A-level
BIOLOGY
(7402/1)

Paper 1

Specimen 2014 Session Time allowed: 2 hours

Materials

For this paper you must have:
- a ruler with millimetre measurements
- a calculator.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the bottom of this page.
- Answer **all** questions.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 91.

Please write clearly, in block capitals, to allow character computer recognition.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

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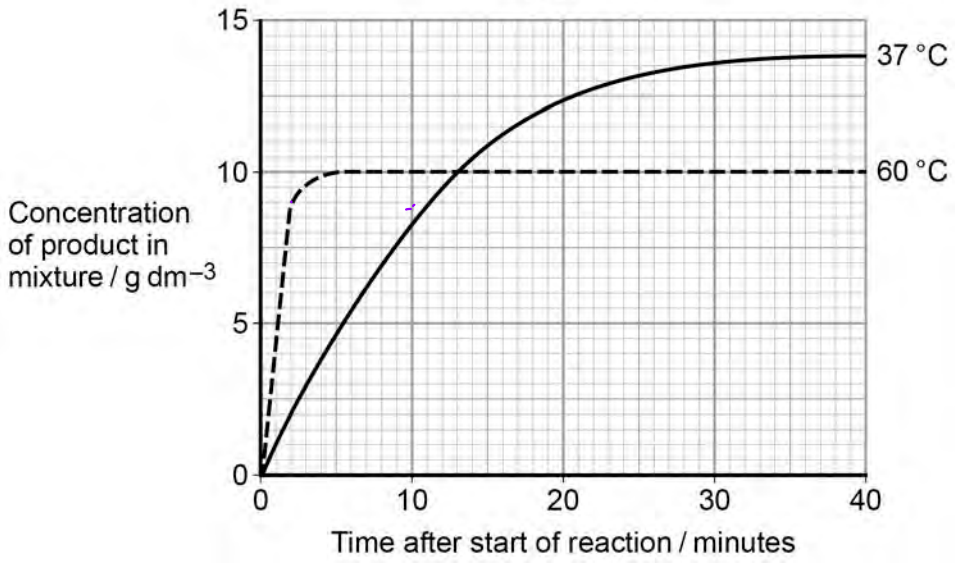
Candidate signature _____

Answer **all** questions in the spaces provided.

1 A technician investigated the effect of temperature on the rate of an enzyme-controlled reaction. At each temperature, he started the reaction using the same concentration of substrate.

Figure 1 shows his results.

Figure 1



0 1 . 1 Give **two** other factors the technician would have controlled.

[1 mark]

1 Concentration of enzyme Vol. of substrate

2 pH

0 1 . 2 Draw a tangent on each curve to find the initial rates of reaction.
Use these values to calculate the ratio of the initial rates of reaction at 60 °C : 37 °C.
Show your working.

[2 marks]

@37°C

$\frac{dy}{dx} = \frac{8.75}{10}$

$= 0.875$

@60°C

$\frac{dy}{dx} = \frac{9}{2} = 4.5$

$\frac{4.5}{0.875} = 5.14$

Ratio = 5.14 :1

0 1 . 3 Explain the difference in the initial rate of reaction at 60 °C and 37 °C.

[2 marks]

At 60°C there is more kinetic energy within the particles and so there are more frequent collisions between enzyme and substrate and so more enzyme-substrate complexes form.

0 1 . 4 Explain the difference in the rates of reaction at 60 °C and 37 °C between 20 and 40 minutes.

[4 marks]

At 60°C, this high temperature has caused denaturation of all enzymes causing a permanent change to the active site causing the reaction to stop. However there is still substrate available when all the enzymes have denatured but aren't converted into product so concentration remains constant.

[Extra space]

0 2 . 1 Describe how oxygen in the air reaches capillaries surrounding alveoli in the lungs. Details of breathing are **not** required.

[4 marks]

Air is taken in through the mouth and nose. Air moves through the trachea and then the bronchi, and then the bronchioles ✓ down the pressure gradient ✓. Air then moves down the diffusion gradient ✓ from an area of high concentration to low concentration across the diffusion gradient. Air moves across the alveolar epithelium ✓ via diffusion as well as across the capillary endothelium ✓ and into the alveoli.

