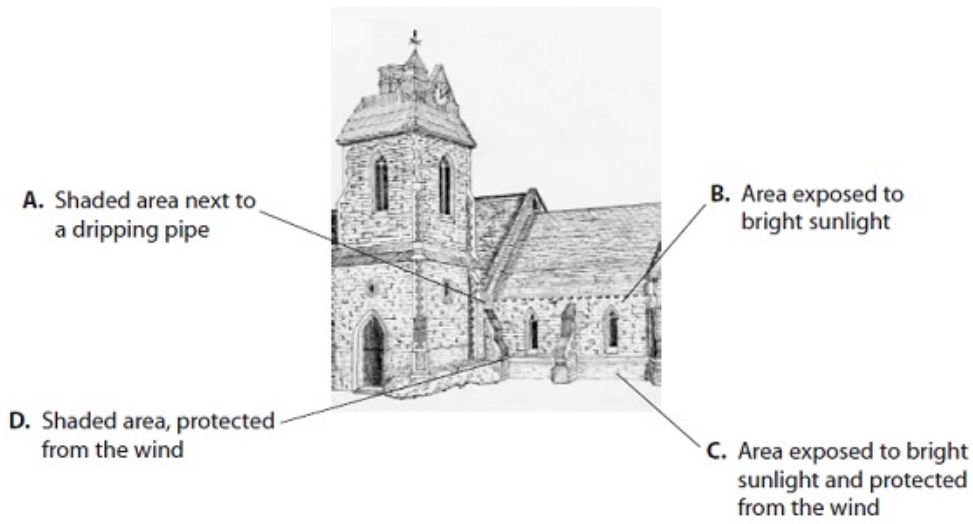
(i) Place a cross



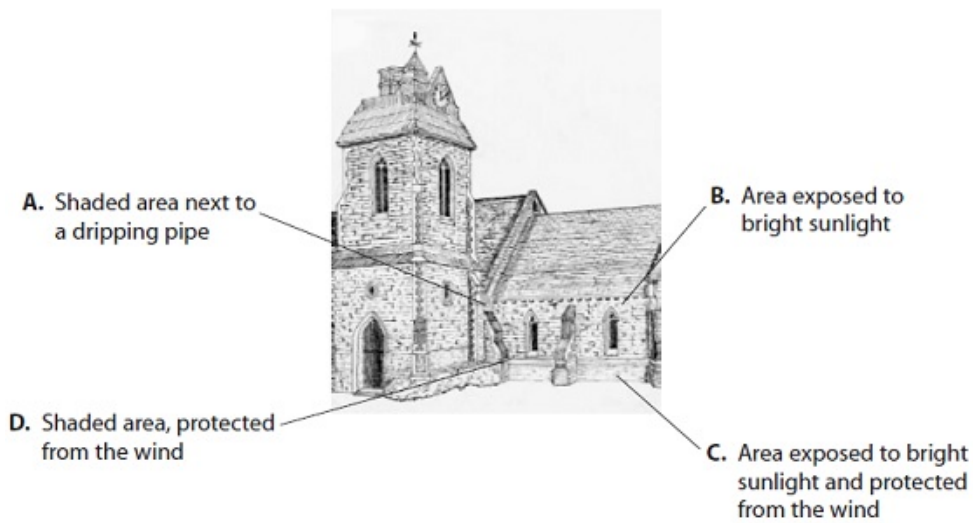
next to the position where the lichen is likely to be most abundant.

in the box

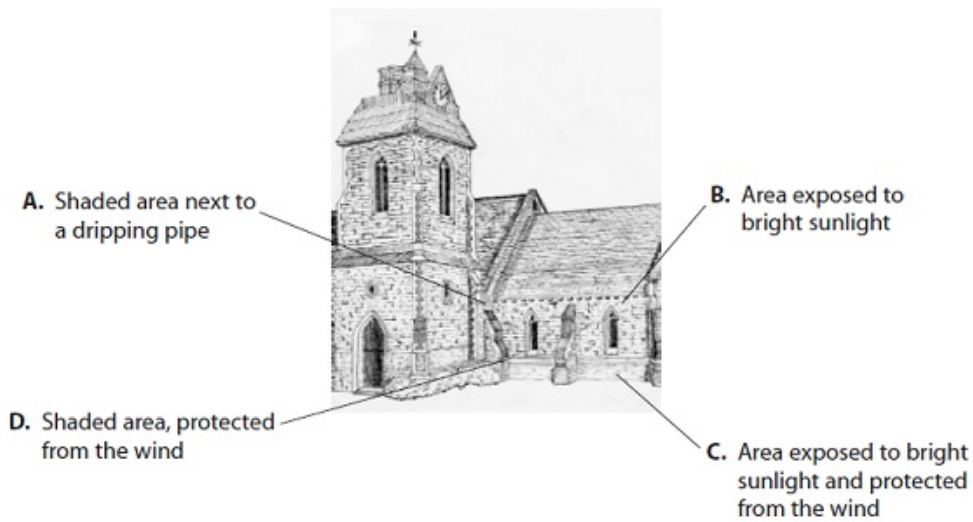
(1)



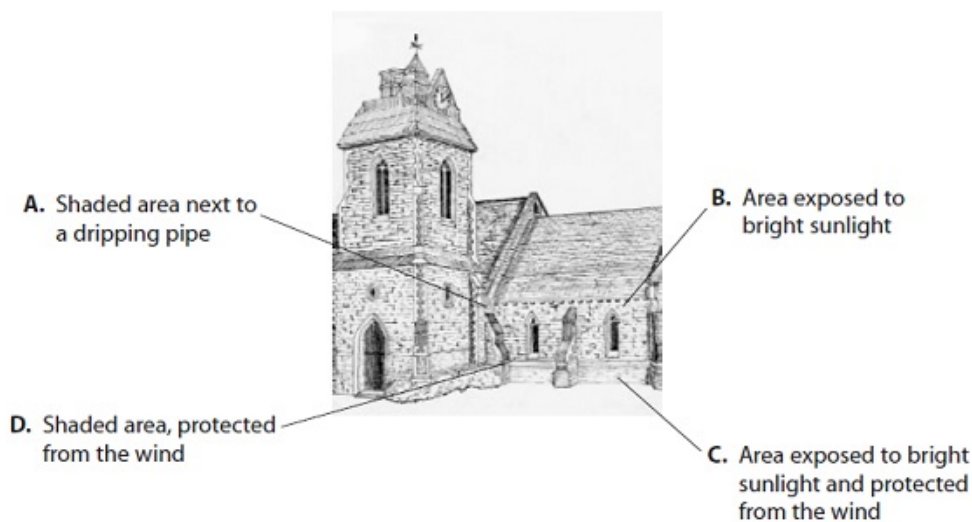
A



B



C



D

(ii) The abundance of lichen on the walls of this building can be measured by determining the percentage cover of lichen.

Suggest how the percentage cover of lichen could be determined.

(3)

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(iii) Explain how light intensity could be measured at the surface of the wall.

(2)

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(iv) Suggest how the data collected could be used to show whether there is a relationship between the abundance of lichen and light intensity.

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(Total for Question = 13 marks)

Q19.

Madagascar is an island rich in biodiversity.

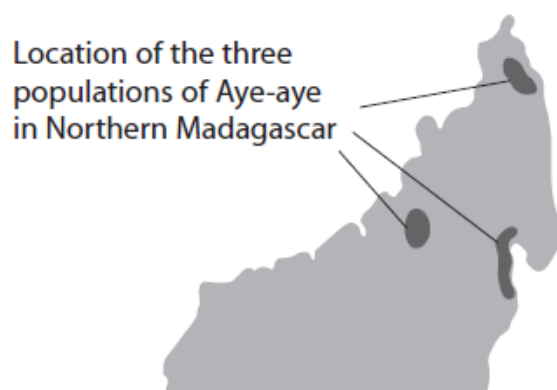
Lemurs are a diverse group of primates endemic to Madagascar.

Scientists suggest there may be as many as 100 different species of lemur.

One species of lemur, the Aye-aye, is found throughout the forests of Northern Madagascar.

Deforestation is taking place in this part of Madagascar.

Scientists have identified three separate populations of Aye-aye in this area, as shown on the map.



Explain how these three populations could become distinct species.

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Q20.

The scientific article you have studied is adapted from several sources.

Use the information from the scientific article and your own knowledge to answer the following questions.

Name one process that would have validated Pettersson's paper before it was published in the journal known as the Proceedings of the National Academy of Science (paragraph 58).

(1)

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(Total for question = 1 mark)

Q21.

The scientific article you have studied is adapted from *Scientific American*.

Use the information from the scientific article and your own knowledge to answer the following question.

Explain why natural selection took place in Darwin's Galapagos finches (paragraph 3).

(3)

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(Total for question = 3 marks)

Q22.

During the civil war in Mozambique, from 1977 to 1992, 90% of the African elephants were killed for the ivory in their tusks.

Since 1992, the elephant population in Mozambique has increased.

The photograph shows a group of elephants in Mozambique.

Elephant
without tusks



Elephant
with tusks

© ALEXANDER JOE/Staff/Getty Images

A study of an elephant population in Mozambique was carried out in 2017.

The elephants studied were all born before 1992.

The table shows the number of elephants with and without tusks.

Elephants	Number of elephants
with tusks	98
without tusks	102

In most African elephant populations, 2% to 4% of elephants do not grow tusks.

(i) Explain why the percentage of elephants without tusks in Mozambique will probably increase in the future.

(3)

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(ii) Describe how the Hardy-Weinberg equation can be used to provide evidence for changes in the elephant population in Mozambique.

(2)

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(Total for question = 5 marks)

Q23.

Climate change has been linked to the release of carbon dioxide from some power stations.

Net primary productivity (NPP) is a measure of the increase in biomass of a plant.

Explain why respiration affects the production of biomass.

(2)

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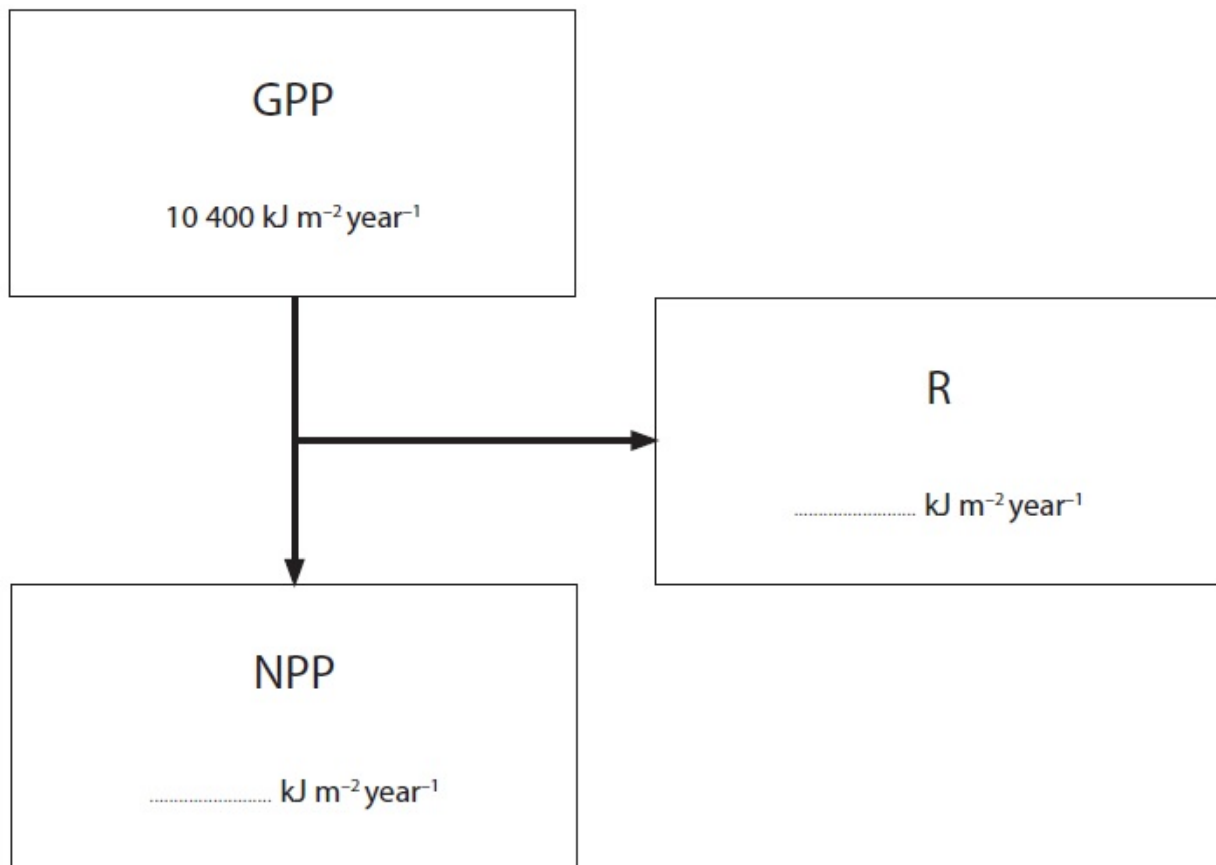
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(Total for question = 2 marks)

Q24. Farmers find it helpful to know the productivity of their land.

