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Pearson Edexcel
Level 3 GCE

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Biology B

Advanced

**Paper 1: Advanced Biochemistry,
Microbiology and Genetics**

Thursday 7 June 2018 – Morning
Time: 1 hour 45 minutes

Paper Reference

9BI0/01

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 90.
- 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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Answer ALL questions.

Write your answers in the spaces provided.

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 The venom from some species of snake contains enzymes that affect the blood clotting process.

(a) (i) Which is a correct statement about enzymes?

(1)

- ☒ **A** enzymes decrease the activation energy of metabolic reactions and decrease reaction time
- ☐ **B** enzymes decrease the activation energy of metabolic reactions and increase reaction time
- ☐ **C** enzymes increase the activation energy of metabolic reactions and decrease reaction time
- ☐ **D** enzymes increase the activation energy of metabolic reactions and increase reaction time

(ii) Which components of the blood clotting process are active enzymes?

(1)

- ☐ **A** fibrin and thrombin
- ☐ **B** fibrinogen and thrombin
- ☐ **C** fibrinogen and thromboplastin
- ☒ **D** thrombin and thromboplastin

(b) Factor Xa is a clotting factor present in human blood.

The table shows the effect of different masses of Factor Xa and snake venom on the time taken for blood to clot.

Mass added / μg	Time taken for blood to clot / s	
	Factor Xa added	Snake venom added
0.002	150	104
0.004	44	50
0.020	40	38
0.040	39	37



Describe the effect of snake venom on the time taken for the blood to clot.

(2)

Increasing the mass of snake venom decreases the clotting time, from 104 s at 0.002 μg to 37 s at 0.040 μg .

At a small mass (0.002 μg) snake venom gives a shorter clotting time than Factor Xa (104 s compared with 150 s).

At larger masses (0.004 μg and over) the venom has little effect on clotting time compared with Factor Xa.

(c) State the role of platelets in the blood clotting process.

(1)

Platelets stick to the damaged blood vessel wall and form a plug (barrier) that seals the wound to stop bleeding, and they release thromboplastin (clotting factors).

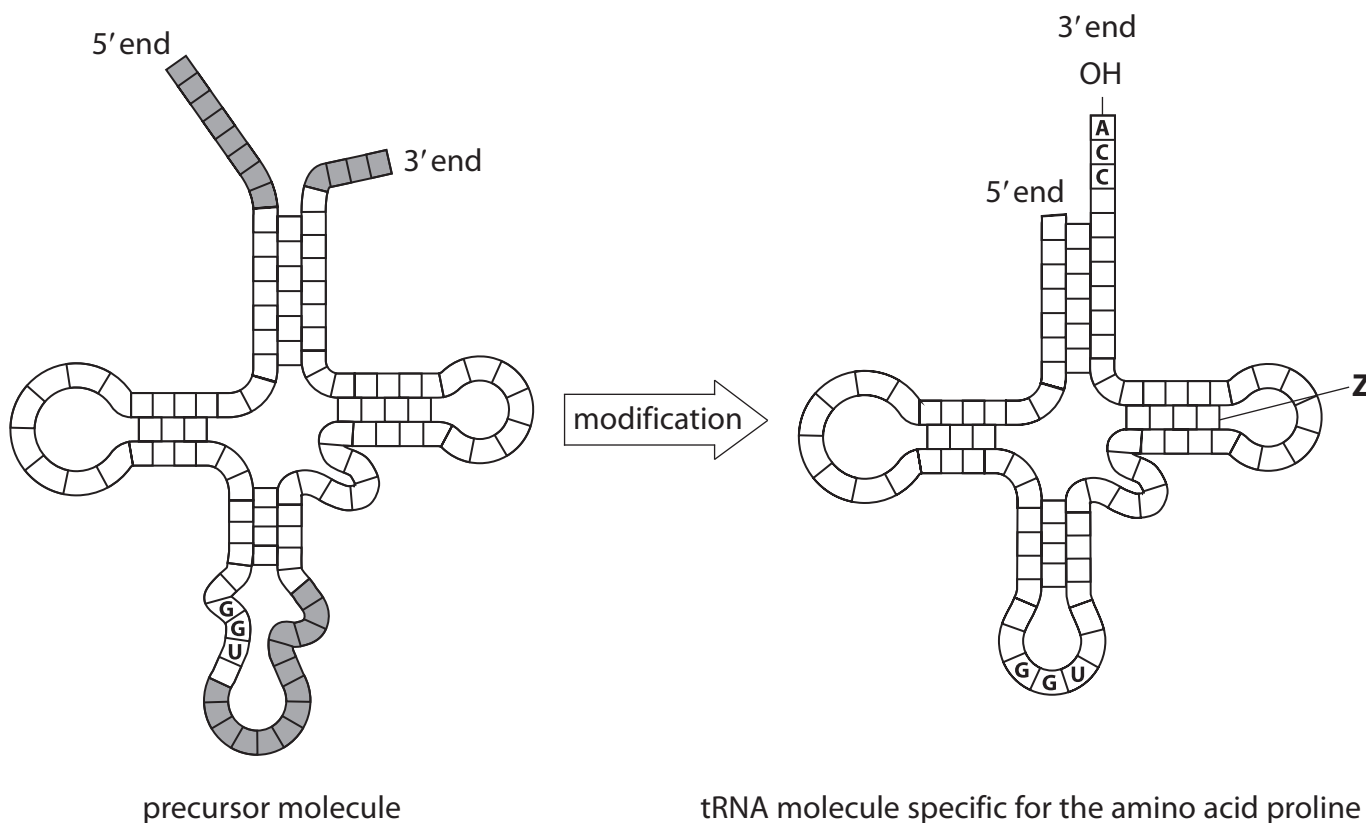
(Total for Question 1 = 5 marks)