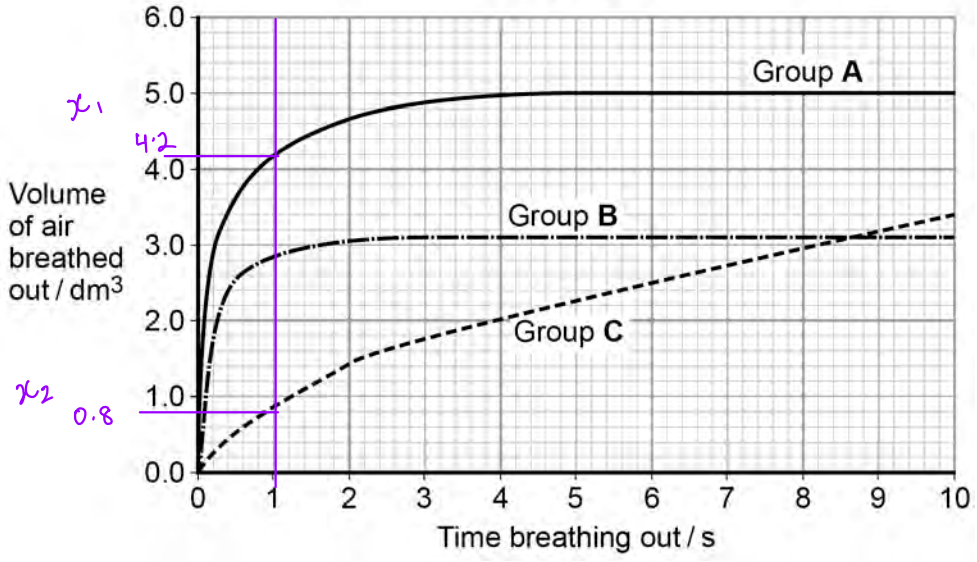
[Extra space]

Forced expiratory volume (FEV) is the greatest volume of air a person can breathe out in 1 second.

Forced vital capacity (FVC) is the greatest volume of air a person can breathe out in a single breath.

Figure 2 shows results for the volume of air breathed out by three groups of people, **A**, **B** and **C**. Group **A** had healthy lungs. Groups **B** and **C** had different lung conditions that affect breathing.

Figure 2



0 2 . 2 Calculate the percentage drop in FEV for group **C** compared with the healthy people. group A **[1 mark]**

$x_1 = 4.2$

$x_2 = 0.8$

$\frac{0.8 - 4.2}{4.2}$

$= -0.809$

perc. decrease $= \frac{x_2 - x_1}{x_1}$

$= -0.809 \times 100$

$= -80.952\%$

Answer = 81%.

0 2 . 3 Asthma affects bronchioles and reduces flow of air in and out of the lungs. Fibrosis does not affect bronchioles; it reduces the volume of the lungs.

Which group, **B** or **C**, was the one containing people with fibrosis of their lungs? Use the information provided and evidence from **Figure 2** to explain your answer. **[3 marks]**

Group B are the ones containing people with fibrosis of their lungs as they have a similar FEV to group A. Therefore the bronchioles aren't affected. However, the total volume breathed out has been reduced, and so this provides evidence to suggest it's group B.

[Extra space]

3 Species richness and an index of diversity can be used to measure biodiversity within a community.

0 3 . 1 What is the difference between these two measures of biodiversity?

[1 mark]

Species richness measures only the number of different species and does not measure the number of individuals.

Scientists investigated the biodiversity of butterflies in a rainforest. Their investigation lasted several months.

The scientists set one canopy trap and one understorey trap at five sites.

- The canopy traps were set among the leaves of the trees 16–27 m above ground level.
- The understorey traps were set under trees at 1.0–1.5 m above ground level.

The scientists recorded the number of each species of butterfly caught in the traps. **Table 1** summarises their results.

Table 1

Species of butterfly	Mean number of butterflies		P value
	In canopy	In understorey	
Prepona laertes	15	0	< 0.001
Archaeoprepona demophon	14	37	< 0.001
Zaretis itys	25	11	> 0.05
Memphis arachne	89	23	< 0.001
Memphis offa	21	3	< 0.001
Memphis xenocles	32	8	< 0.001

N = 196 N = 82

0 3 . 2 The traps in the canopy were set at 16–27 m above ground level. Suggest why there was such great variation in the height of the traps.

[1 mark]

The trees varied in neight

0 3 . 3 By how many times is the species diversity in the canopy greater than in the understorey? Show your working.

Use the following formula to calculate species diversity.

$$d = \frac{N(N-1)}{\sum n\,(n-1)}$$

where N is the total number of organisms of all species and n is the total number of organisms of each species.