The diagram below shows the relationship between GPP (gross primary productivity), NPP (net primary productivity) and R (plant respiration) for an area of grassland.



(a) The efficiency of the transfer of energy from GPP to NPP for this grassland is 45%.

(i) Calculate the values for NPP and R. Write your answers in the diagram above.

(2)

(ii) Using the information given, explain the relationship between GPP and NPP.

(3)

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(b) Suggest why NPP values would be of use to a farmer who wanted to use this land for cattle.

(3)

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(c) The units ($\text{kJ m}^{-2} \text{ year}^{-1}$) used in the diagram show a rate of energy production. Suggest why this is more useful than measurements of biomass in the grassland on a particular day.

(2)

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(Total for Question = 10 marks)

There are two main types of woodland in the UK. One consists of broadleaved deciduous trees, the other contains coniferous trees that have needle-like leaves.

In a study of two woodlands, 11 species of plant were found in a deciduous woodland and 4 different species in a coniferous woodland.

The table shows the other data recorded in this study.

Factor	Deciduous woodland	Coniferous woodland
Mean light intensity 10 cm above soil level / lux	1075	543
Mean pH of soil	7	5
Mean air temperature 10 cm above soil level / °C	18	18
Mean soil moisture content (%)	45	47

Assess the reasons for the differences in the number of species between these two types of woodland.

(4)

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(Total for question = 4 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
(i)	An answer that makes reference to the following: treatment of seeds with sodium chloride or sodium chloride and gibberellin has no effect on the number of seeds that germinate (1)		(1)

Question number	Answer	Additional guidance	Mark																																																				
(ii)	Choose an item. - correct expected value calculated (1) $(O - E)^2$ values calculated (1) - Sum of $(O - E)^2$ values divided by expected value (1)	Example of calculation: = 42 36, 81 and 9 $126 \div 42 = 3$ ALLOW calculations based on E value of 48 or 50 <table> <tr> <th>Obs</th><th>Exp</th><th>$(O - E)^2$</th><th>$(O - E)^2/E$</th></tr> <tr> <td>48</td><td>42</td><td>36</td><td>0.857143</td></tr> <tr> <td>33</td><td>42</td><td>81</td><td>1.928571</td></tr> <tr> <td>45</td><td>42</td><td>9</td><td>0.214286</td></tr> <tr> <td></td><td></td><td></td><td>3</td></tr> </table> <table> <tr> <td>48</td><td>50</td><td>4</td><td>0.08</td></tr> <tr> <td>33</td><td>50</td><td>289</td><td>5.78</td></tr> <tr> <td>45</td><td>50</td><td>25</td><td>0.5</td></tr> <tr> <td></td><td></td><td></td><td>6.36</td></tr> </table> <table> <tr> <td>48</td><td>48</td><td>0</td><td>0</td></tr> <tr> <td>33</td><td>48</td><td>225</td><td>4.6875</td></tr> <tr> <td>45</td><td>48</td><td>9</td><td>0.1875</td></tr> <tr> <td></td><td></td><td></td><td>4.875</td></tr> </table> Correct answer with no working gains full marks	Obs	Exp	$(O - E)^2$	$(O - E)^2/E$	48	42	36	0.857143	33	42	81	1.928571	45	42	9	0.214286				3	48	50	4	0.08	33	50	289	5.78	45	50	25	0.5				6.36	48	48	0	0	33	48	225	4.6875	45	48	9	0.1875				4.875	(3)
Obs	Exp	$(O - E)^2$	$(O - E)^2/E$																																																				
48	42	36	0.857143																																																				
33	42	81	1.928571																																																				
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48	50	4	0.08																																																				
33	50	289	5.78																																																				
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33	48	225	4.6875																																																				
45	48	9	0.1875																																																				
			4.875																																																				

Question number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to the following: - calculated value is significant at $p = 0.05$ (1) - at 2 degrees of freedom (1)		(2)

Q2.

Question Number	Answer	Additional Guidance	Mark
(a)	(rate of) { energy incorporated into / production of / eq } {biomass / organic material} ; - in {plants / producers} ;	2. Accept from photosynthesis	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	- very little GPP in seagrass / majority present in {microphytobenthos and phytoplankton / phytoplankton} ; (roughly) equal distribution (of GPP) between microphytobenthos and phytoplankton ;	1. Accept only 2.5 to 5% in seagrass, 95% in micro and phyto, more than 50% or about 55% of phyto 2. Accept about 50% in each Accept idea that GPP in microphytobenthos is slightly lower than in phytoplankton	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	- idea of obtaining a value from the chart e.g. percentage, area, degrees, ratio ; - idea of how to use this to calculate GPP ;	Ignore units 1. Accept appropriate figures in range 50 – 55 % 2. Accept e.g. (percentage) multiplied by 8.4×10^6 NB $\frac{\text{angle} \times 840 \times 10^6}{360} = 2 \text{ marks}$ $\frac{\text{area of segment} \times 840 \times 10^6}{\text{area of circle}} = 2 \text{ marks}$	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	1. {more / fast / high / eq} photosynthesis ; 2. water less {cloudy / churned up } / shallow water / high light penetration / eq ; 3. high {nutrient / carbon dioxide} levels in the sea / eq ; 4. {high / optimum} temperatures ; 5. high light intensity (in this area) / eq ; 6. idea of less respiration ;	2. Accept less current, less tidal	(2)
Question Number	Answer	Additional Guidance	Mark
(c)	1. $NPP = GPP - R$ / eq ; 2. energy lost as heat / eq ; 3. named use of energy (released by respiration);	1. Accept correct description in words 3. Accept e.g. movement, opening of flowers, glycolysis, metabolic processes	(2)

Q3.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to three of the following - because plants produce {organic compounds/biomass} from photosynthesis (1) - plants remove carbon dioxide (from the atmosphere) (1) - because animals produce (more) carbon dioxide by respiration (1) - because (some) animals produce methane (1)	ALLOW named biological molecule e.g. starch, sugar ALLOW plants are carbon neutral ALLOW converse for plants	Expert (3)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to the following • (deforestation cuts down) trees which are carbon sinks (1) • {burning / decomposition} of these trees releases carbon dioxide into the atmosphere (1) • without trees there is {less/no} photosynthesis to remove carbon dioxide (from the atmosphere) (1)	ALLOW trees are stores of carbon	Expert (3)

Q4.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to four of the following: • select two fields with similar {pests / abiotic} factors (1) • spray one field with a high concentration of pesticide and one with the {minimum / low} concentration of pesticide (1) • using a random sampling method to count pests in each field (1) • repeat sampling over a period of time (1) • description of how results would demonstrate competitive release (1)	ALLOW select patients with similar {cancer / tumours} ALLOW different doses of chemotherapy or cancer-treating drugs ALLOW measurement of size of tumour e.g. if number of pests in field sprayed with high concentration of pesticide show greater number of pests then it will prove the effect of competitive release OR If the cancer responds better to low dose of drugs proves competitive release	Expert (4)

Question number	Answer	Additional guidance	Mark
	A description that makes reference to four of the following: • suitable study group selected (1) • treat one group with high dose and a second group with {minimum / lower} dose (1) • suitable sampling method (1) • repeat sampling over a period of time (1) • description of how results would demonstrate competitive release (1)	e.g. (two) groups of patients with same cancer (two) similar fields (two) flasks of bacteria e.g. chemotherapy agent pesticide antibiotic e.g. scanning random quadrats zones of inhibition e.g. (demonstrates competitive release if eventually) number of pests in field sprayed with high concentration of pesticide greater than number in field sprayed with lower concentration the cancer responds better to low dose of drugs than high dose only the low dose treated group remain sensitive to the antibiotic	Expert (4)

Q5.

Question Number	Answer	Mark
	B light-independent reaction	(1)

Q6.

Question Number	Answer	Mark
(i)	C – humidity <i>The only correct answer is C</i> A is not correct because resistance to infection is a biotic factor B is not correct because pathogens are biotic factors D is not correct because ocean pH is an abiotic factor but not one relevant to plants and their pathogens	(1)

Question Number	Answer	Mark
(ii)	B – global warming <i>The only correct answer is B</i> A is not correct because increase CO₂ to 1080 ppm does not decrease photosynthesis C is not correct because increased CO₂ to 1080 ppm does not increase plant respiration D is not correct because increased CO₂ to 1080 ppm does not cause ozone depletion	(1)

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following - carbon dioxide (is a greenhouse gas and) causes global warming - a relevant description of a change in the distribution of ash trees (with increasing CO₂ concentrations) (because increased CO₂) would result in a change in the range for <i>H. fraxineus</i> (1) - and ash trees will be found in regions without <i>H. fraxineus</i> - change in range of { <i>H. fraxineus</i> / ash trees } linked to a relevant aspect of climate change	e.g. an increase to 430 ppm leads to more ash trees in the east or an increase to 1080 ppm leads to more ash trees in the north e.g. temperature increase, change in humidity, change in rainfall patterns	(5)

Question Number	Answer	Additional Guidance	Mark
	reaction A = phosphorylation ; reaction B = hydrolysis ;		(2)

Q8.

Question Number	Answer	Additional Guidance	Mark
	B carbon dioxide and water		(1)

Q9.

Question Number	Answer	Mark
	C $\text{kJ m}^{-2} \text{year}^{-1}$	(1)

Q10.

Question Number	Answer	Mark
(i)	The only correct answer is D thylakoids <i>A is not correct because the cristae are not found in the chloroplast</i> <i>B is not correct because the matrix is not found in the chloroplast</i> <i>C is not correct because the stroma is not the site of the light-dependent reactions</i>	(1)

Question Number	Answer	Mark
(ii)	The only correct answer is D reduced NADP, ATP and oxygen <i>A is not correct because carbon dioxide is not a product of photosynthesis</i> <i>B is not correct because glucose is the end product of the light independent reactions</i> <i>C is not correct because reduced NAD is not a product of the light-dependent reactions</i>	(1)

Question Number	Answer	Mark
(iii)	The only correct answer is D water <i>A is not correct because glucose is not the source of hydrogen in the light-dependent reactions</i> <i>B is not correct because reduced NAD is not the source of hydrogen in the light-dependent reactions</i> <i>C is not correct because reduced NADP not the source of hydrogen in the light-dependent reactions</i>	(1)

Q11.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to four of the following • fewer seeds will lead to a decrease in the plant population(1) • fewer seeds means that there is less {food / energy} (1) • lipids and carbohydrates contain (large amounts) of stored energy(1) • the monkeys will not be able to generate enough heat to survive the cold winters(1) • the monkey population will decrease in size (1)	ALLOW lipids needed for insulation/less respiration to generate heat	(4)

Q12.

Question Number	Answer
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • standardisation of composition of compost heaps • identification of species • abundance of each species of organism in the sample • determination of C:N / set up compost heaps with different C:N ratios • time e.g. days / intervals / repetition of sampling • other factors to monitor or control e.g. water / gases / humidity / temperature / aeration / mass • sampling technique e.g. location of sample within compost heap / repetition of sampling

Level	Mark	Descriptor	
0	Marks	No awardable content	
Level 1	1-2	An explanation of how the investigation should be modified may be attempted but with limited analysis, interpretation and/or evaluation of the scientific information. Generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Measure / set up compost heaps with different C:N ratios Observe species present over time
Level 2	3-4	An explanation of how the investigation should be modified will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Recording species present / numbers of each species / measuring C:N ratio Monitoring changes over time Control of relevant factors
Level 3	5-6	An explanation of how the investigation should be modified is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured.	Description of a suitable sampling technique Linking species present or species density to C:N measurements Use of a statistical test to compare changes of time / C:N ratio Use information on numbers of species and population sizes to demonstrate succession

Q13.

