Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

23 October 2024

Zone A morning | **Zone B** morning | **Zone C** morning

Candidate session number

2 hours 15 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[72 marks]**.

8824 – 9501

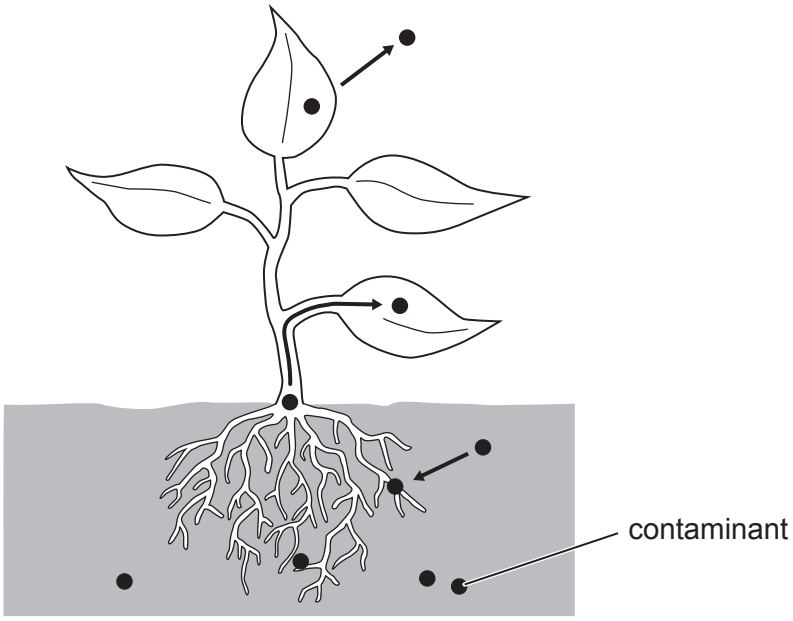
23 pages

Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

1. Phytoremediation is the use of plants to extract and remove contaminants or lower their bioavailability (amount available to organisms) in soil. Tree species are used because they have deep root systems and fast growth rates that enable them to take up contaminants in larger amounts than plants such as grasses. The diagram shows the steps in phytoremediation in plants.

diagram not to scale



A study in North Carolina, USA, used different tree species for phytoremediation of groundwater contaminated by leaked petrochemicals. Four types of hybrid poplar clones (*Populus sp*.), loblolly pine (*Pinus taeda*) and willow (*Salix sp.*) were planted from 2006 to 2008, and measurements were made of trees in 2010 and 2012. The graph shows percent survival of hybrid poplar clones, loblolly pine and willow trees on the phytoremediation site.

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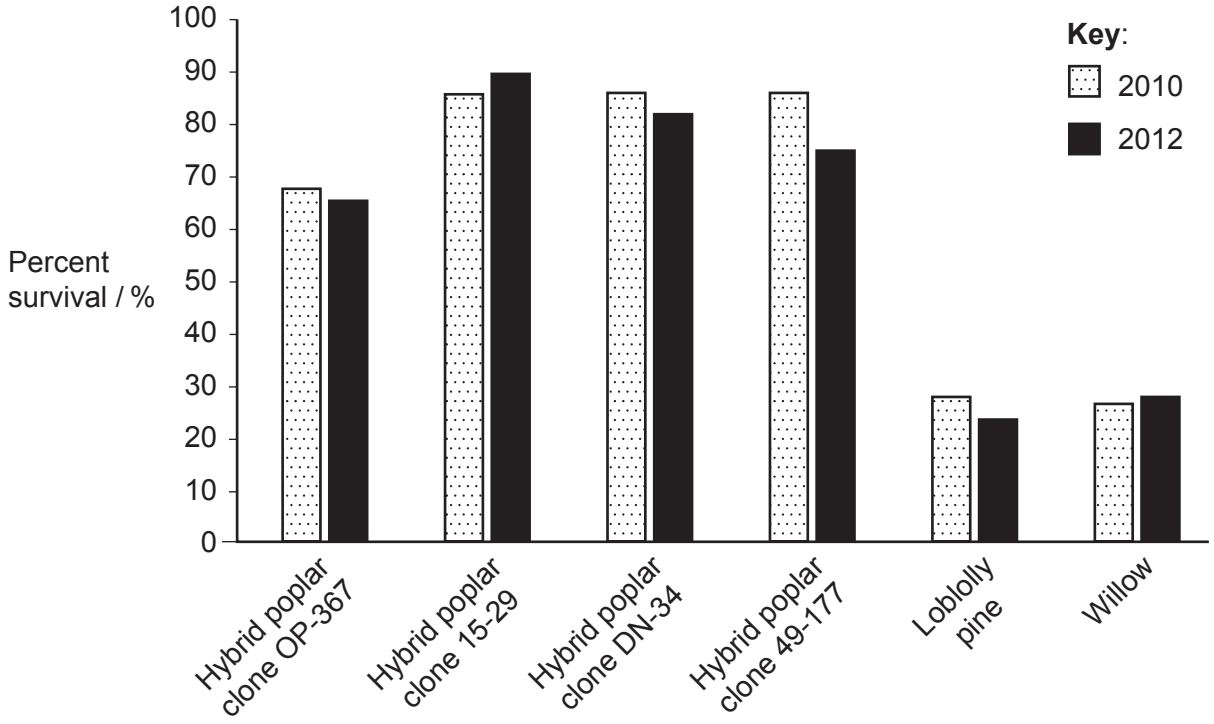
(Question 1 continued)