[3 marks]

Canopy
N = 196

understorey
N = 82

$\frac{196(196-1)}{10236}$

= 3·73

$\frac{82(82-1)}{2010}$

= 3·30

$\frac{3·73}{3·30}$

= 1·13 times bigger

Answer = 1·13

0 3 . 4 The scientists carried out a statistical test to see if the difference in the distribution of each species between the canopy and understorey was due to chance. The P values obtained are shown in **Table 1**.

Explain what the results of these statistical tests show.

[3 marks]

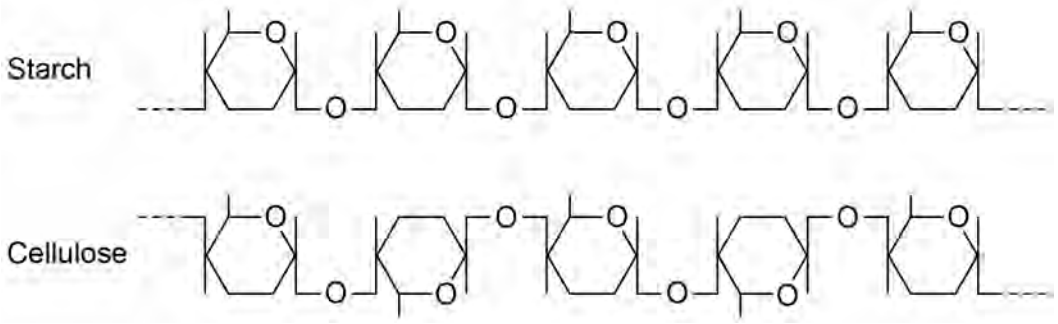
The zanetis ityus difference in distribution is most likely due to chance ✓ as the probability is greater than 5%. All other species have a very unlikely chance of being distributed ✓ differently due to the very low P value that holds high

[Extra space] significance ✓

4 Starch and cellulose are two important plant polysaccharides.

Figure 3 shows part of a starch molecule and part of a cellulose molecule.

Figure 3



0 4 . 1 Explain the difference in the structure of the starch molecule and the cellulose molecule shown in **Figure 3**.

[2 marks]

- Starch is formed from α-glucose monomers, but cellulose is formed from β-glucose monomers.
- Each adjacent glucose molecule is inverted 180° due to a change in the position of the hydrogen and hydroxyl groups.

0 4 . 2 Starch molecules and cellulose molecules have different functions in plant cells. Each molecule is adapted for its function.

Explain **one** way in which starch molecules are adapted for their function in plant cells.

[2 marks]

Starch molecules are helical which enables compactness, in order to save space.

insoluble - doesn't affect the water potential gradient

large molecule - cannot leave the cell

0 4 . 3 Explain how cellulose molecules are adapted for their function in plant cells.

[3 marks]

The adjacent inverted glucose monomers within the cellulose molecule provide for long and straight chains to be produced. The inversion of glucose molecules allow for hydrogen bonding to form being the hydroxyl groups of adjacent parallel chains. This allows for fibrils to form, that increases the structural stability of the cellulose molecule, allowing it to be used to strengthen the cell wall in plant cells.

[Extra space]

0 5 . 1 Contrast the processes of facilitated diffusion and active transport.

[3 marks]

Facilitated diffusion is a passive process and doesn't involve the use of ATP, whereas active transport is an active process and involves ATP. Facilitated diffusion takes place down a concentration gradient (high to low), whereas active transport works against the concentration gradient (low to high). Facilitated diffusion involves both carrier and channel proteins, but active transport only involves carrier proteins.