Question Number	Answer	Additional guidance	Mark
	An answer the makes reference to four of the following: • use pH buffers at a range of pH values below 7 (1) • provide an excess of ATP (1) • (use) F-6-P at an appropriate concentration (1) • suitable variable controlled (1) • measure quantity of F-2,6-BP produced per unit time (1)	e.g. 2 mmol dm⁻³ (values between 1 and 2.5 mmol dm⁻³) e.g. {enzyme / phosphofructokinase } concentration / temperature ALLOW measure change in concentration of F-2,6-BP / phosphate incorporated	(4)

Q14.

Question Number	Answer	Additional guidance	Mark
	An answer the makes reference to five of the following: • description of how temperature will be controlled (1) • identification of another appropriate abiotic factor to control (1) • provide nutrients (for cells) (1) • use of aseptic technique (to prevent contamination of cell culture) (1) • culture for a stated period of time (1) • description of method of measuring growth (1)	e.g. set temperatures using a {water bath / incubator} e.g. pH / humidity/ carbon dioxide concentration / oxygen concentration ALLOW description of aseptic technique ALLOW times greater than 2 hours ALLOW culture at each temperature for the same period of time ALLOW e.g. measure {mass / number / area} of cells at beginning and end of culture	(5)

Q15.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(i)	An answer that makes reference to the following: • {cold / buffered} to stop enzyme denaturation (1) • sucrose to stop osmotic loss of water from chloroplasts (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(ii)	• tube 3 is a control to show DCPIP does not change colour over time (1)		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(iii)	An explanation that makes reference to the following: • set up tubes identical to tube 1 so that chloroplasts are available (1) • set up several tubes to ensure data is reliable (1) • tubes exposed to light of different wavelengths for same time because time affects number of electrons released / tubes exposed to light of same intensity because intensity affects number of electrons released (1) • use a colorimeter with a red filter to measure absorbance (1)		(4)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(i)	C		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(ii)	A		(1)

Q16.

Question Number	Answer	Additional Guidance	Mark
(i)	• (symmetrical) bell-shaped curve drawn (1)		(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	• specimen 7 = 1.277 AND $\Sigma x_1^2 = 12.198$ (1)		(1)

Question Number	Answer	Additional Guidance	Mark
(iii)	• Top line of formula correctly calculated (1) • correct answer to two significance figures (1)	<u>Example of calculation</u> 9.055 – 9.006 = 0.0054 / 0.00544 / 5.4×10^{-3}	(2)

Question Number	Answer	Additional Guidance	Mark
(iv)	- top line of formula correctly calculated (1) - bottom line of formula correctly calculated (1) - correct answer to between three and five significant figures (1)	<u>Example of calculation</u> 0.153 0.0336 (OR 0.0337 if 0.00544 used) = 4.55 (OR 4.54 if 0.00544 used) ALLOW answer between 4.5510 and 4.5540 Correct answer with no working gains full marks	(3)

Question Number	Answer	Additional Guidance	Mark
(v)	An explanation that makes reference to the following: - there was a significant difference between {the 3% and the 5% salt solution / groups} (1) - at the 5% significance level (1)	IGNORE significant correlation / significant relationship ALLOW 95% probability there is a difference e.g. '5% chance that the difference is due to chance' or with 95% certainty' IGNORE $p = 0.05$	(2)

Q17.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: thylakoid membrane / grana / granum (1)	ALLOW phonetic spelling ALLOW lamella	(1)

Q18.

Question Number	Answer	Additional Guidance	Mark
(a)	C ; nucleus and large (80S) ribosomes		(1)

Question Number	Answer	Additional Guidance	Mark
(b)	A ; algae have chloroplasts, the fungi do not		(1)

Question Number	Answer	Additional Guidance	Mark
(c)	1. (advantage of sexual reproduction / meiosis) {genetically different / greater gene pool / greater genetic diversity /eq} ; 2. (advantage of asexual reproduction / mitosis) faster / one of each organism needed / conserves advantageous alleles ;	2. Accept don't need a mate	(2)

Question Number	Answer	Additional Guidance	Mark
(d)(i)	C ; area exposed to bright sunlight and protected from the wind		(1)

Question Number	Answer	Additional Guidance	Mark
(d)(ii)	1. idea of using a quadrat ; 2. idea of {random / systematic} sampling (of wall) ; 3. {count number of squares/ determine area} containing lichen /eq ; 4. credit an indication of how the percentage was calculated ;	1. Accept description of quadrat, use of photo and a grid 3. NB reference to measuring percentage cover only is too vague as it is repeating stem of question	(3)

Question Number	Answer	Additional Guidance	Mark
(d)(iii)	1. ref to use of light {probe / sensor /eq} ; 2. idea of taking several measurements ;	1 Accept description of a light sensor 2. Accept ref to places or times of day	(2)

Question Number	Answer	Additional Guidance	Mark
(d)(iv)	1. plot a (scatter) graph of light intensity against lichen / eq ; 2. reference to looking for a correlation ; 3. reference to use of statistics test ; 4. appropriate named test eg Spearman's rank, Pearson ;	2. Accept ref to line of best fit, ref to correlation coefficient also gets Mp 3	(3)

Q19.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: - deforestation results in (geographical) isolation of the populations of Aye-ayes (1) - resulting in reduced gene flow between the populations (1) - different selection pressures leading to natural selection (1) - leading to sympatric speciation (1)		(3)

Q20.

Question Number	Answer	Additional Guidance	Mark
	peer review (1)	ALLOW reviewed by other scientists IGNORE peer assessment	(1)

Q21.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: • there was isolation of (populations) of finches (1) • there were different selection pressures (at the different locations) (1) • (different / random) mutations in (different) populations of finches (1) • therefore allowing populations to adapt to different selection pressures (1)	ALLOW finches in different locations ALLOW different food sources act as a selection pressure ALLOW different beak shapes due to mutations DO NOT ALLOW selection pressures caused mutations ALLOW finches with better adapted beaks passed on their (favourable) alleles resulting in a change in the {allele frequency / gene pool}	Expert (3)

Q22.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to three of the following • many of the elephants with tusks were killed (for their ivory) / large percentage of population do not have tusks (1) • elephants without tusks were more likely to survive and breed (1) • therefore passing on alleles for not having tusks (1) • increasing the frequency of homozygous recessives in the population (1)	ALLOW converse	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	A description that makes reference to the following - calculate the {allele frequencies/ number of dominant and recessive alleles} (in the population in Mozambique) (1) (regular) sampling over a period of time (1)		(2)

Q23.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to two of the following: - GPP – R = NPP (1) {organic molecules / glucose} used in respiration to provide energy (1) - because the more {organic molecules / glucose} used in respiration, the less is available for the production of biomass (1)	ALLOW word equation or rearranged equation ALLOW more respiration results in less biomass	(2)

Q24.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	NPP = 4680 ; R = 5720 ;	NB If there are no answers in the box, look for answers in the space below question If answers are the wrong way round, award 1 mark If both answers are wrong, accept R = 10168.9 / 10169	(2)

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	1. $\text{NPP} = \text{GPP} - \text{R}$ / eq; 2. 55% (GPP energy) is lost / eq ; 3. energy lost as heat / eq ; 4. to provide energy for {active transport / any other named energy-requiring process} ; 5. NPP is {(stored) energy / energy available for next trophic level / eq} ;	Accept correct description in words eg movement (opening of flowers, turning of leaves), glycolysis Ignore idea that energy is used for respiration unqualified Accept biomass	(3)

Question Number	Answer	Additional Guidance	Mark
(b)	1. cattle {are primary consumers / herbivores / eat grass / eat plants / eq} ; 2. (therefore) gain energy (available as NPP) ; 3. idea of grazing capacity of the grassland ; 4. idea of affect on yield of {meat / milk / eq} ; 5. idea of changing to a more {efficient / NPP yielding} crop ;	Accept idea that farmer is ensuring that there is enough NPP available for his cattle Accept growth rate	(3)

Question Number	Answer	Additional Guidance	Mark
(c)	1. idea of variation over short periods of time; 2. idea that whole year gives an {average / overall / eq} value ; 3. idea that biomass includes {all / undigestible / inedible / eq} organic material ; 4. idea that rate of productivity may influence how much grazing is possible ;	eg more NPP on a sunny day, seasonal	(2)

Q25.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to four of the following points • (difference in number of species) not due to temperature and soil moisture content as they are the {same/similar} in the two woodlands (1) • the light intensity is the most likely reason for the greater number of species as it is higher in the deciduous woodland (1) • description of the effect of light intensity on plant growth (1) • the pH of the soil in the coniferous woodland is acidic so this may also reduce the number of species found (1) • only plant species considered and not other organisms (1)	e.g. high light intensity allows a greater rate of photosynthesis / more photosynthesis or plants need to be adapted to low light intensities	(4)

Q1.

The scientific article you have studied is adapted from an article from '*The Scientist*'.

Use the information from the scientific article and your own knowledge to answer the following questions.

Explain why the 'anaerobic oxidation of methane' could be a 'key climate regulator' (paragraph 2).

(3)

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(Total for question = 3 marks)

Q2.

The genomes of some species of cichlid fish have been sequenced and analysed.

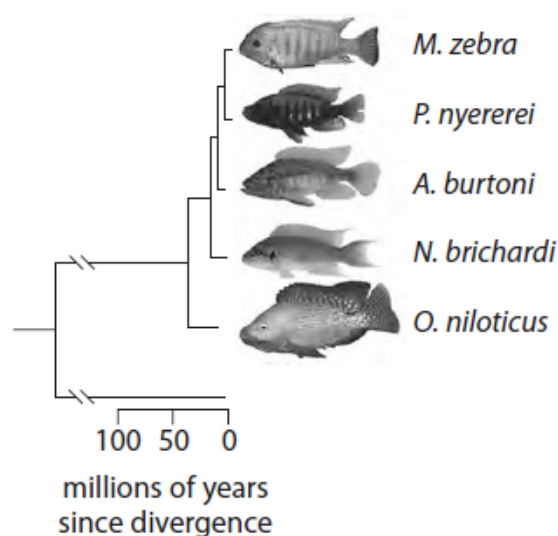
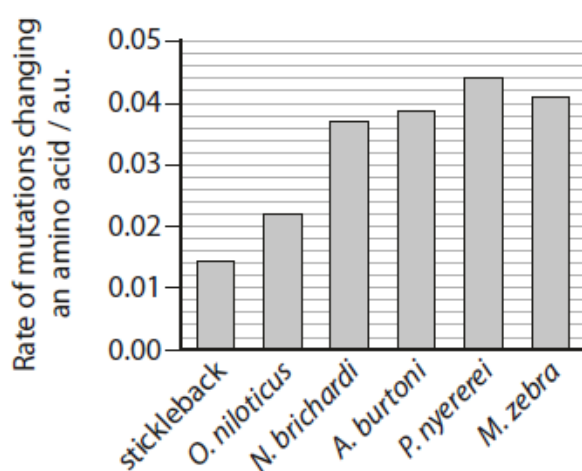
The data collected included:

- the rate at which genes have been duplicated to produce additional copies of genes on a chromosome
- the frequency of mutations in transcription factor binding sites
- the rate of mutations that result in a change of an amino acid in a protein.

This information was used to produce a phylogenetic tree.

A comparison was made with a stickleback, which is a slowly evolving fish.

Speed of evolution	Fish	Rate of gene duplication / a.u.	Number of mutations in transcription factor binding sites (compared to <i>O. niloticus</i>)
Rapidly evolving cichlid fish	<i>O. niloticus</i>	45	0
	<i>N. brichardi</i>	45	214
	<i>A. burtoni</i>	55	140
	<i>P. nyererei</i>	45	129
	<i>M. zebra</i>	60	142
Slowly evolving fish	stickleback	10	0



Analyse all the data provided to discuss how several species of cichlid fish have evolved over a short period of time.