P 5 2 2 8 5 A 0 3 2 8

- 2 A molecule of tRNA is made from a precursor molecule that is modified. Modification includes splicing, trimming and attachment of new nucleotides.

The diagram shows a precursor molecule for a tRNA specific for the amino acid proline, and a tRNA molecule specific for the amino acid proline. Some of the bases are shown in each diagram.



(a) Which bond is labelled **Z**?

(1)

- ☐ A glycosidic
- ☒ B hydrogen
- ☐ C peptide
- ☐ D phosphodiester

- (b) Describe how this precursor molecule is modified to produce a tRNA molecule specific for the amino acid proline.

(3)

The shaded nucleotides (introns) are removed from the precursor molecule by splicing and trimming.

New nucleotides, ACC (and the OH), are attached at the 3' end to form the amino acid binding site (acceptor stem).

The remaining nucleotides are joined together by phosphodiester bonds.

- (c) (i) Which of the following base sequences is the mRNA code for proline?

(1)

- ☐ A AAT
- ☒ B CCA
- ☐ C CCT
- ☐ D CCU

- (ii) Which of the following base sequences is the DNA code for proline?

(1)

- ☐ A ACC
- ☐ B CCA
- ☒ C GGT
- ☐ D UGG

(Total for Question 2 = 6 marks)



P 5 2 2 8 5 A 0 5 2 8

3 The photograph shows an adult mayfly.



(a) *Rhithrogena germanica* is commonly known as the March brown mayfly.

The classification hierarchy for this mayfly is: Animalia
Arthropoda
Insecta
Ephemeropteroidea
Heptageniidae
Rhithrogena germanica

(i) State the genus of this mayfly.

(1)

Rhithrogena

(ii) This mayfly belongs to the phylum Arthropoda.

Which is the order for this mayfly?

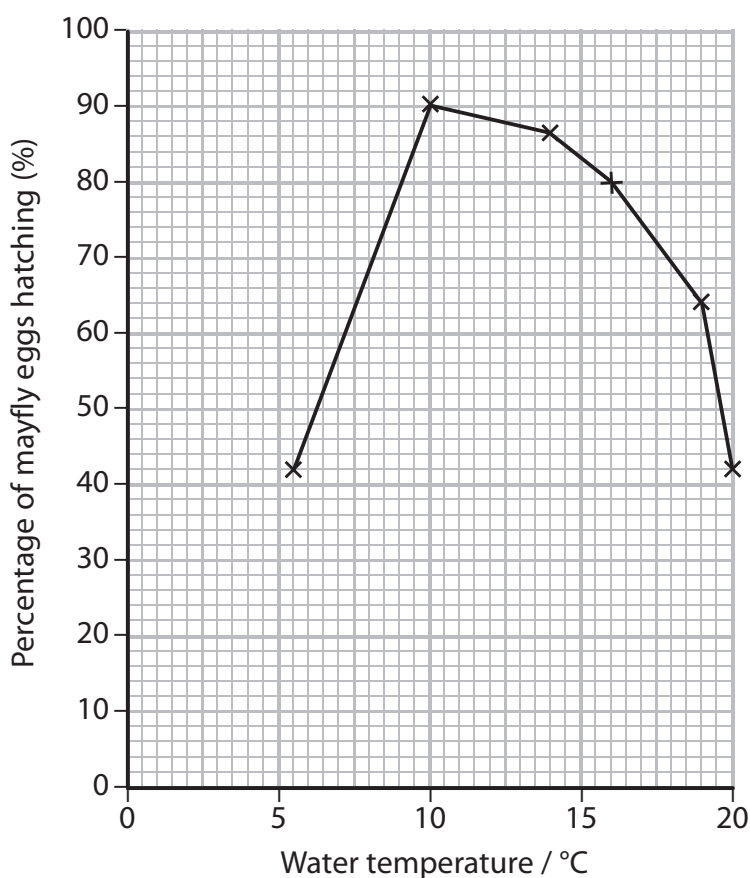
(1)

- ☐ A Animalia
- ☒ B Ephemeropteroidea
- ☐ C Heptageniidae
- ☐ D Insecta



(b) Mayflies lay their eggs in water.