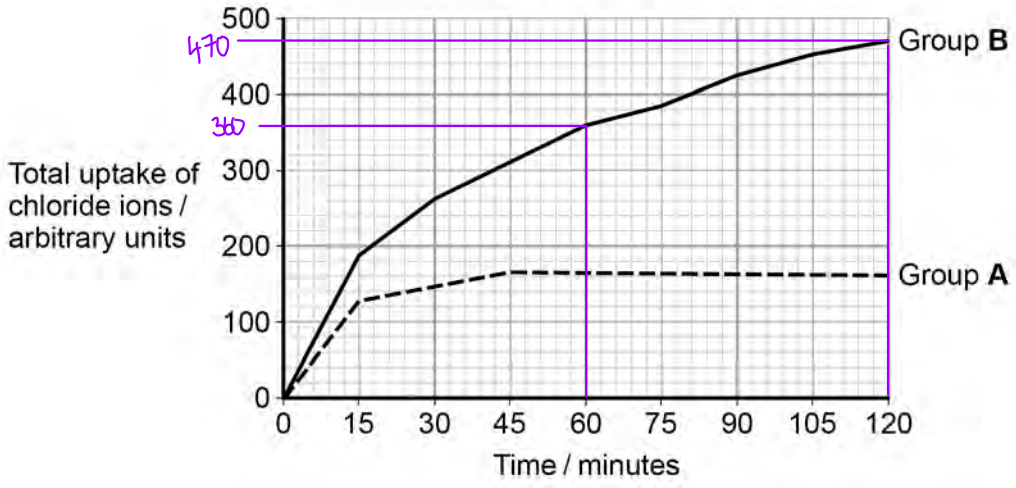
[Extra space]

Students investigated the uptake of chloride ions in barley plants. They divided the plants into two groups and placed their roots in solutions containing radioactive chloride ions.

- Group **A** plants had a substance that inhibited respiration added to the solution.
- Group **B** plants did not have the substance added to the solution.

The students calculated the total amount of chloride ions absorbed by the plants every 15 minutes. Their results are shown in **Figure 4**.

Figure 4



0 5 . 2 Calculate the ratio of the mean **rate** of uptake of chloride ions in the first hour to the **rate** of uptake of chloride ions in the second hour for group **B** plants.

[2 marks]

@60 mins

360

$\frac{360}{60} = 6$

@ 120 mins

470

$\frac{470 - 360}{60} = 1.8\dot{3}$

$6 : 1.8\dot{3}$

$\div 1.8\dot{3} \quad \div 1.8\dot{3}$

$3.2\dot{7} : 1$

Ratio = 3.3 :1

Explain the results shown in **Figure 4**.

[4 marks]

Group A's initial uptake of chloride ions was much slower than Group B's, as only diffusion occurred. Group B's uptake was much higher as active transport as well as diffusion occurred. Group A's uptake of chloride ions eventually levelled off as an equilibrium had been reached. Group B failed to level off as no equilibrium had been reached as active transport is an active process.

[Extra space] Group B's rate slowed down as the respiratory substrate was eventually used up.

6 **Table 2** shows how a bird called the bluethroat (*Luscinia svecica*) is classified by biologists.

Table 2

Taxon	Name of taxon
Domain	Eukaryota
Kingdom	Animalia
Phylum	Chordata
Class	Aves
order	Passeriformes
Family	Muscicapidae
Genus	Luscinia
Species	Svecica

Dear King Philip Came Over From Germany Swimming

0 6 . 1 Complete **Table 2** by filling the seven blank spaces with the correct terms.

[2 marks]

A group of scientists investigated genetic diversity in different species of bird. For each species, the scientists:

- collected feathers from a large number of birds
- extracted DNA from cells attached to each feather
- analysed the samples of DNA to find genetic diversity.

Table 3 summarises their results.

Table 3

Species of bird	Number of genes examined	Number of genes examined that showed genetic diversity
Willow flycatcher	708	197
House finch	269	80
Bluethroat	232	81

bluethroat

$\frac{81}{232} \times 100 = 34.9\%$

willow flycatcher

$\frac{197}{708} \times 100 = 27.8\%$

0 6 . 2 In this investigation, what is meant by **genetic diversity**?

[1 mark]

The number of different alleles of each gene.

number of different base sequences found in each gene

0 6 . 3 The scientists concluded that the bluethroat showed greater genetic diversity than the willow flycatcher. Explain why they reached this conclusion. Use calculations to support your answer.