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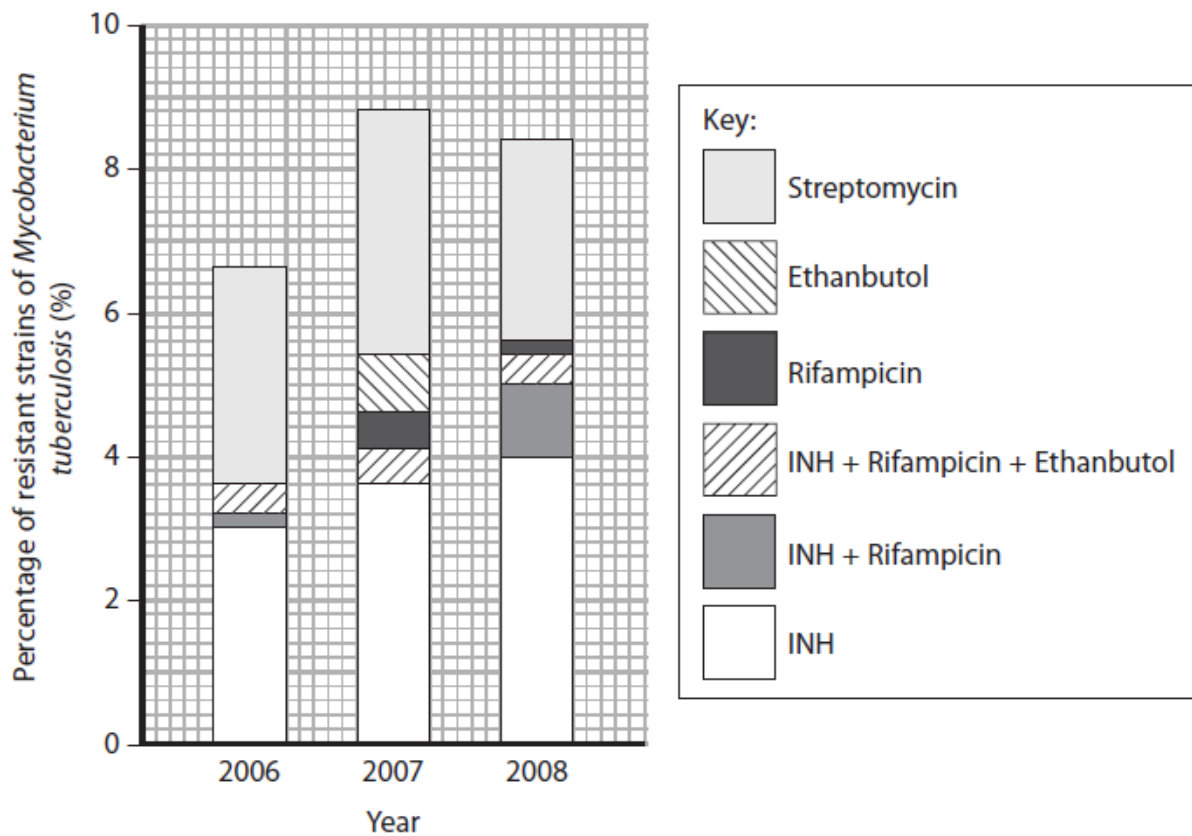
(Total for question = 9 marks)

Q3.

Treating *Mycobacterium tuberculosis* infections can be a problem, as the bacteria are resistant to many antibiotics.

There are many strains of *Mycobacterium tuberculosis*. Different strains are resistant to different antibiotics or combinations of antibiotics.

The chart below shows the percentage of resistant strains of *Mycobacterium tuberculosis* to six different antibiotics, or combinations of antibiotics, in 2006, 2007 and 2008.



(i) Using the information in the graph, compare the types of antibiotics and combinations of antibiotics that the *Mycobacterium tuberculosis* are resistant to in 2006 with 2007.

(3)

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(ii) The percentage of strains of *Mycobacterium tuberculosis* resistant to the antibiotic INH has increased during these three years.

Suggest how natural selection could have resulted in this increase.

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(iii) Suggest how hospitals could prevent an increase in the percentage of strains of *Mycobacterium tuberculosis* resistant to antibiotics.

(2)

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Q4.

Crustose coralline algae are a group of photosynthetic red algae that play an important role in the formation of coral reefs.

These algae deposit calcium carbonate in their cell walls to form encrusting and rock-like structures.

(a) (i) Write an expression that describes net productivity.

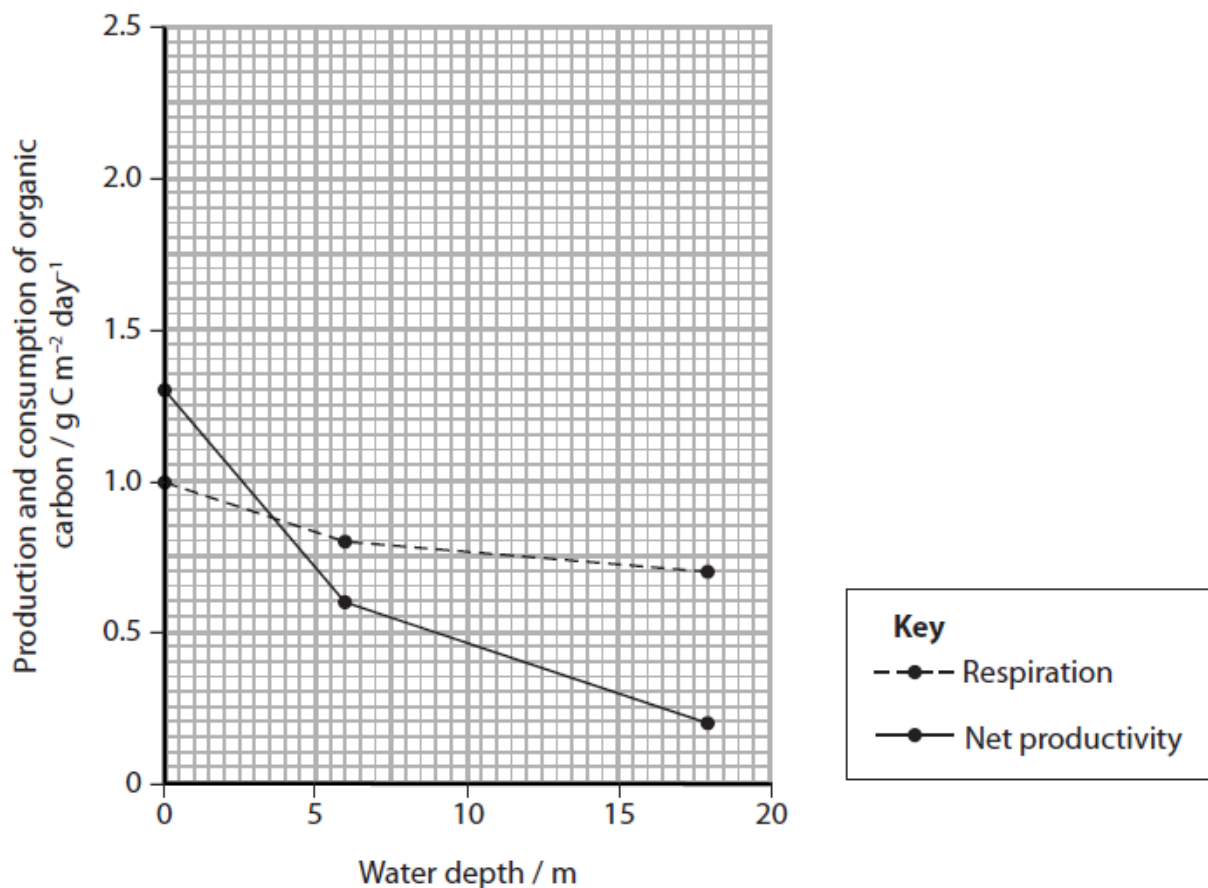
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(1)

(ii) The graph shows net productivity and respiration for one species of crustose coralline algae found at different water depths.



On the graph, plot the gross productivity for this species.

(1)

(iii) Analyse the data to explain the effect of water depth on net productivity.

(3)

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*(b) Scientists investigated the effect of water temperature and carbon dioxide concentration on the growth of one species of crustose coralline algae.

The growth was measured by recording the percentage cover of the algae on a surface.

The results of this investigation are shown in the table.

Growth conditions		Percentage cover (%)
Temperature / °C	CO ₂ concentration / ppm	
17	400	100
17	700	70
20	400	100
20	700	35

The normal temperature and carbon dioxide concentration in the natural habitat of this species are 17°C and 400 ppm CO₂.

Analyse the data in the graph and the table to assess the possible impact of the continued burning of fossil fuels on crustose coralline algae.

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(Total for question = 11 marks)

Q5.

Anthropogenic activities are contributing to global warming.

Scientists from the IPCC (Intergovernmental Panel on Climate Change) say that changes to diet can have a major impact on greenhouse gas emissions. The method of farming affects the level of impact.

The Paris Agreement of 2015 committed countries to reduce carbon emissions.

How many of the following statements about global warming are correct?

(1)

- global warming is caused by a reduction in greenhouse gases
- deforestation may contribute to global warming
- global warming is leading to the melting of sea ice
- global warming may lead to a change in rainfall patterns
- global warming is affecting only the ice caps

- ☐ **A** 2
- ☐ **B** 3
- ☐ **C** 4
- ☐ **D** 5

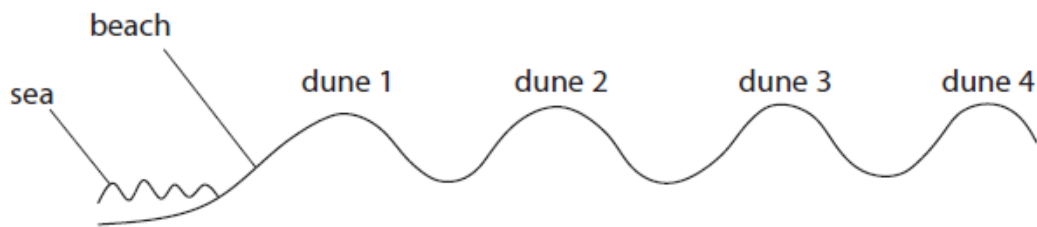
(Total for question = 1 mark)

Q6.

Sand dunes are a habitat that can often be found by the edge of the sea.

An investigation was carried out to study the variety of plant species found on sand dunes.

Four adjacent sand dunes from the sea to further inland were selected, as shown in the diagram.



Each species of plant present on dune 1 was recorded along with the total number of each species of plant present. This was repeated for dunes 2, 3 and 4 and the results are shown in the table.

Plant species	Number of each plant species present			
	dune 1	dune 2	dune 3	dune 4
A	169	9	0	0
B	5	123	19	0
C	0	0	126	182
D	1	44	0	0
E	0	0	5	2
F	0	0	20	10
G	0	0	86	35
H	0	0	0	62
I	0	0	32	17
J	0	0	0	119

Devise a procedure that you could use to find out if the percentage cover of species B is different on the tops of dunes than in between the dunes.

(5)

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Q7.

Scientists are concerned that climate change may be affecting the Arctic environment and the polar bears that live there.

Birds, such as barnacle geese, use the land on Spitsbergen as nesting sites.

Polar bears usually hunt for seals from sea ice. They have also been seen feeding on eggs from barnacle geese nests.

Assess the relationship between the presence of sea ice and the number of eggs taken by polar bears since 2000.

(4)

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(Total for question = 4 marks)

Q8.

Lipids and carbohydrates are found in both plants and animals.

The carbohydrate content of vegetables ranges from 3 to 35%. However, meat contains little to no carbohydrate. Milk is the only food source from animals that contains a significant amount of carbohydrate.

Although plant material contains a higher proportion of carbohydrate than animal tissues, it has been claimed that carbohydrates are more important to animals than they are to plants.

Assess the relative importance of carbohydrates to plants and animals.

(9)

[illegible]

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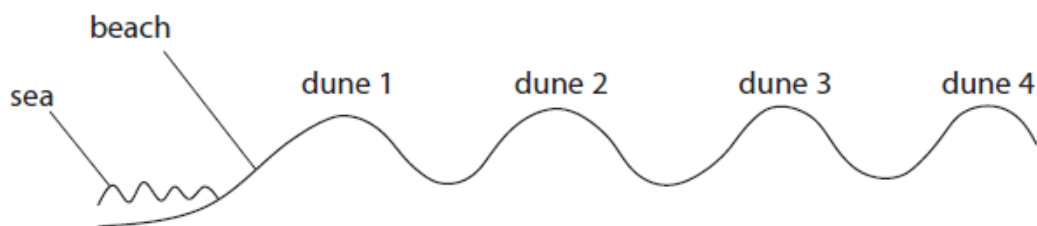
(Total for question = 9 marks)

Q9.