The graph shows the effect of water temperature on the percentage of mayfly eggs that hatch.



Explain the effect of temperature on the percentage of mayfly eggs that hatch.

(4)

As the temperature increases from about 5 °C to 10 °C the percentage of eggs hatching increases to a maximum of 90% at 10 °C, then it decreases to about 42% at 20 °C.

Hatching (the development and growth of the embryo) depends on enzyme activity.

Below 10 °C, increasing the temperature gives the enzyme and substrate molecules more kinetic energy, so there are more successful collisions and more enzyme-substrate complexes form.

Above 10 °C the temperature is too high, so the enzymes are denatured: the shape of the active site changes and the substrate can no longer bind.

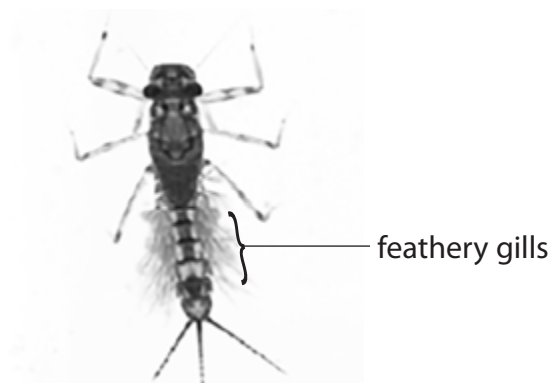
Also, warmer water holds less dissolved oxygen, so less oxygen is available to the eggs for aerobic respiration.



P 5 2 2 8 5 A 0 7 2 8

- (c) Mayfly eggs hatch into immature insects called nymphs. The nymphs live in the water and develop to form adult mayflies.

The photograph shows a mayfly nymph.



Compare and contrast the structure of the gas exchange system of the mayfly nymph with the adult mayfly.

(3)

Similarities: both have a large surface area for gas exchange, and both have a thin exchange surface giving a short diffusion distance.

Differences: the nymph has feathery gills, whereas the adult has spiracles and tracheae.

The nymph's gas exchange system is external (gills on the outside of the body), whereas the adult's system is internal (tracheae and tracheoles inside the body).

(Total for Question 3 = 9 marks)

4 Mitochondria can be extracted from liver cells.

In order to monitor the purification of a sample of mitochondria, a protein concentration : enzyme activity ratio can be determined.

(a) Describe the structure of a globular protein.

(2)

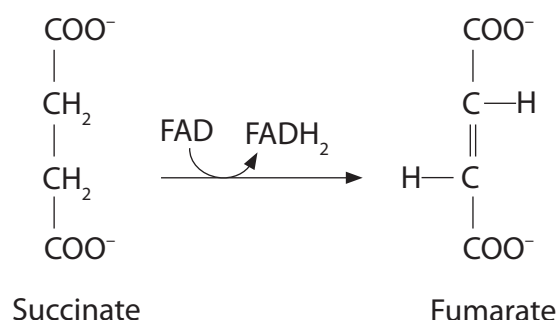
A globular protein has a tertiary structure; the polypeptide chain is folded into a compact, spherical three-dimensional shape (some also have a quaternary structure).

This shape is held by hydrogen bonds, ionic bonds and disulfide bridges between R groups.

Hydrophilic R groups are on the outside of the molecule and hydrophobic R groups are in the centre, so it is soluble in water.

(b) The enzyme used to monitor the purification of mitochondria is succinate dehydrogenase.

This enzyme is involved in the Krebs cycle and converts succinate into fumarate in this reaction.



(i) When succinate is converted into fumarate, succinate is

(1)

- ☐ A hydrolysed
- ☒ B oxidised
- ☐ C phosphorylated
- ☐ D reduced

(ii) Explain the role of the Krebs cycle.

(4)

The Krebs cycle completely oxidises acetyl coenzyme A (from pyruvate, from glucose), releasing carbon dioxide.

This releases as much energy as possible from the respiratory substrate.

It generates ATP directly, by substrate-level phosphorylation.

It produces reduced coenzymes: reduced NAD (NADH) and reduced FAD (FADH₂).

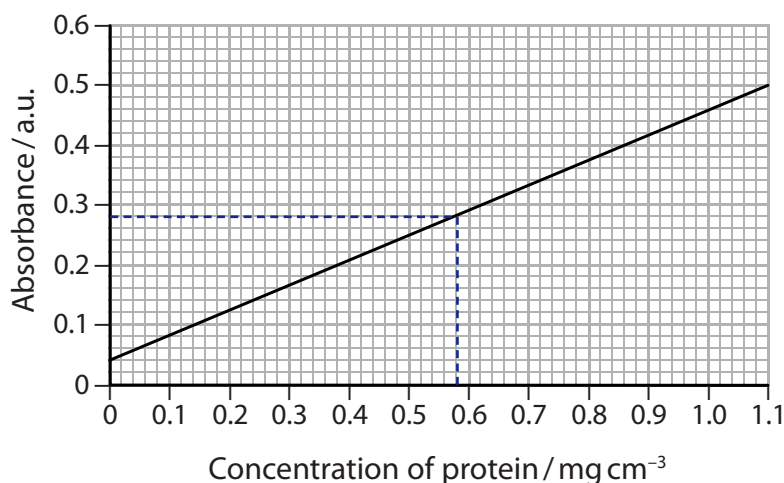
These carry hydrogen to the electron transport chain, so that a large amount of ATP can be produced by oxidative phosphorylation.