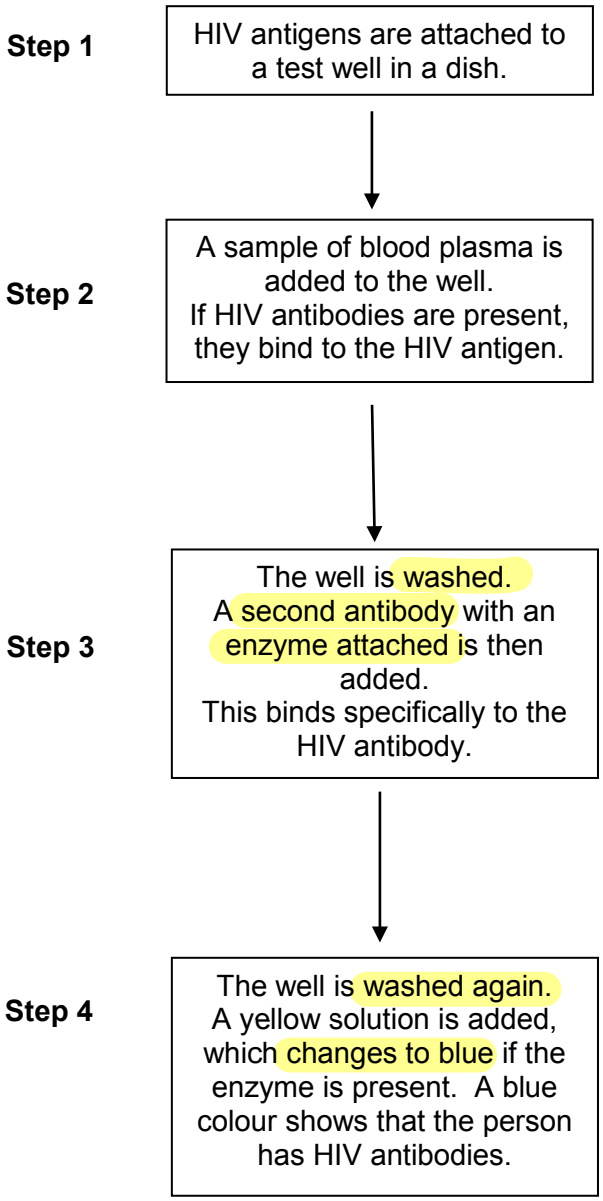
[2 marks]

The bluethroat showed greater genetic diversity as the percentage of genes showing diversity was much higher. In fact, the bluethroat had 34.9% genes of genetic diversity compared to the willow flycatcher at 27.8%.

Turn over for the next question

7 **Figure 5** shows a test that has been developed to find out if a person has antibodies to the human immunodeficiency virus (HIV) antigen.

Figure 5



0 7 . 1 This test only detects the presence of HIV antibodies. Give **two** reasons why it cannot be used to find out if a person has AIDS.

[2 marks]

1 To diagnose Aids, Scientists need to check for Aids-related symptoms

2 To diagnose Aids, Scientists need to check the number of helper T-cells

0 7 . 2 The solution will remain yellow if a person is **not** infected with HIV. Explain why.

[2 marks]

The HIV antibody isn't present and so the second antibody and it's attached enzyme wont be present, and so the person is not infected with HIV.

0 7 . 3 A mother who was infected with HIV gave birth to a baby. The baby tested positive using this test. This does not prove the baby is infected with HIV.
Explain why.

[2 marks]

The maternal antibodies are passed on the the child, which the mother has conceived. As the mother is infected with HIV, the second antibody which the enzyme attached binds and therefore causes a blue positive test.

0 7 . 4 A control well is set up every time this test is used. This is treated in exactly the same way as the test wells, except that blood plasma is replaced by a salt solution.

Use information from **Figure 5** to suggest **two** purposes of the control well.

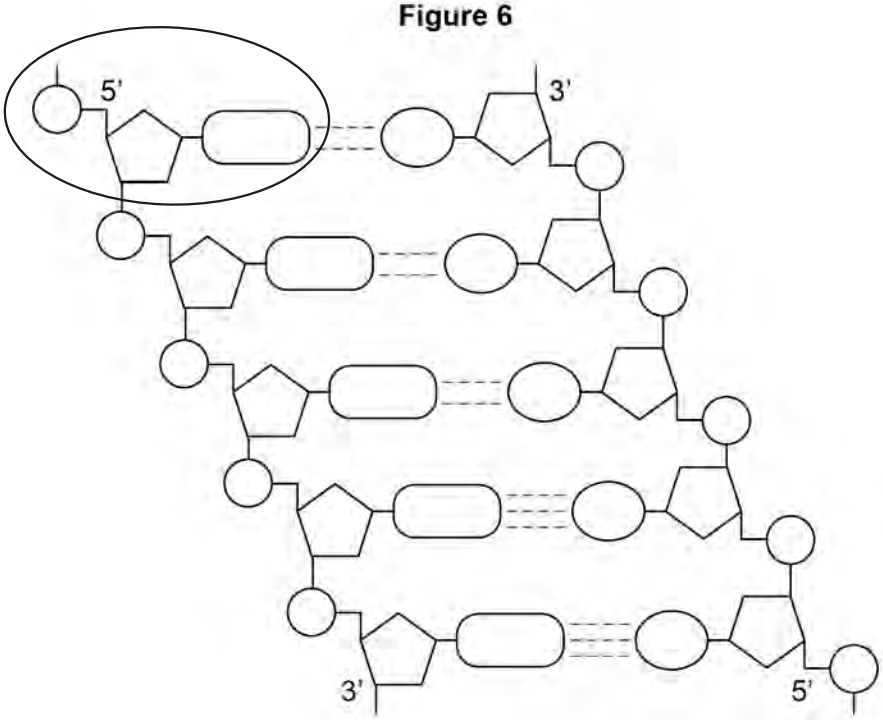
[2 marks]