(a) State the lowest survival rate of a **named** hybrid poplar clone. [1]

Survival rate: . . . . . %

Hybrid poplar clone: . . . . . .

(b) Analyse the data to find the effects of the contaminants on the survival of hybrid poplar clones, loblolly pine and willow trees. [2]

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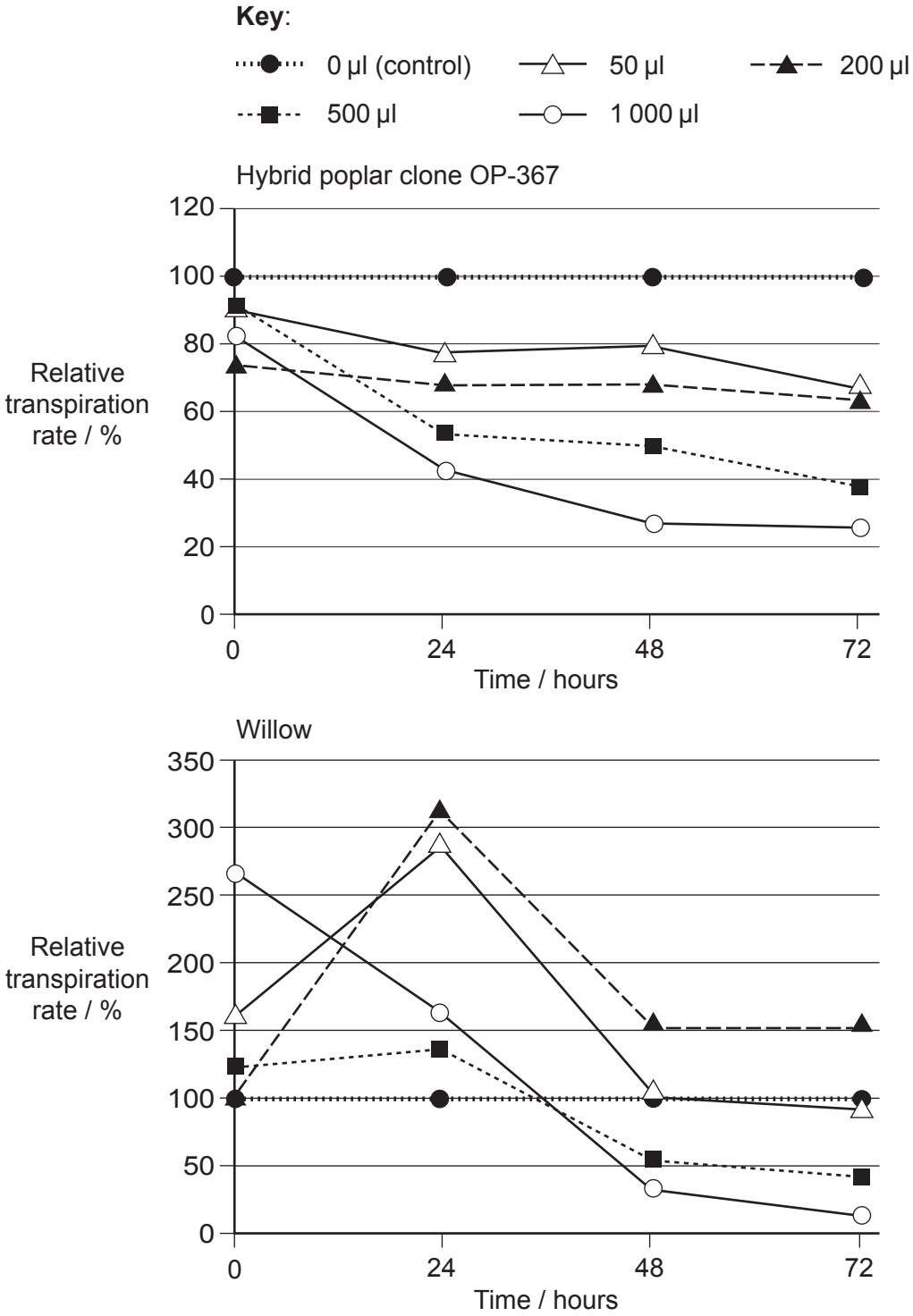
(Question 1 continued)