It also regenerates oxaloacetate so that the cycle can continue.

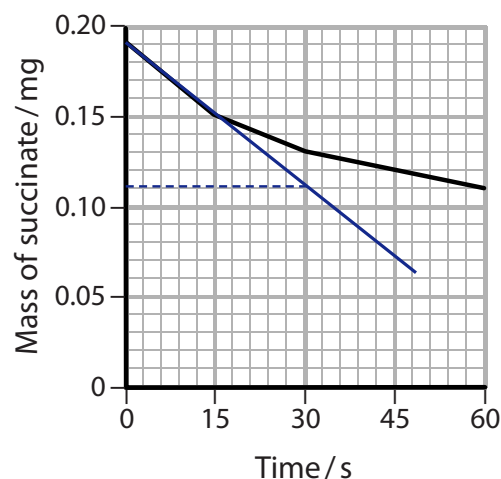
(c) Protein concentrations can be determined by using a calibration curve, shown in graph 1.

The initial rate of activity of succinate dehydrogenase, from a sample of mitochondria, can be determined using graph 2.

Graph 1



Graph 2



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- (i) This sample of mitochondria had an absorbance of 0.28 when the protein concentration was measured.

Determine the protein concentration of this sample of mitochondria.

(1)

Answer 0.58 mg cm^{-3}

- (ii) Determine the initial rate of enzyme activity to obtain the protein : enzyme activity ratio for this sample of mitochondria.

(2)

tangent drawn at $t = 0$ on graph 2:

$$\text{initial rate} = (0.19 - 0.11) \div 30 = 0.0027 \text{ mg s}^{-1}$$

$$\text{ratio} = 0.58 : 0.0027$$

Ratio $214.8 : 1$

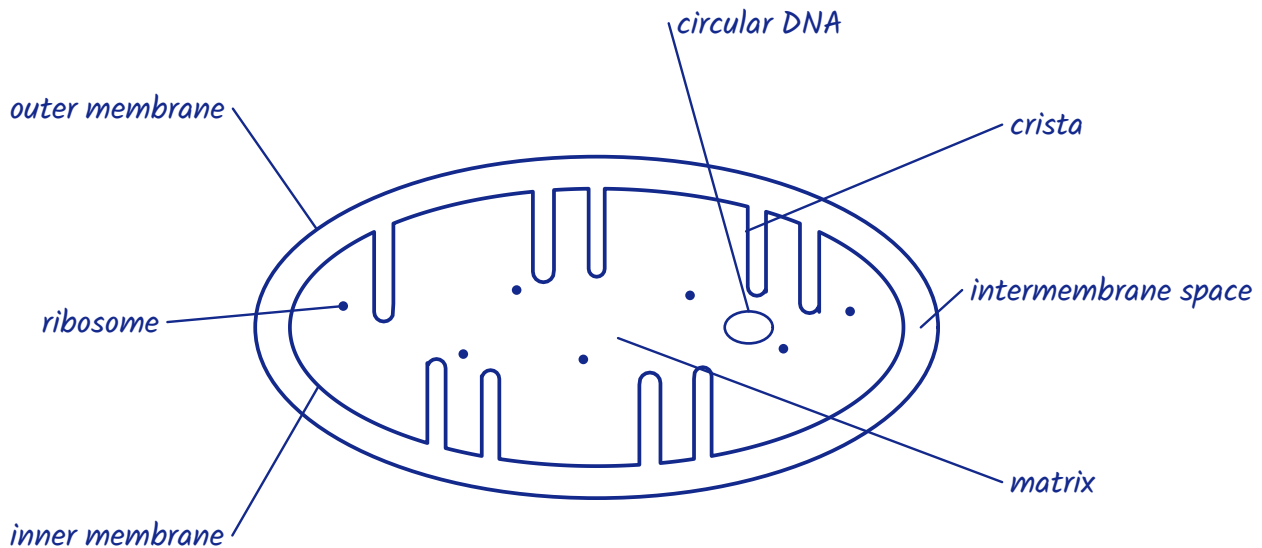
(Total for Question 4 = 10 marks)



- 5 Leigh syndrome is a genetic disorder inherited from the mother. The mother carries genes for the disorder in her mitochondrial DNA.

(a) Draw and label a mitochondrion.

