

Erratum Notice

9BN0/01

Pearson Edexcel GCE Biology

Paper 1: The Natural Environment and Species Survival

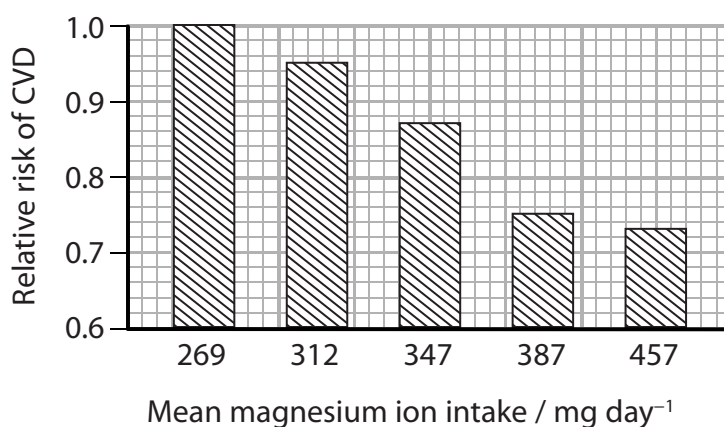
Thursday 7th June 2018 - Morning

Question 1(a)

Please be advised that the graph in question 1(a) has been printed incorrectly on the question paper.

A replacement graph is provided below. Please cross through the graph printed on page 2 of the question paper and use this replacement graph to answer questions 1(a)(i) and 1(a)(ii).

Please select your answer to these questions in the question paper booklet.



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Write your name here

Surname

StemUp Model Solution

Other names

**Pearson Edexcel
Level 3 GCE**

Centre Number

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Candidate Number

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Biology A (Salters Nuffield)

Advanced

Paper 1: The Natural Environment and Species Survival

Thursday 7 June 2018 – Morning

Time: 2 hours

Paper Reference

9BN0/01

You must have:

Calculator, HB pencil, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Show your working in any calculation questions and include units in your answer where appropriate.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You may use a scientific calculator.
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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P 5 2 2 8 8 A 0 1 3 6


Pearson

Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

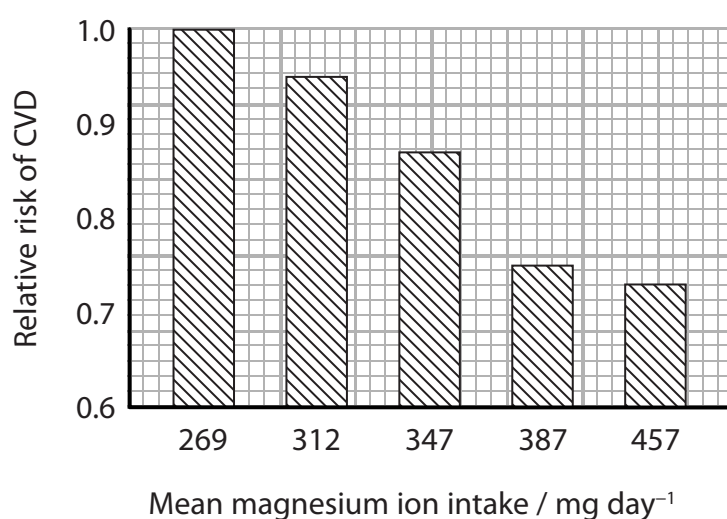
1 Cardiovascular disease (CVD) is a major cause of death and disability in the UK.

(a) The relationship between magnesium ions in the diet and CVD has been studied.

In one study, magnesium ions were added to the diets of a group of men.
The effect of this on the relative risk of CVD was recorded.

The mean normal dietary intake of magnesium ions is 269 mg day^{-1} .

The results of the study are shown in the graph.



(i) Which of the following statements can be made about the relationship between an increased magnesium ion intake and the risk of CVD in this study?

(1)

An increased magnesium ion intake

- ☐ A causes an increase in CVD
- ☐ B causes a reduction in CVD
- ☐ C is correlated with an increase in CVD
- ☒ D is correlated with a reduction in CVD

(ii) What is the daily increase in magnesium ion intake that reduces the relative risk of CVD by 0.13?

(1)

- ☐ A 43 mg day^{-1}
- ☒ B 78 mg day^{-1}
- ☐ C 118 mg day^{-1}
- ☐ D 347 mg day^{-1}



(b) It has been suggested that magnesium ions are involved in regulating the ratio of HDL to LDL in the blood.

(i) Describe the role of LDLs in the development of atherosclerosis.

(3)

LDLs carry cholesterol in the blood; high levels of LDLs increase blood cholesterol.

If the endothelium of an artery is damaged, an inflammatory response occurs and cholesterol from the LDLs is deposited in the artery wall, beneath the endothelium.

Cholesterol builds up with white blood cells, calcium salts and fibrous tissue to form an atheroma (plaque), which narrows the lumen and hardens the artery.

(ii) Explain how atherosclerosis can result in damage to heart muscle.

(3)

The atheroma narrows the lumen of the coronary arteries (or a blood clot forms at the plaque and blocks a coronary artery).

This reduces blood flow, so less oxygen (and glucose) reaches the cardiac (heart) muscle.