Sand dunes are a habitat that can often be found by the edge of the sea.

An investigation was carried out to study the variety of plant species found on sand dunes.

Four adjacent sand dunes from the sea to further inland were selected, as shown in the diagram.



Each species of plant present on dune 1 was recorded along with the total number of each species of plant present. This was repeated for dunes 2, 3 and 4 and the results are shown in the table.

Plant species	Number of each plant species present			
	dune 1	dune 2	dune 3	dune 4
A	169	9	0	0
B	5	123	19	0
C	0	0	126	182
D	1	44	0	0
E	0	0	5	2
F	0	0	20	10
G	0	0	86	35
H	0	0	0	62
I	0	0	32	17
J	0	0	0	119

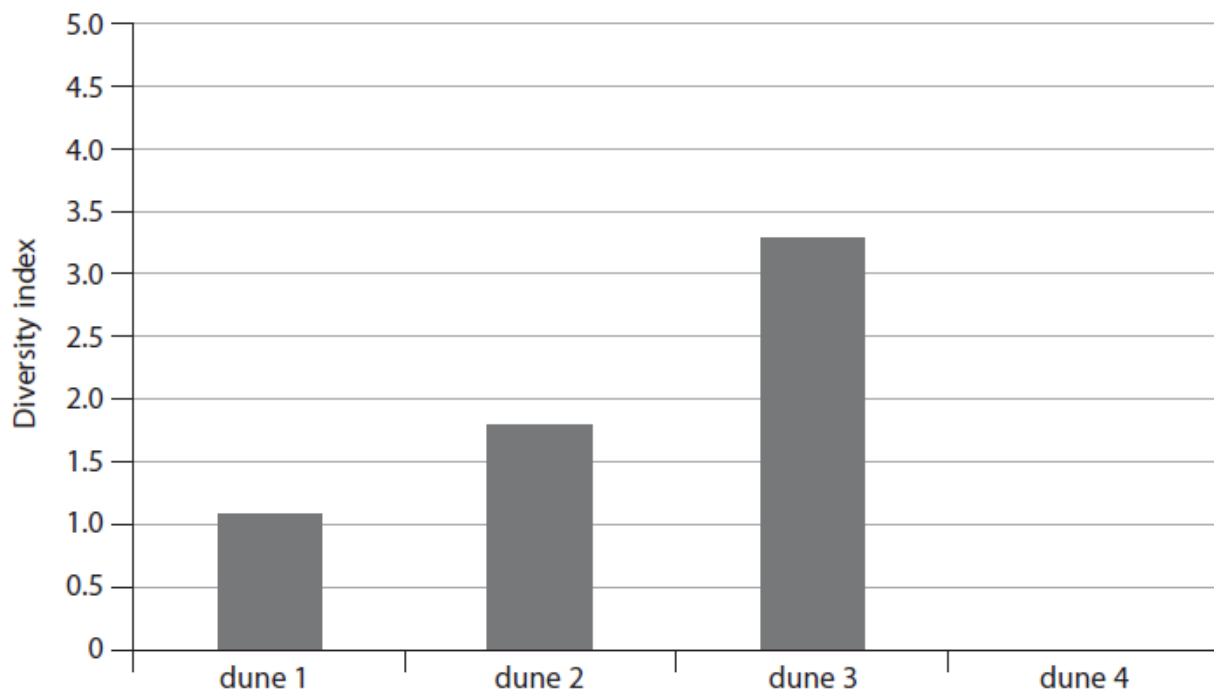
(i) The diversity index was calculated for dunes 1, 2 and 3 using this equation.

$$\text{Diversity index } (D) = \frac{N(N-1)}{\sum n(n-1)}$$

Where N is the total number of all individuals of all species in each dune. Use the table and diversity index equation to calculate the diversity index for dune 4.

Plot your answer on the bar chart.

(3)



(ii) Explain how the data demonstrate the process of succession.

(5)

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Q10. The carbon cycle describes the movement of carbon within an ecosystem.

In this cycle, carbon neutral processes do not change the concentration of carbon dioxide in the atmosphere.

The table below shows the main sources and combustion products of some fuels.

Fuel	Main sources	Main combustion products
Biodiesel	Oils from crops such as soya beans, rape seeds, palm seeds	Carbon dioxide and water vapour
Ethanol	Fermented sugars from crops such as sugar cane, sugar beet	Carbon dioxide and water vapour
Hydrogen	Catalysis of methane from fossil deposits or biogas generation using waste biomass	Water vapour
Methane	Extracted from fossil deposits or biogas generation using waste biomass	Carbon dioxide and water vapour
Propane	Refining of crude oil from fossil deposits	Carbon dioxide and water vapour

(a) Place a cross ☒ in the box next to the names of the four fuels, shown in the table, that could be considered to be biofuels.

(1)

- ☐ **A** biodiesel, ethanol, hydrogen, methane
- ☐ **B** biodiesel, ethanol, hydrogen, propane
- ☐ **C** biodiesel, ethanol, methane, propane
- ☐ **D** biodiesel, hydrogen, methane, propane

*(b) Large areas of land may need to be cleared in order to produce biofuels. This might involve deforestation.

Discuss why the production of biofuels may not be carbon neutral.

(5)

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(c) Explain how the combustion products, from the burning of fuels, may lead to global warming.

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(Total for Question = 10 marks)

Q11.

First generation biofuels are made from sugars and vegetable oils found in food crops.

(a) Some countries are replacing small percentages of petrol and diesel with first generation biofuels to reduce the effect of greenhouse gases on global warming.

(i) Place a cross ☒ in the box next to a pair of greenhouse gases.

(1)

- ☐ **A** carbon dioxide and methane
- ☐ **B** carbon dioxide and carbon monoxide
- ☐ **C** carbon monoxide and nitrogen
- ☐ **D** methane and nitrogen

(ii) Suggest why using first generation biofuels instead of petrol and diesel could reduce global warming.

(3)

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(b) Second generation biofuels are now being developed. These will use non-food parts of crops that contain the polymers cellulose and lignin.

Bacteria can be used to synthesise ethanol from these polymers. However, enzyme treatment is necessary before the bacteria can use these polymers.

(i) Name a part of a plant stem that would contain these polymers.

(1)

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(ii) Suggest why cellulose has to be treated with enzymes before the bacteria can use it as an energy source.

(2)

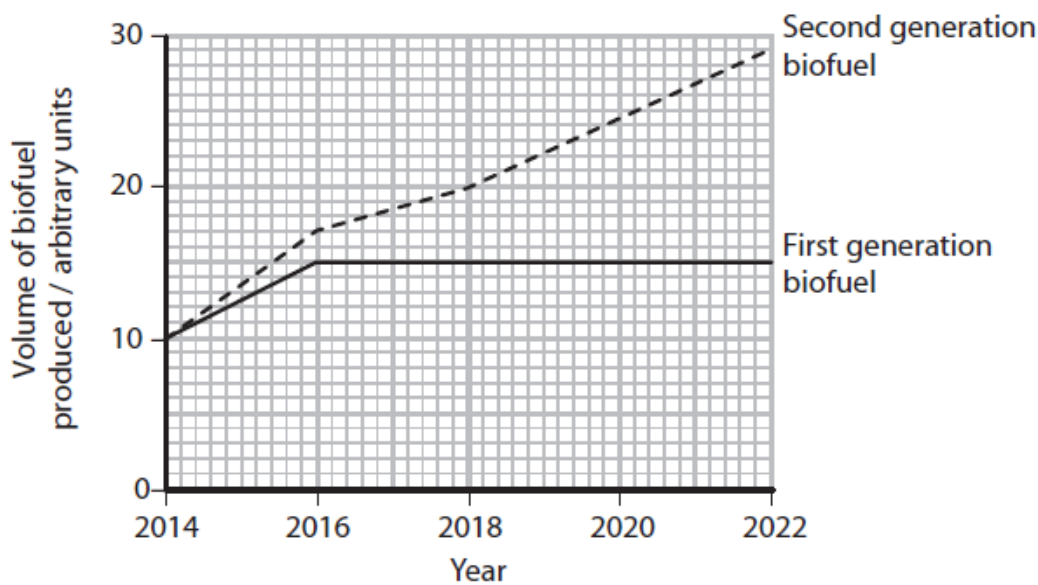
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(c) The graph below shows how the global production of first generation and second generation biofuels could change in the future.



Using the information in the graph, describe the expected changes in the production of first generation and second generation biofuels. Suggest reasons for these changes.

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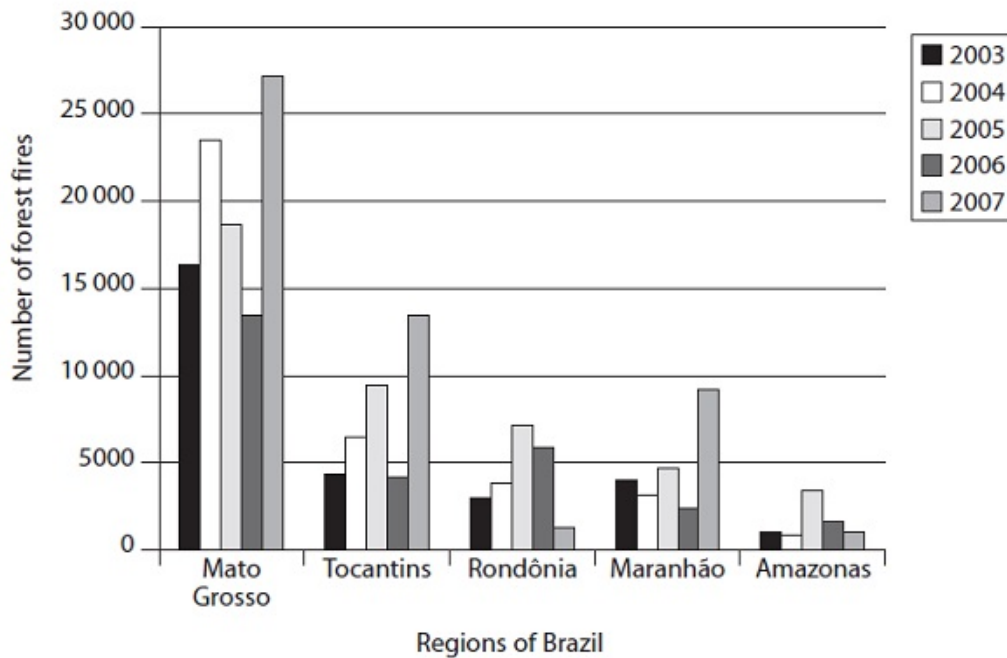
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(Total for question = 11 marks)

Q12. Global warming is a worldwide problem that affects climate and the environment.

(a) The graph below shows the number of forest fires in five regions of Brazil, for 2003 to 2007.



(i) Place a cross ☒ in the box next to the best conclusion that can be drawn from these results about the number of forest fires in Brazil.

(1)

- ☒ **A** The number of forest fires has generally decreased
- ☒ **B** The number of forest fires has generally increased
- ☒ **C** The number of forest fires in Mato Grosso each year is always higher than in other areas
- ☒ **D** There are no clear trends

*(ii) Explain how forest fires may lead to global warming.

(5)

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(b) (i) Explain why the use of biofuels may help to reduce global warming.

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(ii) Explain **one** disadvantage of using biofuels to reduce global warming.

(2)

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(Total for Question = 11 marks)

Q13.

Biofuels are being developed to reduce the effect of greenhouse gases on global warming.

(a) The list below shows some of the gases found in the atmosphere:

- carbon dioxide
- helium
- methane

- nitrogen
- oxygen

Place a cross ☒ in the box next to the number of greenhouse gases in this list.

(1)

☐ **A** 1

☐ **B** 2

☐ **C** 3

☐ **D** 4

(b) Biofuels are produced from crop plants.

Bioethanols are produced from carbohydrates, such as corn starch and sugar.

Biodiesels are produced from lipids, such as soybean oil and rapeseed oil.

(i) Describe the structure of lipids.

(2)

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(ii) The table below gives some information about the **production** of biofuels from four different crop plants.