(4)



- (b) Scientists have developed a technique for producing 'three-parent' babies.

This ensures that a mother with Leigh syndrome will not pass on the genes for this disorder to her baby.

The technique involves:

- removing the nucleus from the ovum of the mother
- removing the nucleus from the ovum of a donor female to produce an enucleated ovum
- inserting the nucleus from the ovum of the mother into the enucleated donor ovum
- fertilising this ovum with the sperm of the father to produce a zygote
- implanting the resulting embryo into the uterus of the mother.



- (i) The 'three-parent' baby produced by this technique will inherit mitochondrial DNA from the

(1)

- ☒ A donor female
☐ B donor female and father
☐ C mother
☐ D mother and father

- (ii) Explain the importance of DNA replication during the development of this zygote into a blastocyst.

(3)

The zygote divides by mitosis many times to form the blastocyst.

Before each division the DNA replicates (semi-conservatively), making identical copies of the DNA molecules (two identical sister chromatids).

So all the cells in the blastocyst are genetically identical and diploid, with two copies of each chromosome (46 chromosomes).

Mitochondrial DNA from the donor also replicates, so that when the mitochondria divide each one has a copy of the DNA, which does not contain the Leigh syndrome genes.

(Total for Question 5 = 8 marks)



6 During the development of active immunity, macrophages present antigens to T helper cells.

(a) Describe how macrophages present antigens to T helper cells.

(2)

The macrophage engulfs the pathogen by phagocytosis, then presents the antigen on its cell surface membrane, bound to an MHC protein.

A T helper cell with a complementary CD4 receptor binds to the antigen-MHC complex on the macrophage.

(b) In an investigation into clonal selection, macrophages and T cells were isolated from two strains of guinea pig, strain 2 and strain 13.

The macrophages from each strain of guinea pig were exposed to an antigen and treated with mitomycin.

Mitomycin forms cross links between complementary strands of DNA.

These macrophages were then cultured with T cells from each of the strains of guinea pig for 72 hours.

Radioactive thymidine was included in the culture. This molecule will become incorporated into DNA during DNA replication instead of thymine.

The table shows the results of this investigation.

Source of macrophages	Level of radioactive thymidine incorporated into T cells / a.u.	
	T cells from strain 2 guinea pigs	T cells from strain 13 guinea pigs
strain 2	180	13
strain 13	17	59

(i) Explain why the macrophages were treated with mitomycin.

(3)

Mitomycin cross-links the DNA strands, so it prevents the DNA from unwinding and separating, so DNA replication cannot occur.

Therefore the macrophages cannot divide by mitosis, so the number of macrophages remains constant.

So radioactive thymidine is incorporated into the T cells only, and any cell division can be attributed to the T cells only.



(ii) Explain how radioactive thymidine becomes incorporated into the DNA.

(2)

During DNA replication, the radioactive thymidine nucleotide forms hydrogen bonds with the complementary adenine on the template strand.

DNA polymerase then joins it to adjacent nucleotides by phosphodiester bonds, forming the sugar-phosphate backbone of the new strand.

(iii) Analyse the data to explain the results of this investigation.

(4)

Most radioactive thymidine was incorporated into T cells from the same strain as the macrophages (180 a.u. for strain 2 and 59 a.u. for strain 13), but only 13 and 17 a.u. when the strains were mixed.

This shows that these T cells were dividing more by mitosis (clonal selection).

This is because the MHC (with antigen) and CD4 receptors bind together better, so antigen presentation is improved (better recognition).

This is due to genetic compatibility: the MHC proteins are self-antigens to T cells of the same strain.

Strain 2 macrophages are better antigen presenters, as strain 2 T cells proliferated faster (180 a.u.) than strain 13 T cells (59 a.u.).

(Total for Question 6 = 11 marks)



7 Xylem and phloem are involved in transport in plants.

- (a) (i) Which row of the table shows some of the substances transported in xylem and phloem?

(1)

	Xylem	Phloem
☐ A	water only	sucrose only
☐ B	water only	water and sucrose
☐ C	water and mineral ions	sucrose only
☒ D	water and mineral ions	water and sucrose

- (ii) Describe the differences between the structure of xylem and that of phloem.

(3)

Xylem cell walls contain cellulose and lignin (lignified), but phloem cell walls contain only cellulose (no lignin).