This reduces aerobic respiration in the heart muscle, so there is more anaerobic respiration and a build-up of lactic acid; the muscle cells cannot release enough energy and die (myocardial infarction).

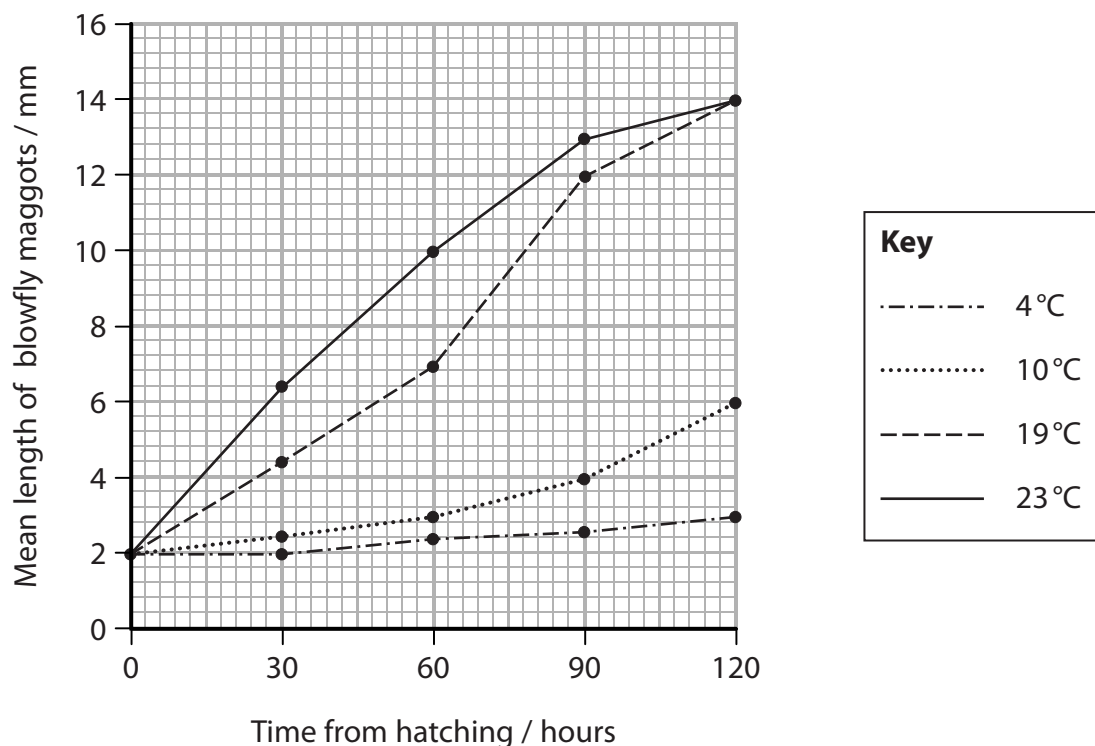
(Total for Question 1 = 8 marks)



P 5 2 2 8 8 A 0 3 3 6

- 2 One method of estimating the time of death is to determine the age of blowfly maggots on a dead body.

(a) The effect of environmental temperature on the growth of blowfly maggots is shown in the graph.



- (i) Blowfly maggots found on a dead body had lengths between 3 and 8 mm. The body had been at a constant environmental temperature of 19°C since death.

Determine the maximum time since these maggots hatched.

(1)

..... 66 hours

- (ii) Determine the fastest rate of growth of a blowfly maggot at a temperature of 19°C.

Give your answer to 2 significant figures.

Steepest part of 19 °C curve is between 60 and 90 hours:

(2)

$$\text{rate} = (12 - 6.8) \div (90 - 60)$$

$$= 5.2 \div 30 = 0.173$$

..... 0.17 mm hour⁻¹



(iii) Explain the effect of temperature on the rate of growth of blowfly maggots.

(3)

Temperature affects the enzymes that control metabolism, e.g. the reactions of respiration, protein synthesis and cell division, so it affects the rate of growth.

An increase in temperature (from 4 °C to 23 °C) increases the kinetic energy of the molecules, producing more frequent collisions between enzyme and substrate molecules, so more enzyme-substrate complexes form.

So metabolic reactions are faster and the maggots grow faster; at a low temperature such as 4 °C there is little kinetic energy, fewer collisions and growth is very slow.

(b) Microorganisms are also found on a dead body.

Describe the role of decomposers, such as microorganisms, in the carbon cycle.

(2)

Decomposers secrete enzymes that break down the organic molecules (e.g. proteins, lipids and carbohydrates) in the dead body and absorb the products.

The decomposers respire, releasing carbon dioxide into the atmosphere (or methane if respiration is anaerobic), which can then be taken up by plants in photosynthesis.

(Total for Question 2 = 8 marks)



P 5 2 2 8 8 A 0 5 3 6

3 A newborn baby can respond to infections.

- (a) The mother of a baby will produce an immune response to any infections that she acquires.

Antibodies providing specific immunity to these infections are found in the milk produced by the mother.

- (i) Which cell produces antibodies?

(1)

- ☐ A macrophage
- ☒ B plasma cell
- ☐ C red blood cell
- ☐ D T cell

- (ii) The type of immunity that the newborn baby obtains from the milk produced by its mother is

(1)

- ☐ A artificial active immunity
- ☐ B artificial passive immunity
- ☐ C natural active immunity
- ☒ D natural passive immunity

- (b) Inflammation is a non-specific response to an infection.