Crop plant	Carbon dioxide emissions from the production of biofuels / kg per MJ of energy produced	Level of resources used in production of biofuels		
		water	fertilisers	pesticides
Corn	81 to 85	High	High	High
Sugar cane	4 to 12	Medium to low	High	Medium
Soy	49	High	Low to medium	Medium
Rape	37	High	Medium	Medium

Using the information in the table, discuss the advantages of producing biodiesels instead of bioethanols.

(3)

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(iii) Fertilisers contain inorganic ions. Name **three** inorganic ions that could be contained in the fertilisers and explain how these would improve the yield of the crop plants.

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(Total for question = 10 marks)

Q14.

Forests are important habitats.

The effect of cutting down trees on the number of bird species observed in two different forest habitats was investigated.

(i) Give two biotic factors, other than cutting down trees, that could affect the number of bird species observed in a forest.

(2)

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(ii) Some of the results of the investigation are shown in the table.

Forest	Number of bird species in areas of the forest where no trees are cut down	Number of bird species in areas of the forest where some trees are cut down
A	35	19
B	16	10

Calculate the Chi-squared value (χ^2) for forest B using the formula shown.

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

(3)

Answer

(iii) The table gives some critical values for the Chi-squared test.

Probability level	Critical value
0.05	3.84
0.01	6.64
0.001	10.83

The Chi-squared value for forest A is 4.74.

Deduce the effect of some trees being cut down on the number of species of birds in these two forests.

(2)

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(Total for question = 7 marks)

Q15.

Anthropogenic climate change is linked to an increase in carbon dioxide in the atmosphere. The World Meteorological Association recorded carbon dioxide levels of 405 ppm in 2017. This is an increase of 46% since 1817. Calculate the level of carbon dioxide in 1817.

(2)

..... ppm

(Total for question = 2 marks)

Q16.

A student investigated the effect of salt concentration on the growth of one species of brine shrimp.

The student placed 100 shrimp eggs in a beaker containing 1dm^3 of 3% salt solution. Three days after the eggs hatched, 10 shrimps were collected and their lengths measured. Seven days after hatching, another 10 shrimps were collected and their lengths measured.

The procedure was repeated using a 5% salt solution. All other variables were kept constant.

The results are shown in the table.

Specimen number	Length of specimen in 3% salt solution / mm		Length of specimen in 5% salt solution / mm	
	3 days after hatching	7 days after hatching	3 days after hatching	7 days after hatching
1	0.75	1.00	0.75	0.98
2	0.78	1.25	0.73	0.95
3	0.66	1.10	0.61	0.93
4	0.73	1.03	0.63	0.83
5	0.85	1.15	0.53	0.98
6	0.78	1.08	0.60	1.08
7	0.90	1.13	0.52	0.95
8	0.90	1.05	0.81	1.03
9	0.80	1.18	0.58	0.88
10	0.85	1.05	0.68	0.88
Mean	0.800	1.102		0.949

(i) Calculate the mean length of shrimp three days after hatching in the 5% salt solution. Give your answer to an appropriate number of significant figures.

(1)

Answer mm

(ii) Explain how these data can be used to show the effect of salt concentration on the rate of growth of brine shrimps.

(2)

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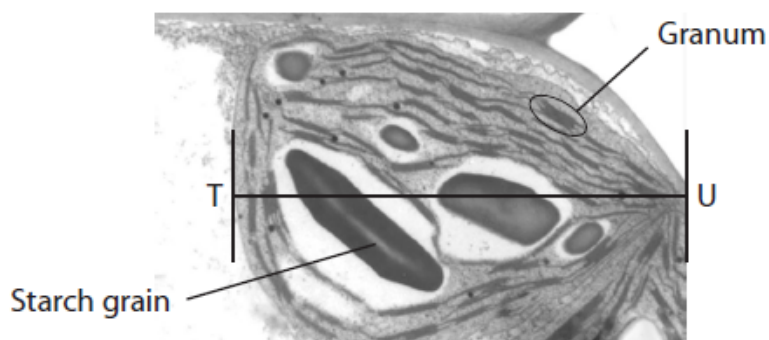
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(Total for question = 3 marks)

Q17.

Photosynthesis is a process that occurs in all green plants.

The electron micrograph shows part of a chloroplast in a plant cell.



(i) The labelled starch grain in the chloroplast is $2.2\text{ }\mu\text{m}$ long.

Calculate the width of this chloroplast between T and U.

(2)

..... μm

(ii) Explain the relationship between the structure and functions of a granum in photosynthesis.

(3)

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(Total for question = 5 marks)

Q18.

The scientific article you have studied is adapted from an article from '*The Scientist*'.

Use the information from the scientific article and your own knowledge to answer the following questions.

State what is meant by the phrase 'fix carbon into biomass' (paragraph 4).

(2)

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(Total for question = 2 marks)

Q19.

Climate change has been linked to the release of carbon dioxide from some power stations.

Some power stations burn wood chips instead of fossil fuels to produce electricity.

The photograph shows wood chips at a power station.



© Mr. Amarin Jitnathum/Shutterstock

It is thought that burning wood chips is more beneficial to the environment because in the long term it does not add carbon dioxide to the atmosphere.

Explain why burning wood chips does not increase carbon dioxide to the atmosphere in the long term.

(4)

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(Total for question = 4 marks)

Q20.

Climate change has been correlated with changing atmospheric carbon dioxide levels.

Scientists measured the productivity of two types of forest and recorded the mass of carbon taken up per square metre per year ($\text{gC m}^{-2} \text{y}^{-1}$).

The table shows data on the mean net primary productivity (NPP) and mean gross primary productivity (GPP) of these two types of forest.

Type of forest	Mean NPP / $\text{gC m}^{-2} \text{y}^{-1}$	Mean GPP / $\text{gC m}^{-2} \text{y}^{-1}$	Ratio of NPP to GPP
Boreal	322	1013	0.32
Temperate deciduous	1301	2165	0.60

(i) Calculate the percentage increase in mass of carbon released due to respiration by temperate deciduous forests compared with that by boreal forests.

(3)

..... %

(ii) The ratio of net primary productivity to gross primary productivity is a measure of the ability of forests to transfer carbon from the atmosphere into biomass.

Scientists concluded that temperate deciduous forests would reduce levels of carbon dioxide in the atmosphere more than boreal forests.

Justify this conclusion.

(3)

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(Total for question = 6 marks)

Q21.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Climate change has been linked to the release of carbon dioxide from some power stations.

The main reason that carbon dioxide acts as a greenhouse gas is because it

(1)

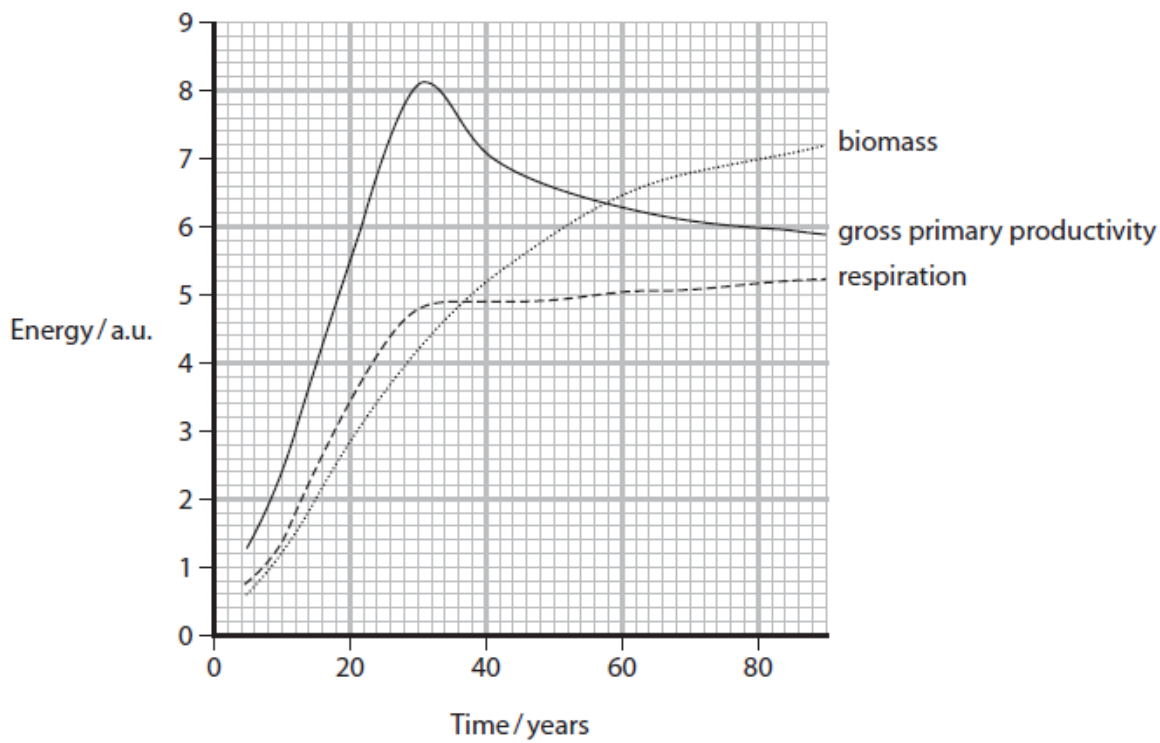
- ☐ **A** absorbs infrared radiation reflected by the surface of the Earth
- ☐ **B** absorbs ultraviolet radiation reflected by the surface of the Earth
- ☐ **C** reflects infrared radiation absorbed by the surface of the Earth
- ☐ **D** reflects ultraviolet radiation absorbed by the Earth's atmosphere

(Total for question = 1 mark)

Q22.

Eukaryotic cells contain membrane-bound organelles.

The graph shows the changes in biomass, gross primary productivity and the energy used in respiration during succession from grassland to mature forest.



(i) Add shading to the graph to show the area that represents net primary productivity.

(1)

(ii) Describe what is meant by the term succession.

(2)

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(iii) Deduce the effect of succession on the level of carbon dioxide in the atmosphere.

(3)

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(Total for question = 6 marks)

Q23.

Some plants are adapted to grow in shady conditions.

A study was carried out to compare the effect of growing in different light intensities on rates of photosynthesis of plants.

The plants are rated for levels of shade tolerance.

Plant seedlings of nine species were grown in either 25% or 5% of full sunlight. All other abiotic factors were controlled.

These seedlings were grown for six weeks and then exposed to full sunlight for 15 minutes. The rate of photosynthesis was measured during the exposure to full light.

The table shows the results of this investigation for four species of plant.

Species	Shade tolerance	Rate of photosynthesis / a.u.	
		Seedlings grown in 25% of full sunlight	Seedlings grown in 5% of full sunlight
A	Intolerant	410	415
B	Intermediate	300	275
C	Tolerant	180	210
D	Very tolerant	150	215

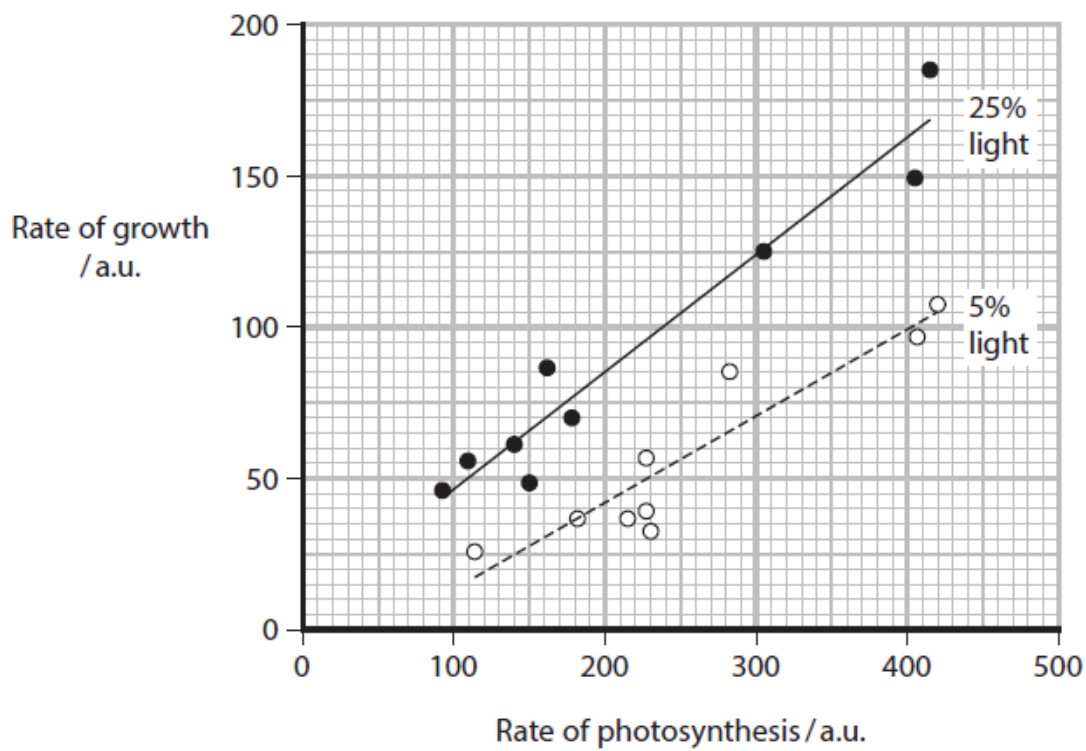
(i) Determine which species had the greatest percentage change in rate of photosynthesis when grown in lower light intensities.