Tree cuttings from one hybrid poplar clone (OP-367) and from willow were rooted and placed in water contaminated by different concentrations of petroleum fuel, from 0–1000 µl fuel. The graphs show the relative transpiration rates of these cuttings.



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(Question 1 continued)

(c) State the relationship between fuel concentration and transpiration rate in the hybrid poplar clone OP-367. [1]

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(d) Compare and contrast the effect of fuel concentration on the hybrid poplar clone OP-367 and willow cuttings. [2]

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(e) Removal of excess soil water increases oxygen levels in the soil. Suggest how this may be beneficial in soil phytoremediation. [1]

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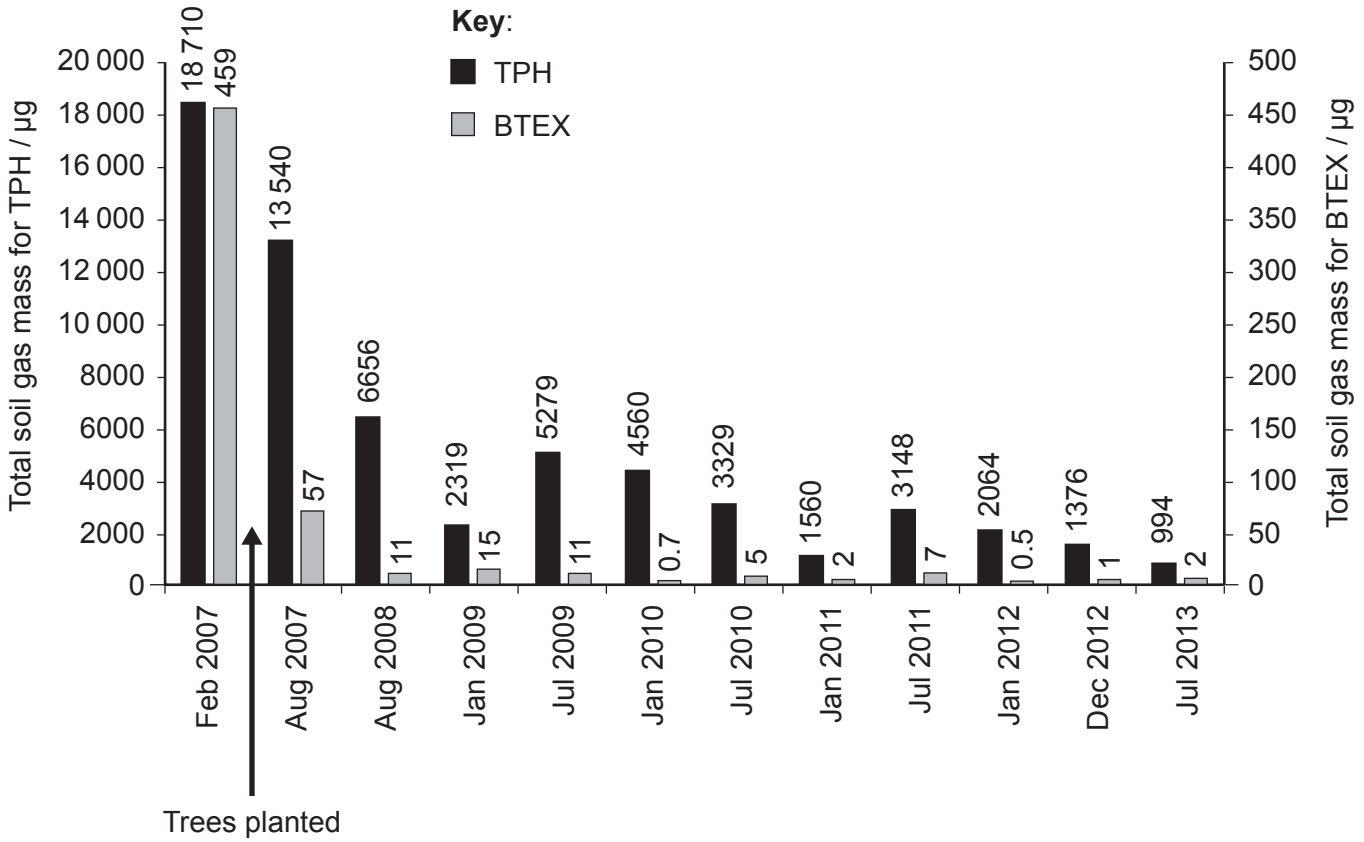
(This question continues on page 7)