Explain how changes in the blood vessels result in the redness and swelling seen at the site of inflammation.

(4)

Damaged cells and mast cells release histamine. Histamine causes the arterioles to dilate (vasodilation), which increases the blood flow to the infected area, causing redness (and heat).

Histamine also increases the permeability of the capillaries, making them leaky, so blood plasma leaves the capillaries and enters the tissues. This causes oedema, which is the swelling.



(c) Interferon is involved in the response to viral infections.

(i) The influenza virus can be lethal to mice.

The effects of interferon on influenza infection in mice was investigated.

Mice were infected with influenza virus and then given interferon.

The results of the investigation are shown in the table.

Interferon dose / units per mouse	Median survival time / days
No dose	3.3
8×10^3	4.4
8×10^4	8.5
8×10^5	>42

Explain these results.

(3)

As the dose of interferon increases, the median survival time of the mice increases

(positive correlation), from 3.3 days with no dose to over 42 days at 8×10^5 units.

This is because interferon inhibits viral replication inside cells (e.g. it inhibits viral protein synthesis) and prevents the virus infecting other cells.

So the greater the dose of interferon, the fewer virus particles are produced and released to infect other cells, so less tissue damage occurs and the mice survive longer.



P 5 2 2 8 8 A 0 7 3 6

- (ii) Interferon can be used to treat people with viral hepatitis.

Interferon can be made by animal cells or by genetically modified bacteria.

The table shows information about interferon made by these animal cells and genetically modified bacteria.

Source of interferon	Type of molecule	Folding	Antiviral activity
Animal cells	Glycoprotein	Correctly folded	High
Genetically modified bacteria	Protein	Incorrectly folded and needs to be refolded before it can be used	Low

Explain why the interferon made by genetically modified bacteria is different from the interferon made by animal cells.

(2)

Bacteria are prokaryotes, so they do not have rough endoplasmic reticulum or a Golgi apparatus.

So the polypeptide chain is not processed or modified properly after translation:

carbohydrate is not added (it is not glycosylated) and the protein is incorrectly folded, so it has low antiviral activity.

- (iii) Glycoproteins made in animal cells are released into the extracellular fluid by

(1)

- ☐ A endocytosis
- ☒ B exocytosis
- ☐ C facilitated diffusion
- ☐ D phagocytosis

(Total for Question 3 = 12 marks)



4 Leptin is a protein hormone with a role in the control of appetite in humans.

(a) The leptin gene is located on chromosome 17.

(i) State what is meant by the term gene.

(2)

A sequence of bases (nucleotides) in DNA that codes for the sequence of amino acids (primary structure) of a polypeptide.

(ii) Describe the role of tRNA in the production of leptin.

(3)

Each tRNA molecule carries a particular amino acid, which is determined by its anticodon.

tRNA molecules transport the amino acids to the ribosome.

The anticodon on the tRNA binds (by complementary base pairing) to a codon on the mRNA, so the amino acids are brought in the correct order and joined by peptide bonds to form leptin.



P 5 2 2 8 8 A 0 9 3 6

(iii) Describe how the primary structure of leptin enables it to be soluble in water.

(3)

The primary structure (sequence of amino acids, so the position of the R groups) determines how the polypeptide folds, i.e. its tertiary structure.

Leptin folds to form a globular structure, with the hydrophobic (non-polar) R groups located in the centre of the protein and the hydrophilic (polar) R groups located on the outside.

Water molecules form hydrogen bonds with the hydrophilic groups on the surface of the protein, so leptin is soluble in water.

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- (b) Several mutations of the leptin gene have been identified. All these mutations are frameshift mutations that result in shortened primary structures.

A frameshift mutation involves the insertion or removal of one or two nucleotides from a gene.

Describe how a frameshift mutation could result in the production of leptin with a variety of shorter primary structures.

(2)

Inserting or removing one or two nucleotides changes the triplet code from the point of the mutation onwards (the reading frame shifts), so different codons are produced.

This can introduce a new stop codon earlier in the sequence, so translation stops early and a shorter sequence of amino acids is coded for.

Mutations at different positions in the gene produce stop codons in different places, giving a variety of shorter primary structures.

(Total for Question 4 = 10 marks)



5 Cigarette smoking is associated with several medical problems.

In an investigation, some female mice were exposed to cigarette smoke during pregnancy.

The ability of their male offspring to produce sperm and the activity of the sperm were investigated.

The results of this investigation are shown in the table.

Group	Percentage of sperm that are motile (%)	Ability of sperm to cross the zona pellucida of an egg cell	Percentage of stem cells producing sperm in the testes (%)
Offspring of control mice	68	Good	100
Offspring of mice exposed to cigarette smoke	45	Poor	40

- (a) Analyse the data to explain why exposing pregnant mice to cigarette smoke affects the fertility of their male offspring.

(3)

In offspring of exposed mice only 40% of stem cells produce sperm compared with 100%

in the control, so fewer sperm are produced.