(2)

..... Answer

(ii) The rate of growth for all nine species of plant was also measured.

The graph shows the effects of the rate of photosynthesis on the rate of growth of these plants.



Explain the effect of light intensity during the first six weeks of growth on the growth rate of these species of plant.

(4)

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(Total for question = 6 marks)

Q24.

Some plants are adapted to grow in shady conditions.

A study was carried out to compare the effect of growing in different light intensities on rates of photosynthesis of plants.

The plants are rated for levels of shade tolerance.

Plant seedlings of nine species were grown in either 25% or 5% of full sunlight. All other abiotic factors were controlled.

These seedlings were grown for six weeks and then exposed to full sunlight for 15 minutes. The rate of photosynthesis was measured during the exposure to full light.

The table shows the results of this investigation for four species of plant.

Species	Shade tolerance	Rate of photosynthesis / a.u.	
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A	Intolerant	410	415
B	Intermediate	300	275
C	Tolerant	180	210
D	Very tolerant	150	215

* Differences in the rate of photosynthesis may be due to the light-dependent reactions in chloroplasts.

Devise an investigation to compare the rate of the light-dependent reaction in shade tolerant and shade intolerant plants grown at different light intensities.

(6)

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(Total for question = 6 marks)

Q25.

Climate change has been linked to the release of carbon dioxide from some power stations.

Name the plant organelle that fixes carbon dioxide from the atmosphere.

(1)

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(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: - methane is a greenhouse gas (1) - greenhouse gases {absorb / trap} {heat / infra red / long wave} energy (1) (anaerobic oxidation of methane results in) less methane in the atmosphere (1) (the breakdown of methane) could {reduce the greenhouse effect / result in less heat being trapped / reduce global warming} (1)		(3)

Q2.

Question Number	Indicative content
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Section of relevant data - higher rate of mutations than in {slowly evolving fish / sticklebacks} - relatively high rate of mutations that change amino acids compared to slowly evolving fish - low rate of gene duplication in slowly evolving fish / high rate of gene duplication in cichlid fish - higher rate of mutations in regulatory sequences in cichlid fish - variety of habitats available providing different selection pressures Consequences of data described - more {amino acid changes / gene duplications} the greater number of alleles in gene pool - altered amino acids result in altered protein function - changes in regulatory sequences allow for different gene expression in tissues etc - duplicated genes can be used for new functions without loss of original function / polygenic phenotypes - variety of habitats provide a number of niches suitable for cichlid fish with different adaptations to exploit Linkages made to rate of evolution - example of an altered protein function e.g. enzymes that work at different pH / temperature tolerance - development of new phenotypes {new enzymes/ different mouth shapes} allow new food types to be exploited - changes in {pigmentation / mouth shape} allow speciation

Level	Mark	Descriptor	Additional guidance
Level 0	Marks	No awardable content	
Level 1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.	At least one relevant piece of data described e.g. higher mutation rate. A consequence described for the data – e.g. linking mutations to protein structure Basic clear conclusion attempted e.g. different proteins are produced
Level 2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.	At least two pieces of relevant data referred to. Consequences of at least two pieces of data explained Linkages made to evolution of the fish e.g. changes in phenotype
Level 3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	At least three pieces of relevant data referred to Consequences of each piece of data explained Linkages to evolution discussed, e.g. the types of adaptations that may arise due to mutations

Q3.

Question Number	Answer	Additional Guidance	Mark
(i)	- idea that bacteria are resistant to fewer {antibiotics / antibiotic combinations} (in 2006 than 2007) ; - in both years there are resistant strains to {streptomycin / INH + rifampicin + ethambutol / INH } ; - idea that there are resistant strains to INH + rifampicin in 2006 but not in 2007 ; - idea that there are resistant strains to {ethambutol / rifampicin} in 2007 but not in 2006 ;	ACCEPT clear abbreviations to the names of the antibiotics throughout 1 ACCEPT a description e.g. new resistances, resistant to 4 in 2006 and 5 in 2007 3 ACCEPT idea that {resistance decreased to zero / no longer resistant} 4 ACCEPT idea of resistance developing NB development of new resistances to {ethambutol / rifampicin} = Mp 1 and 4	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	1. bacteria have a mutation in {DNA / gene / eq } ; 2. idea that the {presence / usage of} {antibiotic (INH) / INH} acts as a selection pressure ; 3. idea that the allele (for resistance) is passed on ; 4. idea that bacteria {divide by asexual reproduction / divide by binary fission / produce clones / eq} ; 5. idea of increasing the allele frequency ;	3 NOT gene 4 ACCEPT divide by mitosis / conjugation / transduction / transformation / eq	

Question Number	Answer	Additional Guidance	Mark
	6. idea that the more resistant bacteria there are, the more likely new strains will acquire the (resistance) gene ;		(3)

Question Number	Answer	Additional Guidance	Mark
(iii)	- reference to codes of {practice / conduct / eq } ; - idea that appropriate {antibiotics / named example} should be given to patients ; - idea of {educating patients about taking antibiotics / taking the full course of antibiotics ; - credit another appropriate procedure e.g. hand washing, screening ;	1 ACCEPT named policy /code NB Mp5 is for named practice 2 ACCEPT not giving antibiotics if not necessary / not using antibiotics for prophylactic treatment / using narrow spectrum antibiotics / rotate antibiotic use	(2)

Q4.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(i)	net (primary) productivity = gross (primary) productivity - respiration	Allow $NPP = GPP - R$	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(ii)	correctly plotted value	2.3 at 0 1.4 at 6 0.9 at 18	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(iii)	An explanation that makes reference to three of the following: • there will be a large decrease in net productivity as depth increases (1) • (due to) large decrease in gross productivity as depth increases (1) • lower light intensity results in less photosynthesis (1) • and (only a) small decrease (in utilisation of carbon) in respiration as depth increases (1)		(3)

Question Number	Indicative content	
* (b)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • burning fossil fuels increases atmospheric concentrations of CO₂, a greenhouse gas leading to rising sea levels, increased surface temperatures and increased CO₂ concentration in oceans • small changes in sea level have limited effect on the crustose coralline algae • algae are adversely affected by increased carbon dioxide concentrations • there is a greater effect of increased carbon dioxide at higher temperatures • continued burning of fossil fuels may reduce productivity of crustose coralline algae • reefs will grow more slowly, become more susceptible to damage resulting in loss of habitat	
Level	Mark	Descriptor
Level 0	Marks	No awardable content
1	1-2	An answer may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The answer will contain basic information with some attempt made to link knowledge and

Level	Mark	Descriptor
		understanding to the given context.
2	3-4	An answer will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The answer shows some linkages and lines of scientific reasoning with some structure.
3	5-6	An answer is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The answer shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Q5.

Question Number	Answer	Mark
	The only correct answer is B 3 Global warming is not caused by a reduction in greenhouse gases Global warming is not affecting only the ice caps	Computer (1)

Q6.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • systematic sampling (1) • quadrats used at the tops and in between dunes (1) • details of method used for measuring percentage cover (1) • repeats to make a valid comparison (1) • a named relevant statistical test (1)		(5)

Q7.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: - negative correlation described (1) - polar bears eating fewer seals (1) - as the length of time that ice is present decreases more polar bears are seen on land (1) (because polar bears are on land more often) more eggs are eaten (1)	e.g. as presence of ice decreases the number of eggs taken increases ALLOW hunting / feeding on / catching ALLOW polar bears seen more often on land	(4)

Q8.

Question Number	Indicative content
*	Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant. Give examples of relevant biological knowledge and understanding: Evidence of isolated elements of biological knowledge: • glucose for respiration in both • starch for energy storage in plants / glycogen for energy storage in animals • cellulose for cell walls in plants Evidence of adequate biological knowledge with linkages made • starch composed of amylose and amylopectin in plants • sucrose as a transport sugar in phloem in plants, glucose in animals • lactose in milk for energy • a judgement on the importance of carbohydrates in plants and animals is made e.g. cellulose as a structural carbohydrate in plants therefore a greater proportion of carbohydrate in plants than animals or animals require more energy, therefore need more carbohydrate Evidence for comprehensive biological knowledge and understanding with sustained linkages • pentose sugars ribose and deoxyribose { in nucleic acids / DNA/ RNA / ATP } in both • ribulose as part of the Calvin cycle in plants • glycoprotein in { mucus / receptors on cell surface membranes / antibodies } • glycolipids in cell membranes • a supported judgement on the relative importance of carbohydrates in plants and animals is given e.g. animals store more energy in lipids than carbohydrate, therefore carbohydrate more important as a storage molecule in plants or the idea of carbohydrates as part of complex molecules or the proportion of carbohydrates present is not the same as importance

Level	Mark	Descriptor	Additional guidance
0	0	No awardable content	
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Glucose for respiration Polysaccharides for energy storage Cellulose for plant cell walls Simple conclusion made
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Branched storage molecules for rapid energy release in starch Roles of sucrose, lactose A judgement on the importance of carbohydrates in plants and animals is made
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	All of the above plus discussion of carbohydrates as part of complex molecules A supported judgement on the relative importance of carbohydrates in plants and animals

Q9.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	- correct calculation of numerator (1) - correct calculation of denominator (1) - correct calculation of diversity index / correctly plotted on the graph (1)	<u>Example of calculation:</u> $(N(N-1) = 427 \times 426 = 181\,902)$ $\div (\Sigma n(n-1) =) 52\,320)$ $= 3.48 ;$ Allow full marks for correct answer with no working	(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: - succession is the sequence of { species / communities } replacing each other with time (1) - dune 4 is older than dune 1 (1) - no species of plant inhabits all 4 dunes /example from table quoted to show one species inhabiting no more than 3 dunes (1) - plant diversity increases with time (1) - description of increasing diversity index from dune 1 to dune 4 (1)	e.g. species G only found on dunes 3 and 4	(5)

Q10.

Question Number	Answer	Additional Guidance	Mark
(a)	A ;		(1)

Question Number	Answer	Additional Guidance	Mark
*(b)	QWC – Spelling of technical terms must be correct and the answer must be organised in a logical sequence - idea that biofuel production may (overall) results in more carbon dioxide in the atmosphere ; OR idea that carbon neutral means that the carbon dioxide produced equals the carbon dioxide used ; - idea of forests as carbon {sinks / eq} ; - idea that {clearing land / deforestation} results in (net) increase in carbon dioxide (in atmosphere) ; {less plants means} less carbon dioxide {removed / used / eq} by photosynthesis ; {burning / eq} trees produces carbon dioxide ; - idea that (increased) decomposition produces carbon dioxide; - idea of using {(fossil) fuels / petrol / diesel} by {lorries / machinery / eq} produces carbon dioxide ; {burning /eq} of biofuels produces carbon dioxide ;	QWC emphasis is clarity of expression Accept stores / sumps	(5)

Question Number	Answer	Additional Guidance	Mark
(c)	- reference to production of {greenhouse gases / named greenhouse gas} ; - idea that these gases {build up/ remain / form a layer} in (upper) atmosphere; - which {absorb / trap / eq} {heat energy / infra-red / IR / eq} ; - reflected from earth's surface ; - idea that increased levels of these gases increase the greenhouse effect ; - idea that (mean) temperature of earth's {surface / atmosphere} is increasing ;	Accept carbon dioxide, water vapour, sulphur dioxide, oxides of nitrogen Not methane Accept long wavelength light	(4)

Q11.