Please **do not** write on this page.

Answers written on this page
will not be marked.

(Question 1 continued)

In the same study, the levels of TPH (total petroleum hydrocarbons) and BTEX (benzene, toluene, ethylbenzene and xylene) present in the soil of contaminated areas were measured each winter and summer from 2007 to 2013 before and after planting trees.



(f) Calculate the percentage change in BTEX from February 2007 to July 2013. [1]

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(g) Determine with evidence from the bar chart which type of contaminant is removed at a greater rate from the soil between February 2007 and August 2007. [1]

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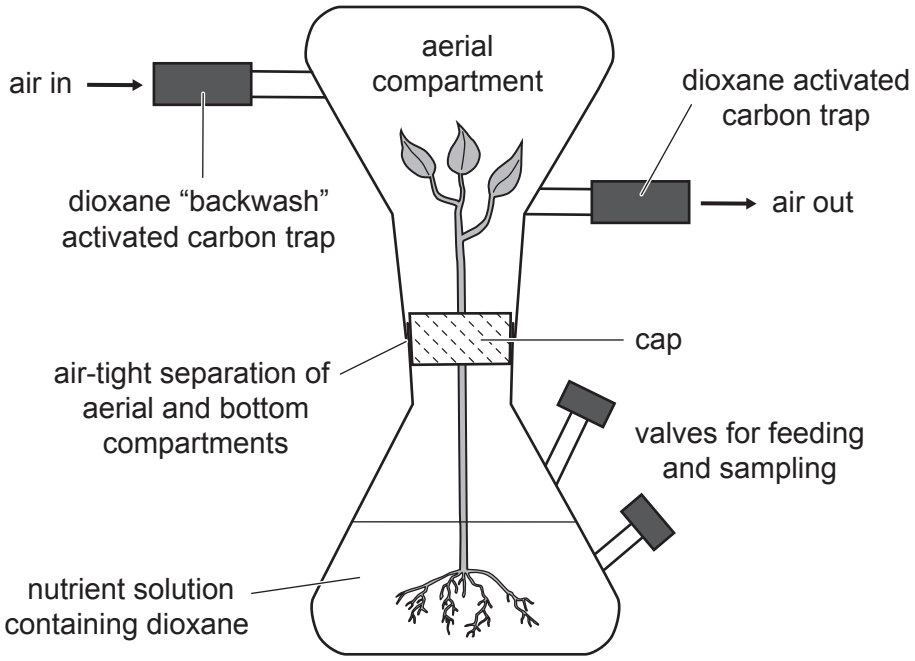
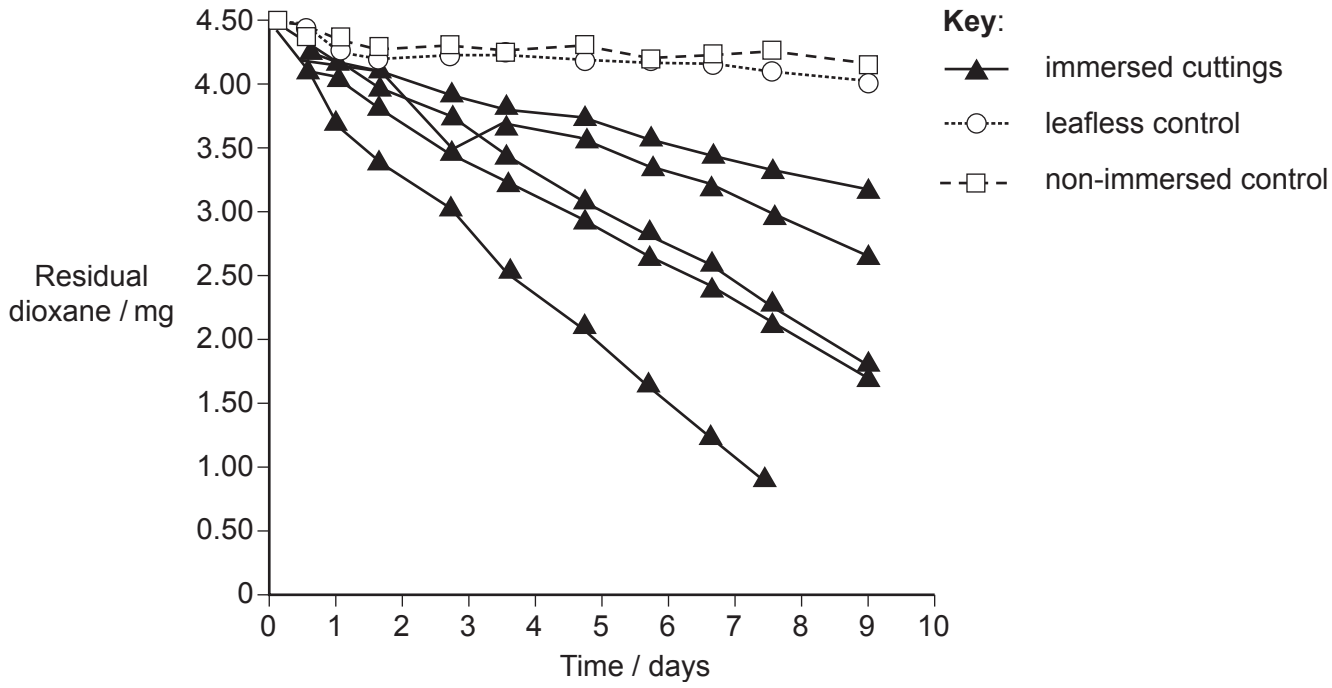
(Question 1 continued)