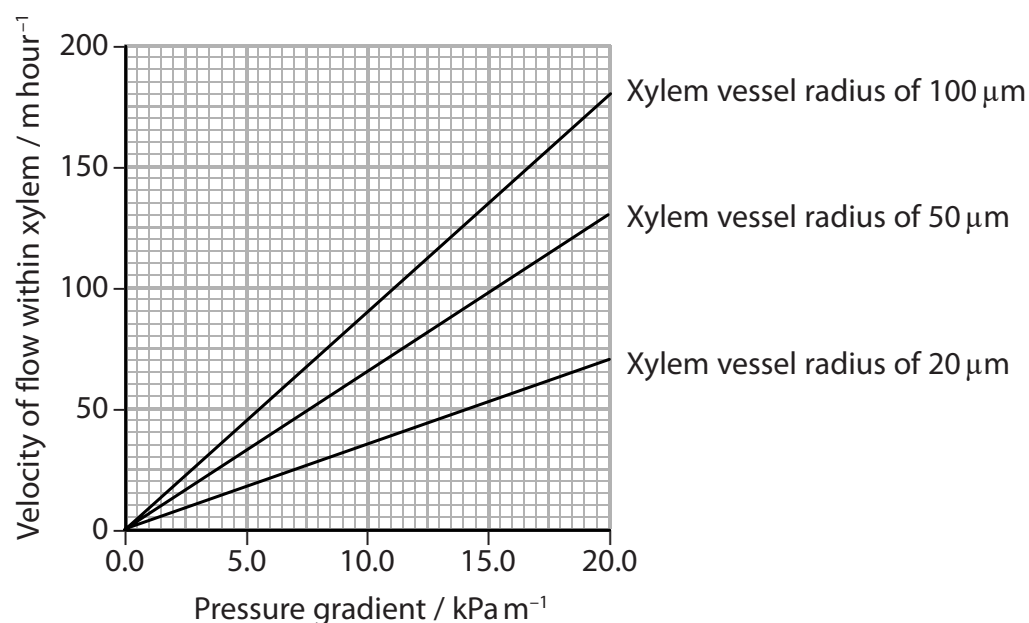
Xylem vessels are hollow with no end walls, but phloem sieve tubes have cell contents and sieve plates.

Xylem has pits, but phloem does not.

Xylem is dead and has no companion cells, but phloem has companion cells.



- (b) The graph shows the effect of pressure gradient on the velocity of flow within three xylem vessels.



- (i) Describe the effect of pressure gradient and radius on the velocity of flow within the xylem vessels.

(2)

As the pressure gradient increases, the velocity of flow increases linearly, for all three radii.

As the radius of the xylem vessel increases, the velocity of flow increases.

- (ii) Calculate the percentage increase in the velocity of water flowing through a xylem vessel of radius 20 μm and a xylem vessel of radius 100 μm , at a pressure gradient of 17.5 kPa m^{-1} .

(2)

at 17.5 kPa m^{-1} : 100 μm vessel = 156 and 20 μm vessel = 61 m hour^{-1}

% increase = $(156 - 61) \div 61 \times 100 = 155.7\%$

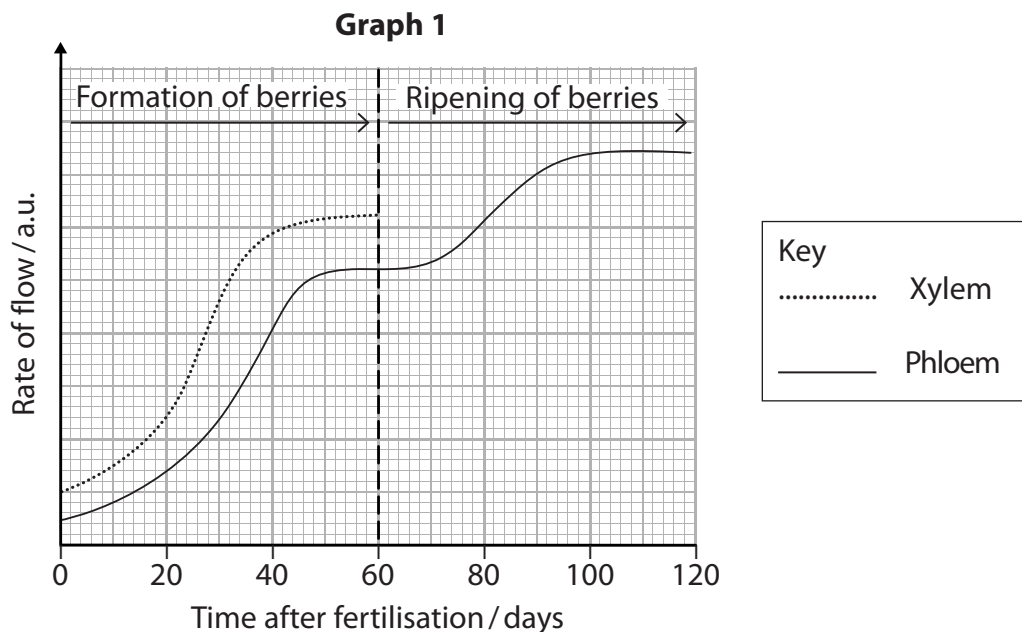
Answer 155.7%



*(c) Double fertilisation in some plants leads to the development of fruits, such as berries.

In an investigation, the rate of flow in xylem during the formation of berries was measured. The rate of flow in the phloem during the formation and ripening of the berries was also measured.

The results are shown in graph 1.