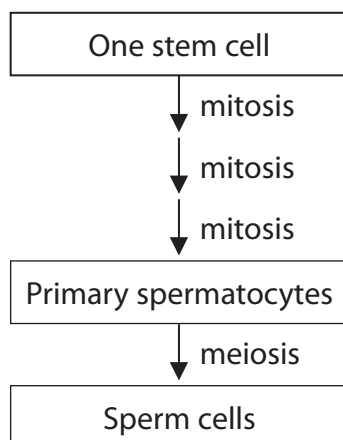
Only 45% of sperm are motile compared with 68%, so fewer sperm will reach the egg.

Their sperm have a poor ability to cross the zona pellucida (the acrosome reaction may be inhibited), so sperm will not reach the egg cell membrane and fuse with it.

Therefore the chance of fertilisation is reduced, so fertility is lower.



- (b) Sperm are produced from stem cells in a process that involves several cycles of mitosis and a single cycle of meiosis, as shown in the diagram.



- (i) State what is meant by the term stem cell.

(2)

A cell that is undifferentiated (unspecialised), that can give rise to specialised (differentiated) cells, and that can divide continuously to produce more stem cells.



- (ii) Compare and contrast the results of mitosis and meiosis in the production of sperm cells from stem cells.

(4)

Similarity: both mitosis and meiosis increase the number of cells.

Differences: mitosis produces diploid cells whereas meiosis produces haploid cells with half the number of chromosomes.

Mitosis produces genetically identical cells whereas meiosis produces cells that are genetically different from each other (due to independent assortment and crossing over).

The three cycles of mitosis result in 8 primary spermatocytes from each stem cell (2 daughter cells per division), whereas meiosis results in 4 sperm cells from each primary spermatocyte.

(Total for Question 5 = 9 marks)

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6 Tuberculosis (TB) is an infectious disease caused by mycobacteria.

(a) Most cases of TB are caused by infection with *Mycobacterium tuberculosis* (*M. tuberculosis*).

The ribosomes of bacteria are

(1)

- ☐ A larger than the ribosomes in eukaryotes
- ☒ B smaller than ribosomes in eukaryotes
- ☐ C the same size as ribosomes in animal cells
- ☐ D the same size as ribosomes in plant cells

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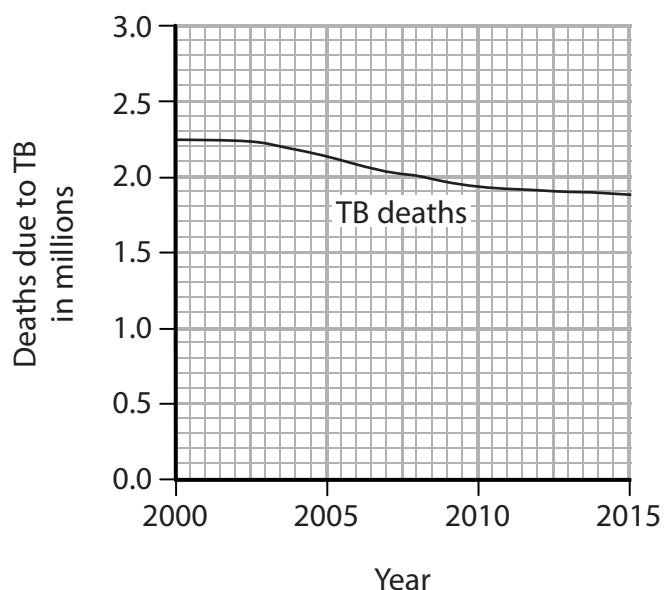
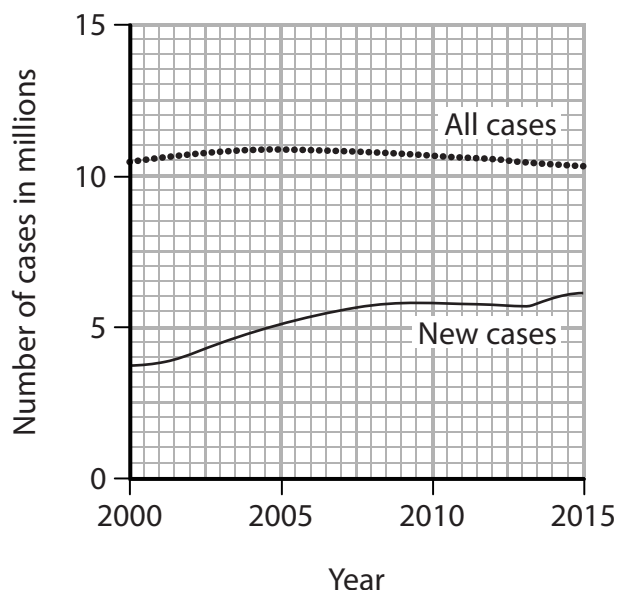
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(b) The graphs show the number of cases of TB and the number of deaths from TB worldwide from 2000 to 2015.



In 1993 the World Health Organisation (WHO) declared TB a global public health emergency. Since then, there has been a programme to reduce the impact of this disease.

Analyse the data to deduce the effectiveness of this programme.

(3)

The number of new cases has increased, from about 3.7 million in 2000 to about 6 million in 2015, but the total number of cases has stayed relatively constant at about 10.5 million.