Dioxane is another environmental contaminant that is difficult to remove from contaminated sites. Hybrid poplar cuttings (*Populus deltoides* x *nigra*) were grown. Once they had rooted, seven cuttings were transferred to individual reactors, as shown in the diagram. Five cuttings were as shown and two were controls. One control had the leaves removed, and the stem and roots of the other control were not immersed in the nutrient solution. The concentration of dioxane that remained in the nutrient solution was measured daily.





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(Question 1 continued)

(h) Outline the purpose of the non-immersed control. [1]

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(i) Explain the difference in results for immersed cuttings and leafless control. [2]

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(j) Using all the data, evaluate the use of trees in phytoremediation. [3]

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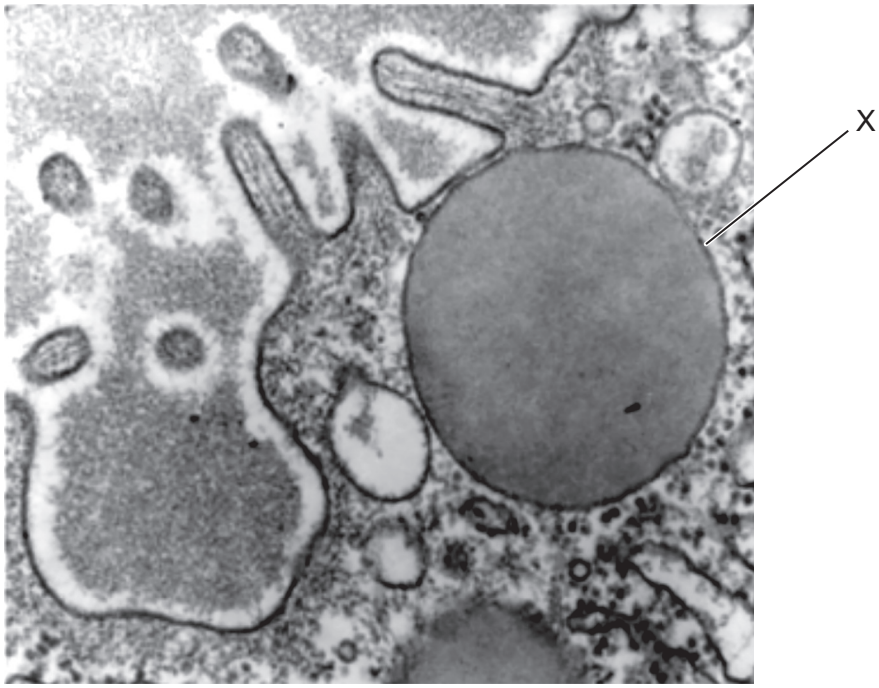
2. The electron micrograph shows part of a pancreas cell that secretes digestive enzymes.