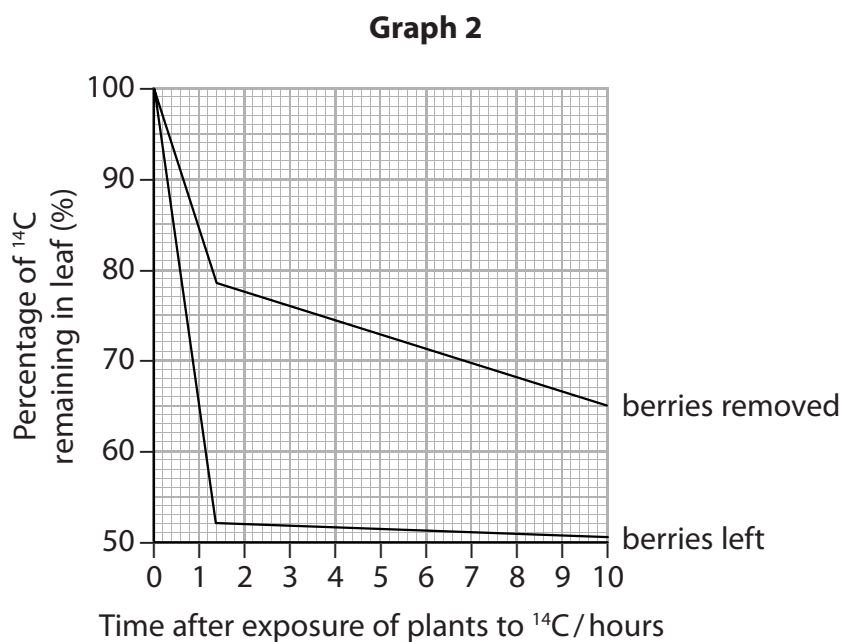


In a second investigation, two plants with berries were exposed to radioactive carbon dioxide (^{14}C).

After exposure to ^{14}C , the berries were removed from one plant and left on the second plant.

The percentage of ^{14}C remaining in the leaves of each plant was determined during the next 10 hours.

The results are shown in graph 2.



Analyse the data to explain the role of double fertilisation, xylem and phloem in the development of the berries.

(6)

Double fertilisation: one male gamete nucleus fuses with the female gamete (egg cell) nucleus to form a diploid zygote, which develops into the embryo.

The other male gamete nucleus fuses with both polar nuclei to form a triploid endosperm nucleus, so endosperm forms as a store of starch, protein and oils.

The ovules become the seeds inside the berries.

Graph 1: xylem flow increases rapidly from 20 to 50 days during berry formation, so xylem transports the water needed for berry formation and for hydrolysis of food stores, and mineral ions such as nitrate.

Phloem flow increases during formation, levels off at 50 to 70 days and increases again during ripening, so phloem transports the sucrose needed for berry formation and ripening.

Graph 2: ^{14}C is incorporated into glucose during photosynthesis, which is converted into sucrose for transport in the phloem.

With berries left, ^{14}C in the leaf falls to about 52% within 1 hour, but with berries removed only to 78%, and 65% at 10 hours. So more sucrose is transported from the leaves when berries are present, as the berries are a sink.

(Total for Question 7 = 14 marks)



8 *Salmonella* are Gram negative bacteria found in the large intestine of humans.

(a) Which is the correct statement about *Salmonella*?

(1)

- ☐ A *Salmonella* has a thick peptidoglycan cell wall and produces endotoxins
- ☐ B *Salmonella* has a thick peptidoglycan cell wall and produces exotoxins
- ☒ C *Salmonella* has a thin peptidoglycan cell wall and produces endotoxins
- ☐ D *Salmonella* has a thin peptidoglycan cell wall and produces exotoxins

(b) A scientist studied the growth of *Salmonella*.

- (i) *Salmonella* was isolated from a mixed culture of bacteria, using streak plating onto selective media.

Explain why this is a suitable method for isolating the *Salmonella*.

(4)

The selective medium allows only Salmonella (certain bacteria) to grow, as it contains substances that inhibit the growth of other bacteria.

Streaking spreads the culture out across the surface of the agar, which separates out individual bacteria.

So the colonies that grow are discrete (separate), each from a single cell.

So only one type of bacteria (a single colony) can be picked up, giving a pure culture.



- (ii) The scientist made a broth culture of *Salmonella* at a concentration of 5×10^3 cells per cm^3 .

Ten hours later the concentration of *Salmonella* was 4×10^6 per cm^3 .

Calculate the exponential growth rate constant (k) for this culture of *Salmonella* using the formula

(3)

$$k = \frac{\log_{10} N_t - \log_{10} N_0}{0.301 \times t}$$

$$\log_{10}(4 \times 10^6) = 6.602$$

$$\log_{10}(5 \times 10^3) = 3.699$$

$$k = (6.602 - 3.699) \div (0.301 \times 10)$$

$$= 2.903 \div 3.01 = 0.964$$

Answer 0.964

- (iii) In this calculation, the scientist did not allow for the time that the *Salmonella* spent in the lag phase.