1 To make sure that the washings have been effective and that unbound antibodies have been washed away.

2 Only the enzyme and nothing else has caused a colour change in the test.

8 **Figure 6** represents part of a DNA molecule.

Figure 6



0 8 . 1 Draw a box around a single nucleotide.

[1 mark]

Table 4 shows the percentage of bases in each of the strands of a DNA molecule.

Table 4

DNA strand	Percentage of each base			
	A	**C**	**G**	**T**
Strand **1**	16	34	21	29
Strand **2**	29	21	34	16

0 8 . 2 Complete **Table 4** by adding the missing values.

[2 marks]

0 8 . 3 During replication, the two DNA strands separate and each acts as a template for the production of a new strand. As new DNA strands are produced, nucleotides can only be added in the 5' to 3' direction.

Use **Figure 6** and your knowledge of enzyme action and DNA replication to explain why new nucleotides can only be added in a 5' to 3' direction.

[4 marks]

The enzyme used in DNA replication is DNA polymerase. The enzyme active site is extremely specific in terms of what it can bind to. In this case DNA polymerase is complementary to the 5' end of the DNA strand, and so as a result, enzyme movement can only occur from the 5' to 3' direction. As the shape of the 5' end and the 3' end differ, the enzyme must move from a 5' to 3' direction in order to remain complementary to its substrate i.e. the DNA strand.

[Extra space]

Turn over for the next question

0 9 . 1 Describe the mass flow hypothesis for the mechanism of translocation in plants.

[4 marks]

At the source of the plant, photosynthesis is continuously occurring, and glucose is produced. Glucose is converted into sucrose and at a particular point, the companion cells actively transport sugars and sucrose into the phloem. This in fact lowers the water potential inside the phloem / sieve cell, and causes water to move into the phloem from the xylem by osmosis. This increases the hydrostatic pressure at the top of the phloem and causes mass movement of substances to the sink of the plant. At the sink of the plant, the substances are used for respiration and storage.

[Extra space]

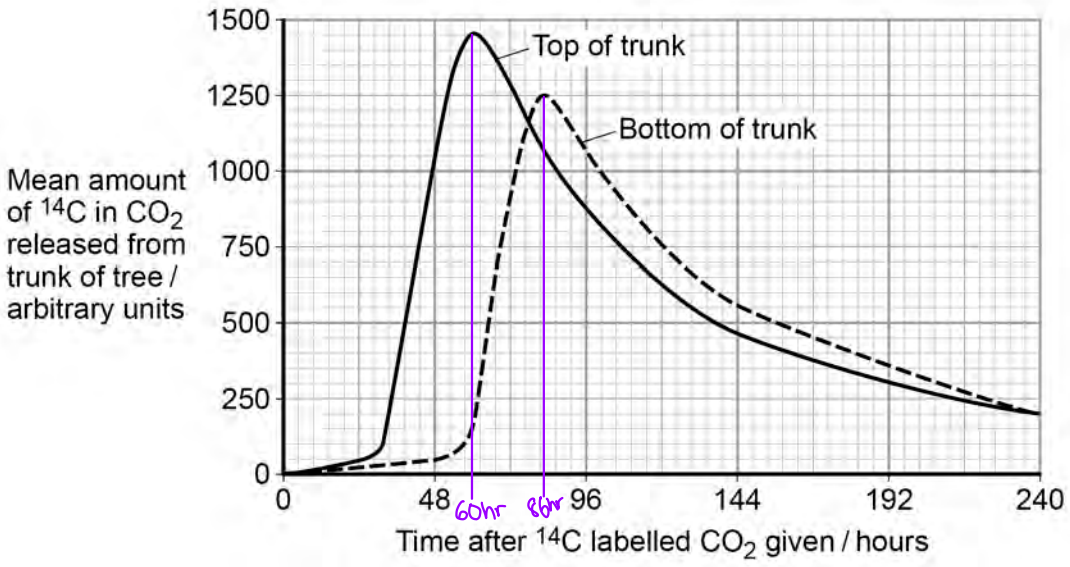
Scientists measured translocation in the phloem of trees. They used carbon dioxide labelled with radioactive ^{14}C.