Question Number	Answer	Mark
(a)(i)	A carbon dioxide and methane	(1)

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	- idea that {using / burning} {fossil fuels / petrol / diesel} releases carbon dioxide ; - reference to {carbon dioxide / CO₂} as a greenhouse gas ; - idea that carbon dioxide is taken in for {photosynthesis / light-independent reaction / carbon fixation / eq} (during production of plants for biofuels) ; - idea of no net change of carbon dioxide in the atmosphere when biofuels are burnt / eq ;	- NOT methane Ignore burning biofuels releases carbon dioxide 4. ACCEPT biofuels are carbon neutral	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	(plant) fibres / woody parts / xylem (vessels / tissue) / sclerenchyma (fibres / tissue) / lignified tissue / eq ;	ACCEPT vascular bundles / tissue	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	- idea that bacteria cannot breakdown cellulose fast enough ; - idea that {enzymes / cellulase} needed to break down cellulose into (β) glucose ; - by hydrolysing (1,4) glycosidic bonds / eq ; - idea of {respiration / fermentation} of {glucose / eq} (by bacteria) ;	- NOT hydrogen bonds 3. ACCEPT breaking	(2)

Question Number	Answer	Additional Guidance	Mark
(c)	1. idea that production of first generation biofuel increases until 2016 and then level off ; 2. idea that production of second generation biofuel will continue to increase ; For second generation biofuels: 3. idea that second generation biofuels do not affect food supply ; 4. idea that made using the non-edible components ; 5. cheaper ; 6. idea that people are becoming more responsible for their environment ;	Piece mp 1 and 2 together ACCEPT the converse of mps 3, 4 and 5 in context of first generation biofuel production 4. ACCEPT (cellulose and) lignin idea of less waste	(4)

Q12.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	C ; The number of fires in Mato Grosso each year is always higher than other areas ;		(1)

Question Number	Answer	Additional Guidance	Mark
* (a)(ii)	(QWC – Spelling of technical terms must be correct and the answer must be organised in a logical sequence - reference to {fires / burning / eq} produces carbon dioxide ; - which is a greenhouse gas ; - idea that these gases {build up / remain / form a layer / increase} in (upper) atmosphere ; - which {absorb / trap / eq} {heat energy / infra red / IR / eq} ; - reflected from earth's surface ; - idea that increased levels of these gases increase the greenhouse effect ; - idea that (mean) temperature of earth's {surface / atmosphere} is increasing ; - idea that less carbon dioxide {removed / used / eq} by photosynthesis ;	QWC emphasis clarity of expression 1. Accept carbon dioxide, water vapour, sulphur dioxide, oxides of nitrogen Not methane 2. NB do not penalise ref to methane twice 4. Accept long wavelength light	(5)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	- reference to biofuels being (possibly)carbon neutral ; - idea that {plants / crops} are used for biofuels ; - idea that carbon dioxide used for photosynthesis (by plants / in production of biofuels) ; - idea of using biofuels to replace fossil fuels ;	Ignore carbon unqualified 1. Accept idea of no (net) change in carbon dioxide levels in atmosphere	(3)

Question Number	Answer	Mark
(a)	B 2	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	(only) contain hydrogen, carbon and oxygen ; - reference to fatty acids and glycerol {joined by / eq} ester{bonds / eq} ; - idea of saturated and unsaturated (fatty acids / lipids);		(2)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	- uses less fertiliser / eq ; - idea of not using more pesticides / eq ; - idea that greenhouse gas emissions are not that different ; - credit manipulation of figures to support marking point 3 ;	1. & 2. IGNORE comparisons between the different crops 3. ACCEPT less than corn but more than sugar cane	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	- credit three correctly named ions ; - nitrates for {protein / amino acids / nucleic acids / named nucleic acid} ; - proteins used for growth ; - calcium ions for {other nutrients uptake / promotes cell elongation / strengthen cell walls / enzyme function / protection against heat stress / protection against diseases / eq} ; - magnesium ions for chlorophyll production ; - for photosynthesis ;	e.g. nitrates, calcium ions, magnesium ions, sulphates, potassium ions, phosphates ACCEPT Sulphates for amino acids Potassium ions for stomata function	(4)

Q14.

Question number	Answer	Additional guidance	Mark
(i)	An answer that makes reference to two of the following: • food availability (1) • interspecific competition (1) • predation (1) • disease (1)	IGNORE time of year / availability of resources ALLOW grazing / migration IGNORE competition unqualified or competition between birds	Choose an item. (2)

Question number	Answer	Additional guidance	Mark
(ii)	• correct expected value (1) • correct values for observed minus expected squared (1) • correct answer (1)	$26 \div 2 = 13$ $(16 - 13)^2 = 9$ and $(10 - 13)^2 = 9$ 1.38 ECF for incorrect expected value ALLOW one mark for 2.25 / 3.6	Choose an item. (3)

Question number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to the following: • cutting down trees decreases the number of bird species in both forests (1) • the decrease is significant (at $p=0.05$) in forest A (1) • the decrease was not significant (at $p=0.05$) in forest B (1)	ALLOW decreases species richness ALLOW less than {5% / 0.05 probability} reduction in forest A due to chance ALLOW more than {5% / 0.05 probability} reduction in forest B due to chance ALLOW 1 mark chi squared value was {greater than the critical value for forest A / less than critical value for forest B} with no reference to p value or significance	Choose an item. (2)

Q15.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to - correct method for calculation the change in value (1) - correct answer (1)	<u>Example of calculation</u> $405 \div 1.46$ 277.4 (ppm) ALLOW 277 Correct answer without working gains full marks	(2)

Q16.

Question Number	Answer	Additional Guidance	Mark
(i)	correct answer to four significant figures (1)	<u>Example of calculation</u> $6.44 \div 10 = 0.644$ (mm)	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: - divide change in mean length by time (1) - comparison between the rate for 3% and 5% (1)	ALLOW (growth) rate = change in mean length $\div$ time ALLOW grow faster in 5%	(2)

Q17.

Question Number	Answer	Additional Guidance	Mark
(i)	- correct measurements from the photograph (1) - correct answer	<u>Example of calculation</u> Starch grain 27mm and width of chloroplast 60mm $27000 \div 22 = 12\,273$ $60000 \div 12\,273 = 4.889\,(\mu\text{m})$ ALLOW 4.9 / 4.89 / 4.8 recurring (μm) (ALLOW one mark for correct calculation from different measurements)	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: (granum) is formed from many layers of thylakoid membranes to increase surface area (for absorbing light) - thylakoid membranes contain chlorophyll to absorb light - electron carrier molecules in thylakoid membrane involved in ATP production	ALLOW stacks of thylakoids provide a large surface area ALLOW photosystems / photosynthetic pigments in place of chlorophyll ALLOW for light dependent reaction in place of absorb light ALLOW ATP synthase / photophosphorylation	(3)

Q18.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: - transfer carbon from an {inorganic source / CO_2} into organic compound (1) - that becomes part of the mass of that organism (1)	ALLOW correct named organic compound e.g. cellulose / protein ALLOW description of light independent reactions of photosynthesis ALLOW part of biomass	(2)

Q19.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following - carbon dioxide produced by burning wood replaces that absorbed by the trees (1) - trees absorb carbon dioxide (from the atmosphere) for photosynthesis (1) - new trees are grown to replace those that are cut down (1) - therefore no net increase in carbon dioxide (1)	ALLOW converse ALLOW fix carbon ALLOW carbon neutral	(4)

Q20.

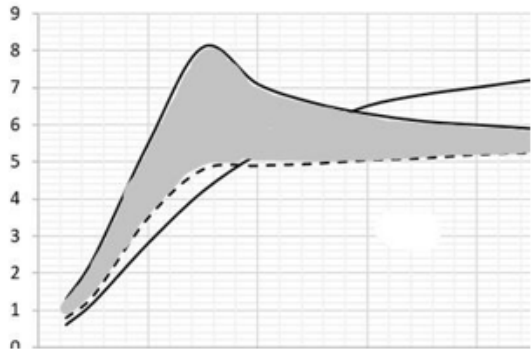
Question Number	Answer	Additional Guidance	Mark
(i)	- correct values for carbon released by boreal forest and deciduous forest respiration (1) - correct use of values to calculate percentage increase (1) - correct answer (1)	<u>Example of calculation</u> 1013 – 322 = 691 (Boreal) 2165 – 1301 = 864 (Deciduous) = 173 ÷ 691 deciduous release 25% (25.04%) more than boreal Correct answer with no working gains full marks	3

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following: - the ratio of NPP to GPP is higher in deciduous forests (1) - NPP is higher / more of the carbon (fixed) is used to produce biomass (1) (in deciduous forests) more carbon (dioxide) removed (by photosynthesis) than returned by respiration (1)	ALLOW converse for boreal forests for all points	3

Q21.

Question Number	Answer	Mark
	The only correct answer is A absorbs infrared radiation reflected by the surface of the Earth <i>B is incorrect because it does not absorb ultraviolet</i> <i>C is incorrect because it does not reflect infrared</i> <i>D is incorrect because it does not reflect ultraviolet</i>	(1)

Q22.

Question number	Answer	Additional guidance	Mark
(i)	Choose an item. 	ALLOW solid or hatched shading Shading must be complete (e.g. not stop at biomass line)	Graduate (1)

Question number	Answer	Additional guidance	Mark
(ii)	A description that makes reference to the following: - change in communities (1) (taking place) over time (1)	ALLOW change in species ALLOW a description of succession as a change from pioneer species to climax communities	Expert (2)

Question number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to three of the following: (the energy lost in) respiration {levels off / stops increasing} (1) - accumulation of (the energy incorporated into) biomass continues (1) - therefore, with succession more carbon dioxide is fixed (1) - reduces the amount of carbon dioxide (in the atmosphere) (1)	ALLOW more carbon sinks ALLOW more photosynthesis to remove carbon dioxide ALLOW (with succession) carbon dioxide released from respiration is less than the carbon dioxide fixed (by RUBSCO)	Expert (3)

Q23.

Question Number	Answer	Additional guidance	Mark
(i)	An answer that makes reference to the following - species D (1) - correct calculation of percentage change as {43.3/ 43} % (1)	Example of calculation $(215-150) \div 150 \times 100$	graduate (2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to four of the following - the rate of growth increases as rate of photosynthesis increases (1) - growth rate is higher for plants grown at a higher light intensity (1) - role of light in light-dependent reactions described (1) - more photosynthesis means more {glucose/carbohydrate} produced (1) (more carbohydrate produced) means more glucose for {energy/respiration } (1)	ALLOW correlation between rate of growth and rate of photosynthesis e.g. photolysis / photophosphorylation – production of ATP or reduced NADP ALLOW other named product of photosynthesis	Expert (4)

Q24.

Question Number	Answer	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content • Use shade tolerant and shade intolerant plants • Plants grown in the same conditions e.g. temperature, humidity • Plants grown in either 5% light or 25% light or a range of light intensities • Take same masses of leaf • Add to equal volume of isolation medium • Homogenise (e.g. blend / grind in pestle and mortar) for same length of time • Filter suspensions of plant material (through muslin) or centrifuge to concentrate chloroplasts • Resuspend pellet of chloroplasts if centrifuged • Expose suspensions to 5% and 25% light intensity • Keep temperature controlled • Add DCPIP and record time for DCPIP to decolourise • Carry out repeats to calculate mean time to decolourise the DCPIP • If the difference is due to the light dependent reaction, shade tolerant plants would decolourise more quickly at lower light intensity	Expert (6)

Level	Marks		Additional Guidance
0	0	No awardable content	
1	1-2	An explanation of how the investigation should be modified may be attempted but with limited analysis, interpretation and/or evaluation of the scientific information. Generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Compare shade tolerant and shade intolerant plants (allow A and C from the table) Control of at least one relevant variable Reference to different light intensities
2	3-4	An explanation of how the investigation should be modified will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Growing plants at different light intensities Use of DCPIP to measure rate of photosynthesis Correct description of methodology Sensible number of repeats Correct change in DCPIP/use of colorimeter to measure colour change

3	5-6	An explanation of how the investigation should be modified is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured.	Link between change in DCPIP and rate of photosynthesis Link with light dependent reaction How this would support the difference between shade tolerant and shade intolerant plants Use of a named statistical test eg T test
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Q25.

Question Number	Answer	Additional guidance	Mark
	Chloroplast		(1)