Explain the effect that this will have on the calculated value for the growth rate constant.

(3)

The value of t used in the calculation (10 hours) is greater than the actual time the bacteria spent growing exponentially.

Therefore the calculated value for k will be smaller than the actual value.

This is because during the lag phase the *Salmonella* are not replicating (dividing), as they are adjusting to the medium and synthesising enzymes.

(Total for Question 8 = 11 marks)



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9 Soya beans are an important crop for the production of food and oil.

- (a) In the 2012 to 2013 growing season, production of soya beans was highest in the United States and second highest in Brazil.

The United States produced 93 million tonnes of soya beans from 31 million hectares.

This was 9.4% more than Brazil produced from 28 million hectares.

Calculate the difference in the yield per hectare of soya beans from these two countries.

(3)

$$\text{Brazil} = (93 \text{ million} \times 100) \div 109.4 = 85.01 \text{ million tonnes}$$

$$\text{US yield} = 93 \text{ million} \div 31 \text{ million} = 3.000 \text{ tonnes per hectare}$$

$$\text{Brazil yield} = 85.01 \text{ million} \div 28 \text{ million} = 3.036 \text{ tonnes per hectare}$$

$$\text{difference} = 3.036 - 3.000 = 0.036 \text{ tonnes per hectare}$$

(Brazil's yield is higher than the US yield)

Answer 0.036 t per hectare



(b) Soya beans can be genetically modified to form transgenic plants.

A study of the nutritional content of soya beans from non-transgenic soya bean plants and from transgenic soya beans plants was carried out in two regions of Brazil.

The regions were Ponta Grossa and Londrina.

Tables 1 and 2 show the results of this study.

Table 1

Type of plant	Region	Mean mineral content / mg per 100 g dried soya beans		
		Iron	Copper	Manganese
Non-transgenic	Ponta Grossa	3.34	0.76	1.38
Transgenic	Ponta Grossa	3.44	0.86	1.40
Non-transgenic	Londrina	4.59	1.35	2.20
Transgenic	Londrina	4.15	1.25	2.02

Table 2

Type of plant	Region	Mean organic content / mg per 100 g dried soya beans		
		Protein	Lipid	Carbohydrate
Non-transgenic	Ponta Grossa	38.61	21.09	23.88
Transgenic	Ponta Grossa	38.80	21.19	23.41
Non-transgenic	Londrina	41.68	18.56	25.74
Transgenic	Londrina	40.62	19.87	25.26



- * (i) Analyse the data to assess the nutritional content of soya beans from transgenic and from non-transgenic soya bean plants grown in these two regions.

(6)

Table 1: in Ponta Grossa, transgenic soya beans have a higher mineral content than non-transgenic beans (e.g. iron 3.44 compared with 3.34 mg per 100 g).

In Londrina, transgenic beans have a lower mineral content than non-transgenic beans (e.g. iron 4.15 compared with 4.59).

Both types grown in Londrina have more iron, copper and manganese than both types grown in Ponta Grossa.

Table 2: in Ponta Grossa, transgenic beans have higher protein and lipid but lower carbohydrate than non-transgenic beans.

In Londrina, transgenic beans have higher lipid but lower protein and carbohydrate than non-transgenic beans.

Both types from Londrina have more protein and carbohydrate but less lipid than both types from Ponta Grossa.

Conclusions: Londrina soya beans are generally the most nutritious. In Londrina non-transgenic beans are more nutritious, while in Ponta Grossa transgenic beans are more nutritious. However, the differences are very small, so there is very little difference in nutritional content overall.



- (ii) The soil in Londrina is more fertile than the soil in Ponta Grossa. Londrina has higher temperatures and rainfall during the growing season.

Explain the differences in the nutritional content of soya beans grown in these two regions.

(5)

Londrina has more fertile soil, so the soya beans have a higher mineral ion content (iron, copper and manganese).

The fertile soil also has more nitrates, needed to make amino acids, so the beans have a higher protein content. More magnesium ions for chlorophyll also means faster photosynthesis.

Londrina has higher temperatures, so photosynthesis (the Calvin cycle and carbon fixation) is faster, as enzymes such as RUBISCO have more kinetic energy and increase the rate of reaction.

Therefore more organic molecules, such as carbohydrates and proteins, are made.

Londrina has higher rainfall, so more water is available for photolysis in the light-dependent reactions and for the transport of minerals.

- (iii) Explain why this study also analysed the types of fatty acid found in soya beans from transgenic plants and from non-transgenic plants.

(2)

To compare the fatty acids in the two types of soya bean, e.g. to see if transgenic beans have less saturated fatty acid, less linoleic acid and more oleic acid.

So that the transgenic soya beans would be less likely to increase the risk of heart disease, and less likely to oxidise and go rancid.

(Total for Question 9 = 16 marks)

TOTAL FOR PAPER = 90 MARKS



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