They put a large, clear plastic bag over the leaves and branches of each tree and added $^{14}CO_2$. The main trunk of the tree was not in the plastic bag.

At regular intervals after adding the $^{14}CO_2$ to the bag, the scientists measured the amount of $^{14}CO_2$ released from the top and bottom of the main trunk of the tree. On the surface of the trunk of these trees, there are pores for gas exchange.

Figure 7 shows the scientists' results.

Figure 7



0 9 . 2 Name the process that produced the $^{14}CO_2$ released from the trunk.

[1 mark]

respiration

0 9 . 3 How long did it take the ^{14}C label to get from the top of the trunk to the bottom of the trunk? Explain how you reached your answer.

[2 marks]

26hours - we found the time between which the ^{14}C label moved from the peak at the top and bottom of the trunk.

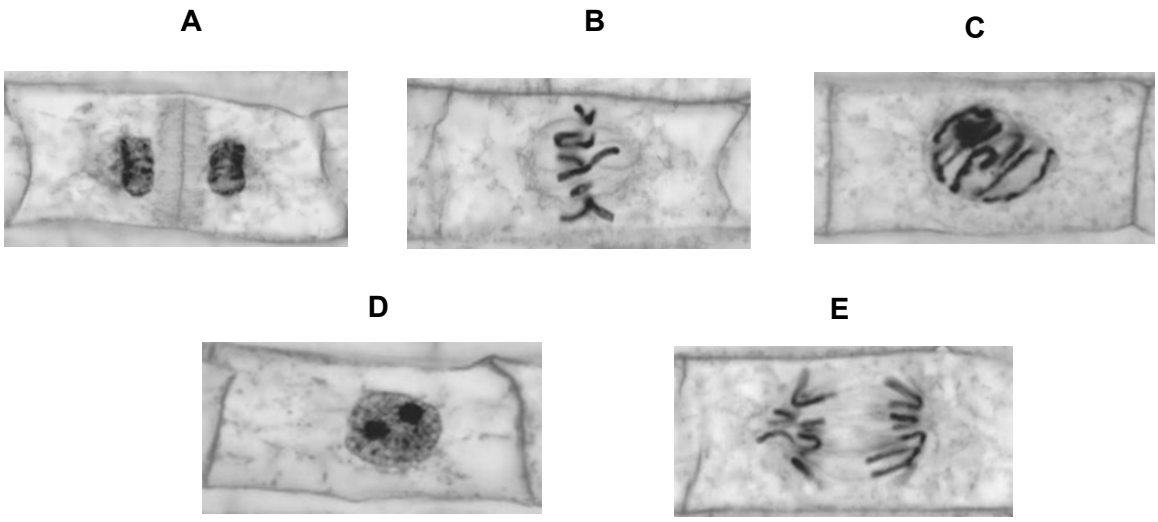
0 9 . 4 What other information is required in order to calculate the mean rate of movement of the ^{14}C down the trunk?

[1 mark]

We need to know the length of the trunk from both the top and bottom.

1 0 **Figure 8** shows some cells from an onion root tip at different stages of the cell cycle.

Figure 8



Place stages **A** to **E** in the correct order. Start with stage **D.**

[1 mark]

D, C, B, E, A

To obtain these images, the onion root tip was cut off, stained and put on a microscope slide. A cover slip was placed on top. The root tip was then firmly squashed and viewed under an optical microscope.

1 0 . 2 Complete **Table 5** to give **one** reason why each of these steps was necessary.