The number of people dying from TB has decreased, from about 2.3 million to about 1.9 million.

So, although the total number of cases has not fallen, more people are being diagnosed and more are being successfully treated, so the programme is effective.



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*(c) Individuals infected with *M. tuberculosis* can be treated with antibiotics.

Four of the antibiotics used to treat TB are shown in the table.

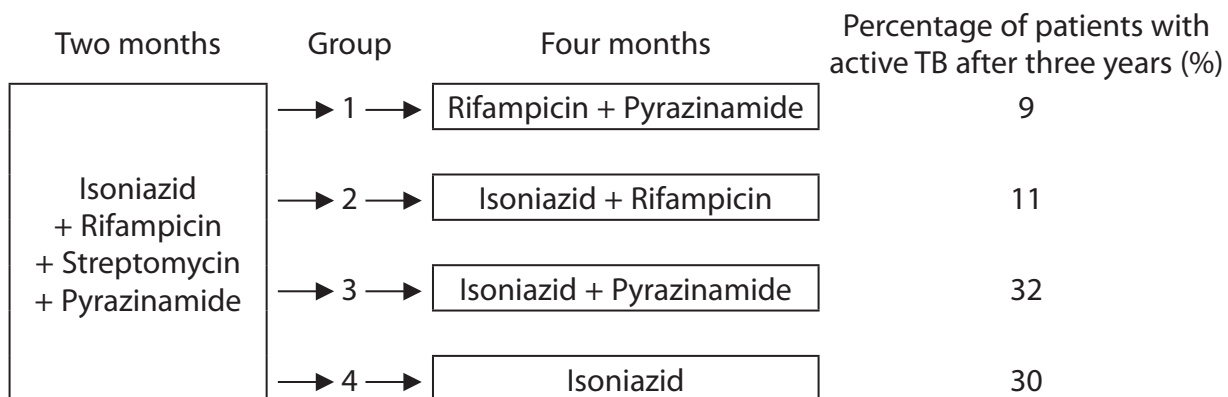
Antibiotic	Mechanism of action
Isoniazid	Inhibits the synthesis of a fatty acid needed to make bacterial cell walls
Rifampicin	Inhibits bacterial RNA polymerase
Streptomycin	Binds to bacterial ribosomes to prevent the binding of tRNA
Pyrazinamide	Not yet known, but not the same mechanisms as the other three antibiotics

In one clinical trial lasting six months, the effect of treating TB with these antibiotics was investigated.

All patients were treated with all four antibiotics for two months. Then they were treated with different pairs of antibiotics or isoniazid alone for a further four months.

All patients were free of any signs of active TB at the end of the clinical trial.

The design of the trial and the percentage of these patients with TB three years after the trial ended are shown in the diagram.



Analyse the data to comment on the effectiveness of these antibiotics for the treatment of TB.

(6)

All four treatments were effective at treating TB, as all patients were free of active TB at the end of the trial, but every group had some relapses three years later.

Groups 1 and 2 (rifampicin + pyrazinamide 9%, isoniazid + rifampicin 11%) had the lowest percentage of patients with TB; groups 3 (32%) and 4 (isoniazid alone, 30%) had about three times as many. So relapse depends on the four-month part of the treatment, and combinations involving rifampicin were most effective.

Rifampicin inhibits bacterial RNA polymerase, stopping transcription and so protein synthesis, so RNA polymerase may be the best target. Isoniazid, which targets synthesis of cell wall fatty acids, was least effective in terms of relapses: adding it to pyrazinamide (32%) was no better than isoniazid alone (30%).

The antibiotics act on different targets in the bacteria, so a combination of antibiotics with different modes of action is most effective, as bacteria resistant to one are killed by the other.

However, there are gaps in the information: not all combinations were tested, so other combinations or other timescales might be more effective. TB three years later could be due to reinfection rather than failure of the antibiotics, and there is no information about dormant TB, only active cases. No sample sizes or statistics are given, so the difference between 9% and 11% may not be significant.

(Total for Question 6 = 10 marks)



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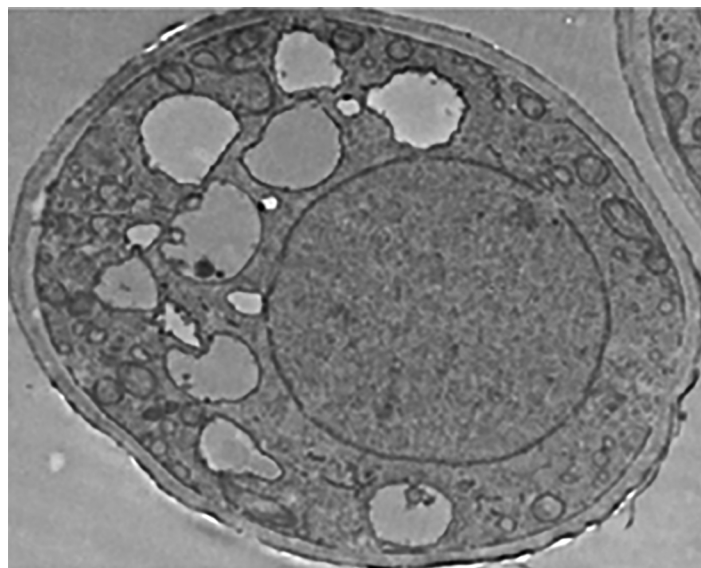
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- 7 *Hymenoscyphus fraxineus* (*H. fraxineus*) is the fungus that causes ash dieback. This disease usually kills all the ash trees that it infects.

(a) The electron micrograph shows a section through a fungal cell.



Magnification $\times 1000$

To which group do fungi belong?

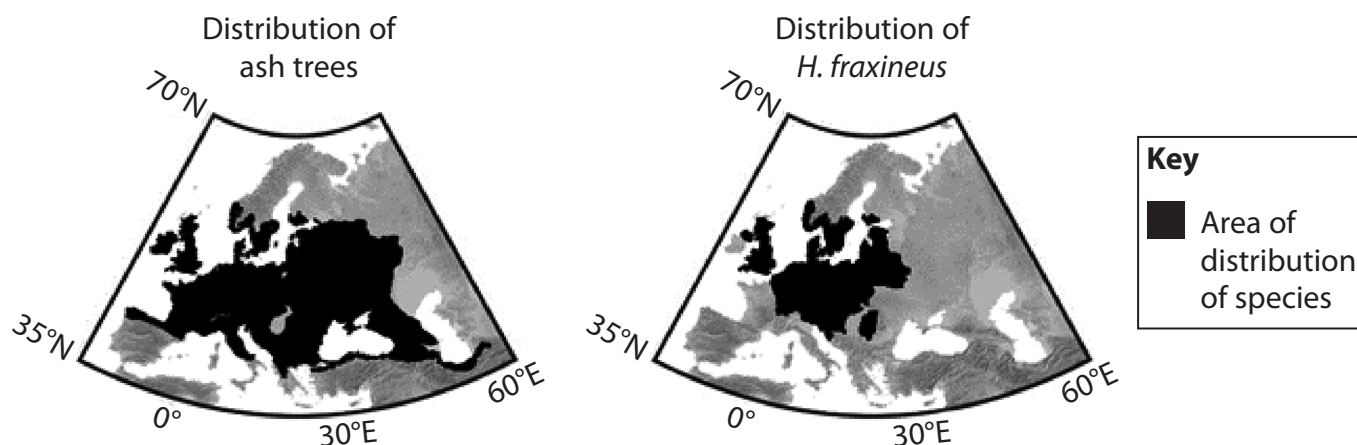
(1)

- ☐ A Archaea
- ☒ B Eukaryota
- ☐ C Prokaryota
- ☐ D Viruses



P 5 2 2 8 8 A 0 2 1 3 6

(b) 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)

Carbon dioxide is a greenhouse gas, so increasing its concentration from 398 ppm causes global warming and climate change: temperatures rise and rainfall patterns and humidity change.

This changes the region suitable for ash trees: at 430 ppm it moves further north and east, and at 1080 ppm it is mainly in the north and east (Scandinavia and Russia), with less of southern and western Europe suitable.

Increased carbon dioxide also changes the range of *H. fraxineus*: at 430 ppm its suitable region shrinks to parts of northern and central Europe, and at 1080 ppm it is restricted to a small area, mostly in Scandinavia, as the fungus needs cool, humid conditions.

Ash trees are killed wherever the fungus is present, so they will be found in regions without *H. fraxineus*: at 430 ppm the predicted distribution of ash is mainly in eastern Europe, and at 1080 ppm there are more ash trees in the north-east, but none where the fungus is in Scandinavia.

(Total for Question 7 = 8 marks)



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

Trypsin specifically acts on a polypeptide to form amino acids.

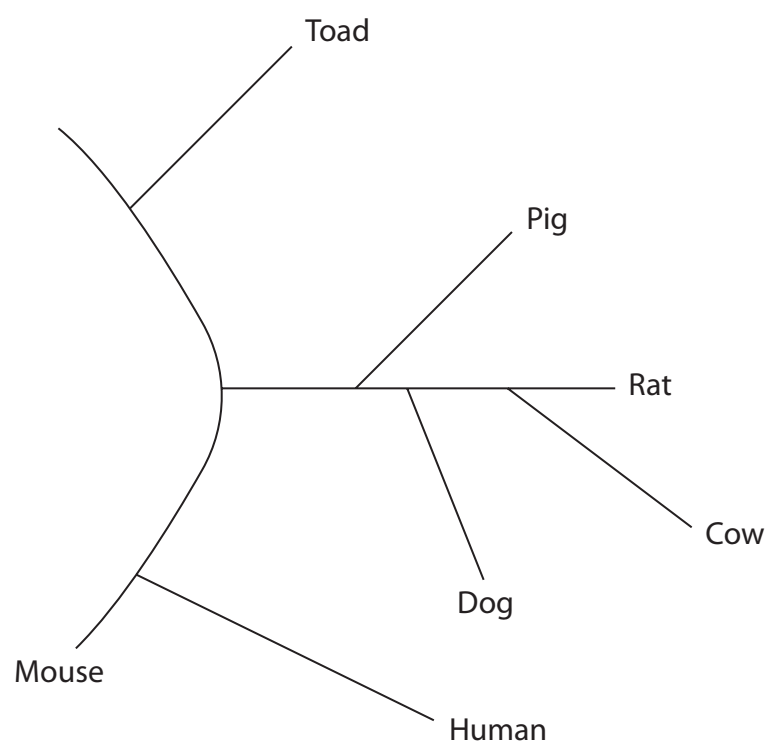
(a) State the type of chemical reaction catalysed by trypsin.