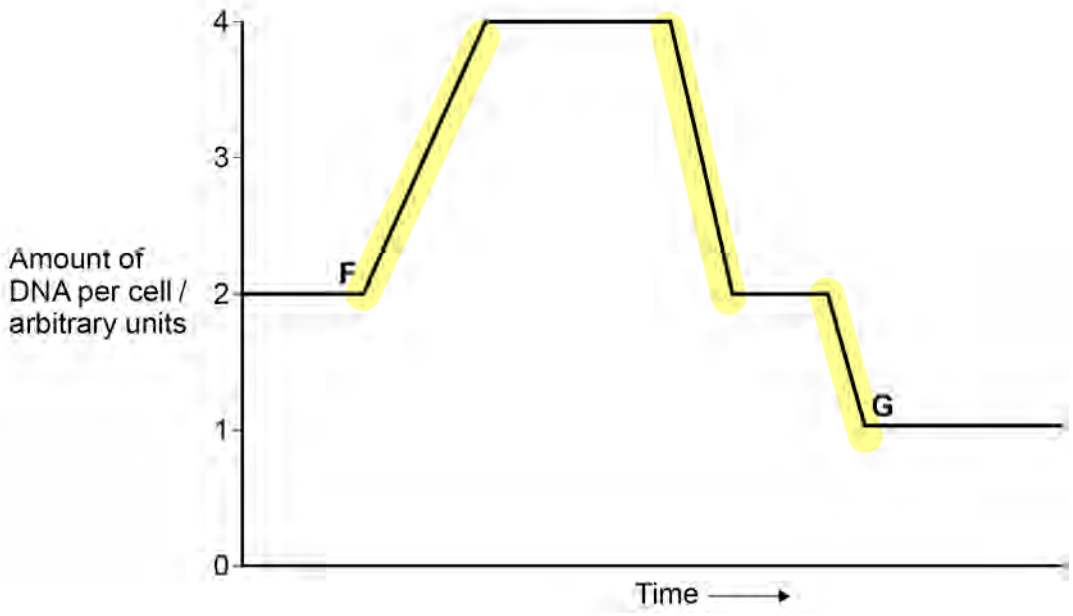
[2 marks]

Table 5

Step	Reason
Taking cells from the root tip	obtain an area where cell division is occurring.
Firmly squashing the root tip	to allow for light to penetrate through

Figure 9 shows how the amount of DNA per cell changed during interphase and meiosis in an animal.

Figure 9



1 0 . 3 Explain how the behaviour of chromosomes causes these changes in the amount of DNA per cell between **F** and **G**.

[3 marks]

The DNA increased due to DNA and chromosome replication. First decrease is due to the homologous chromosomes separating and forming 2 daughter cells. The second decrease is due to the sister chromatids separating.

[Extra space]

1 0 . 4 What would happen to the amount of DNA per cell at fertilisation of cell **G**?

[1 mark]

The DNA would double and go to 2 arbitrary units

1 1 . 1 Messenger RNA (mRNA) is used during translation to form polypeptides.
Describe how mRNA is produced in the nucleus of a cell.

[6 marks]

Helicase enzyme breaks the hydrogen bonds between the DNA strands. This unzips the DNA, exposing the nitrogenous bases. One of the DNA strands acts as a template strand, to which free RNA nucleotides are attracted to the exposed bases. The free RNA nucleotides and exposed bases are attracted to eachother by the complementary base pairing rule that Adenine-Thymine and Cytosine-Guanine are attracted to eachother. After the bases have aligned, RNA polymerase joins RNA nucleotides together. Pre-mRNA is spliced to remove the introns.

[Extra space]

11.2 Describe the structure of proteins.

[5 marks]

The primary structure is an order of amino acids that have undergone a condensation reaction to form a peptide bond with an adjacent amino acid. The secondary structure is formed from the folding of the polypeptide chain due to hydrogen bonding. The secondary structure takes the form of either an alpha helix or β-pleated sheet. The tertiary structure introduces 3D-folding due to hydrogen bonding as well as ionic and disulfide bonds. The quaternary structure has 2 or more polypeptide chains that

[Extra space] are bonded together with a possible introduction of a prosthetic group i.e. iron.

• polymer of amino acids

Question 11 continues on the next page

11.3 Describe how proteins are digested in the human gut.

[4 marks]

Endopeptidases break polypeptides into smaller peptide chains by hydrolysing peptide bonds between each amino acid. Exopeptidases remove the end-of-chain amino acids at the same time as endopeptidases, which increases the efficiency of protein digestion. After endo/exopeptidases have done their work, dipeptidases hydrolyse dipeptides into amino acids which can be assimilated by the body.

[Extra space]

END OF QUESTIONS

There are no questions printed on this page

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