(1)

Hydrolysis

(b) The primary structures of trypsin molecules from different species have been used to produce a phylogenetic tree for trypsin.

Each branch of the following phylogenetic diagram represents trypsin from a different species.



Explain how the primary structure of trypsin molecules can be used to produce a phylogenetic tree.

(3)

Determine the sequence of amino acids in trypsin from each species.

Compare the sequences to determine the number of differences (and similarities) in the amino acid sequences between species.

The greater the number of differences, the less closely related the species are and the longer the time since they shared a common ancestor, so species with the most similar sequences are placed on branches closest together.

- (c) 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)

There was variation in the trypsin gene caused by random mutations.

Some mutations resulted in the production of trypsin with a calcium ion binding site.

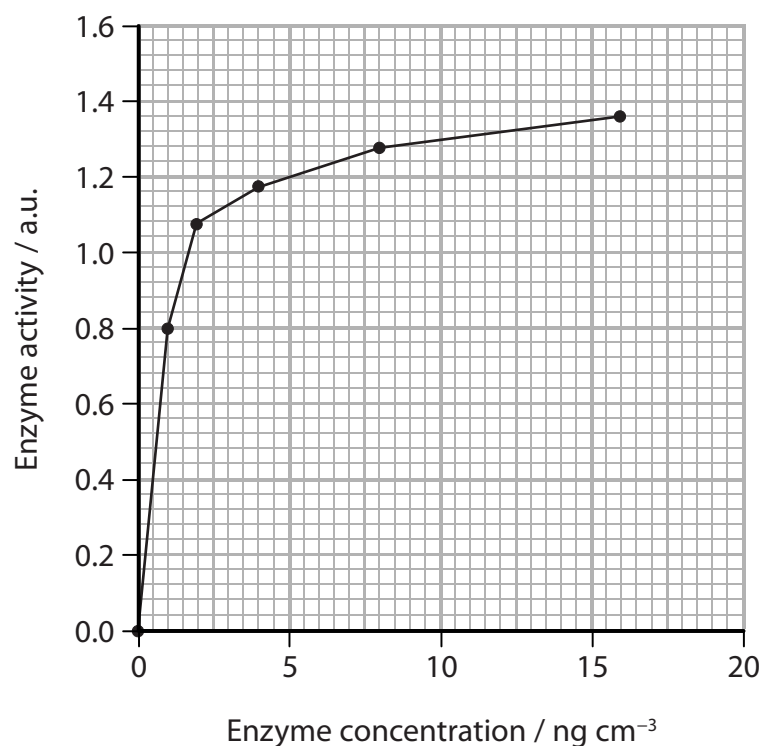
The calcium ion binding site made the enzyme more effective, conferring a selective advantage on those vertebrates.

These vertebrates were more likely to survive, reproduce and pass on this trypsin allele, so the frequency of the allele increased in the population over many generations.



- (d) In an experiment, the effect of enzyme concentration on the activity of human trypsin was measured.

The results are shown in the graph.



Explain which range of enzyme concentrations should be used to compare the activity of trypsin from different species.

(2)

Use enzyme concentrations between 0 and 2.0 ng cm^{-3} , where activity is directly proportional to enzyme concentration, so enzyme concentration is the only limiting factor.

This is because the initial rates of reaction have to be compared; above 2 ng cm^{-3} the curve levels off as substrate becomes limiting.

(Total for Question 8 = 9 marks)



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

(a) In a mature tropical rainforest, there is no net increase in biomass.

(i) Which statement describes the role of photosynthesis in the carbon cycle?

(1)

- ☐ A carbon dioxide is oxidised to form organic molecules
- ☒ B carbon dioxide is reduced to form organic molecules
- ☐ C organic molecules are combusted to produce carbon dioxide
- ☐ D organic molecules are decomposed to release carbon dioxide

(ii) The gross primary productivity (GPP) for one mature tropical rainforest was found to be $24\,800\text{ kJ m}^{-2}\text{ year}^{-1}$. It was estimated that 65% of GPP was used in respiration.

Calculate the energy transferred to the next trophic level.

(2)

$$\text{Percentage not used in respiration} = 100 - 65 = 35\%$$

$$\text{Energy transferred} = 0.35 \times 24\,800$$

$$= 8680$$

$$\text{..... } 8680 \text{ kJ m}^{-2}\text{ year}^{-1}$$

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

(3)

Planting new, young growing trees results in a net uptake of carbon dioxide, as more carbon dioxide is taken in by photosynthesis than released by respiration, so the trees act as a carbon sink.

This reduces carbon dioxide in the atmosphere, reducing the greenhouse effect and slowing the rate of global warming.



P 5 2 2 8 8 A 0 2 7 3 6

(c) Information on biodiversity has been collected from various rainforest habitats in Madagascar.

(i) Describe what needs to be measured in order to compare the biodiversity of two rainforests.

(2)

Count the number of different species in each rainforest (species richness).

Count the number of individuals of each species (population sizes), using the same sampling method and area in both rainforests, so that a diversity index can be calculated and compared.

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(ii) The biodiversity of the land area of Earth has been estimated.

The table shows information on the number of species of plants and vertebrate animals in the rainforests of Madagascar and for the land area of Earth.

Region	Plants		Vertebrate animals		Land area / km ²
	Number of known species	Number of known endemic species	Number of known species	Number of known endemic species	
Madagascar	12 000	9704	987	771	59 300
Land area of the Earth	300 000	300 000	27 300	27 300	149 000 000

Analyse the data to determine the importance of the rainforests of Madagascar in maintaining biodiversity on Earth.

(3)

Madagascar has $12\,000 \div 300\,000 = 4\%$ of the world's plant species and $987 \div 27\,300 = 3.6\%$ of vertebrate species, but only $59\,300 \div 149\,000\,000 = 0.04\%$ of the land area.

So the species density of plants and animals in Madagascar is much higher than for the Earth (about 0.20 plant species per km² compared with 0.002 per km², about 100 times higher).

Also $9704 \div 12\,000 = 80.9\%$ of its plants and $771 \div 987 = 78.1\%$ of its vertebrates are endemic, so many of the species found in Madagascar are not found anywhere else; if these rainforests are lost, these species would become extinct.

(Total for Question 9 = 11 marks)



P 5 2 2 8 8 A 0 2 9 3 6

10 Photosynthesis is a process that occurs in all green plants.

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



(a) (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)

Measured length of starch grain = $27\text{ mm} = 27\,000\text{ }\mu\text{m}$

Magnification = $27\,000 \div 2.2 = 12\,273$

Measured width T to U = $60\text{ mm} = 60\,000\text{ }\mu\text{m}$

Actual width = $60\,000 \div 12\,273 = 4.89\text{ }\mu\text{m}$

4.9 μm



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

(3)

A granum is formed from many layers (a stack) of thylakoid membranes, which provides a large surface area for absorbing light.

The thylakoid membranes contain chlorophyll (photosynthetic pigments in photosystems) to absorb light for the light-dependent reactions.

The membranes also contain electron carrier molecules and ATP synthase, so ATP is produced by photophosphorylation (and NADP is reduced) for the light-independent reactions.

- (b) Describe how starch is formed from the products of the light-independent reactions of photosynthesis.

(4)

Two molecules of GALP (triose phosphate) from the Calvin cycle are used to produce one glucose molecule.

Glucose (α -glucose) molecules are joined together by condensation reactions, releasing water, forming 1,4 glycosidic bonds (and 1,6 glycosidic bonds at branch points) to form starch.

This produces amylose (unbranched and helical) and amylopectin (branched), which are stored as starch grains in the chloroplast.



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*(c) Herbicides kill weeds by affecting their growth.

The effect of herbicides on the production of starch in the leaves of *Echinochloa crus-galli* (barnyard grass) has been investigated.

The table shows the results for four herbicides: Diuron, Propanil, Linuron and Swep.

Concentration of herbicide / $\mu\text{g cm}^{-3}$	Relative percentage of starch produced (%)			
	Diuron	Propanil	Linuron	Swep
0.0	100	100	100	100
0.1	0	50	50	100
1.0	0	0	0	50
10.0	0	0	0	0
100.0	0	0	0	0

It is thought that these herbicides act on the light-dependent reactions of photosynthesis.

Devise an investigation that would produce quantitative data on the effectiveness of the herbicides on the light-dependent reactions of photosynthesis.

(6)

Isolate chloroplasts from barnyard grass leaves of the same age by grinding them in ice-cold buffer solution, filtering and centrifuging; keep the chloroplast suspension on ice. Use the Hill reaction: DCPIP is a blue electron acceptor that is reduced and turns colourless when the light-dependent reactions occur, so the rate of decolourisation measures the rate of the light-dependent reactions.

For each of the four herbicides (Diuron, Propanil, Linuron and Swep) make a range of concentrations focused between 0 and $1 \mu\text{g cm}^{-3}$, e.g. 0, 0.1, 0.2, 0.4, 0.6, 0.8 and $1.0 \mu\text{g cm}^{-3}$, as above $1 \mu\text{g cm}^{-3}$ starch production has almost stopped.

Add the same volume of chloroplast suspension, DCPIP and herbicide solution to each tube.

Control variables: keep temperature constant with a water bath (e.g. 25°C), use a buffer to keep pH constant and keep light intensity constant by placing all tubes the same distance from the same lamp.



Controls: a tube with no herbicide, a tube kept in the dark (wrapped in foil) and a tube with no chloroplasts, to show the colour change is due to the light-dependent reactions.

Quantify the reaction using a colorimeter (red filter) to measure absorbance at fixed time intervals, or record the time taken for the DCPIP to decolourise. Repeat each concentration at least three times and calculate means and standard deviations.

The more effective the herbicide, the longer the time taken to decolourise the DCPIP; the most effective herbicide is the one that inhibits decolourisation at the lowest concentration.

Use a statistical test, e.g. ANOVA, to see whether the differences in effectiveness between the herbicides are significant.

(Total for Question 10 = 15 marks)

TOTAL FOR PAPER = 100 MARKS



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