(a) Calculate the magnification of the micrograph. [1]

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(b) Identify the organelle labelled X. [1]

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(c) State the organelle where digestive enzymes are synthesised. [1]

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(This question continues on the following page)

(Question 2 continued)

(d) Identify the process by which digestive enzymes are secreted. [1]

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(e) The pancreas secretes other chemicals as well as enzymes. State an example of a chemical **and** the type of pancreatic cell that secretes it. [1]

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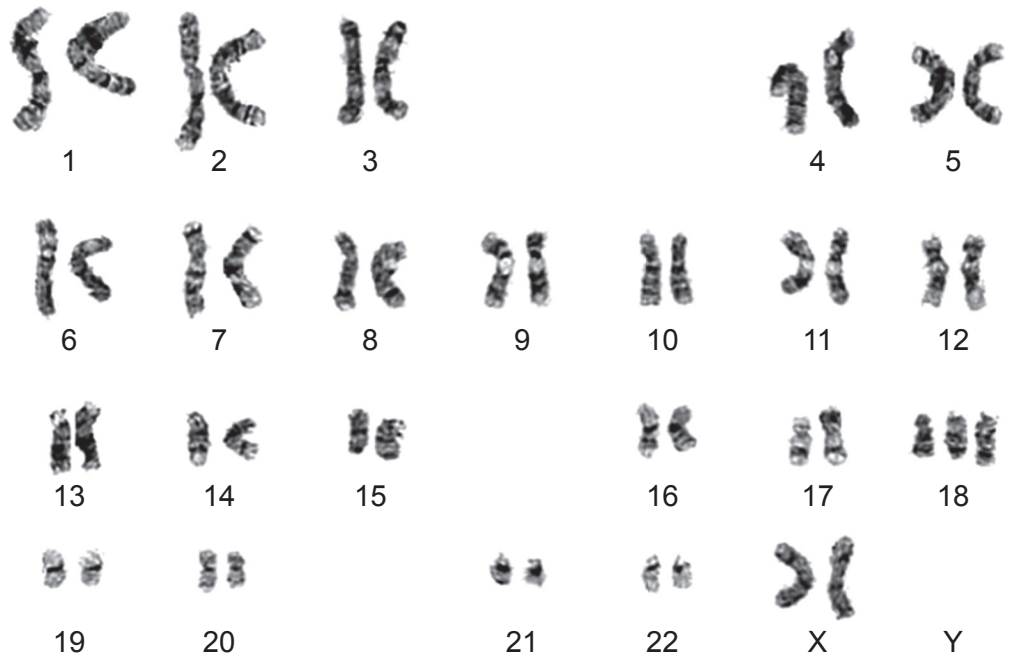
3. (a) A karyogram of a human female with trisomy is shown below.



(i) Describe how the trisomy may have occurred. [2]

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(ii) Suggest a reason that there are no live births with trisomy of chromosomes 1, 2 and 3. [1]

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(Question 3 continued)

(b) Budgerigars (*Melopsittacus undulatus*) can have blue, green, yellow or white feathers.

Two genes, A/a and D/d, are involved in the inheritance of feather colour in budgerigars. The possible phenotypes are shown. Dashes (_) mean that either allele can be present.

Genotype	Colour of feathers
A_D_	green
A_ dd	blue
aaD_	yellow
aadd	white

(i) Green birds, heterozygous at both loci, were mated with blue birds, heterozygous at the A locus. Construct a Punnett grid of the cross. [2]

(ii) State the ratio of phenotypes. [2]

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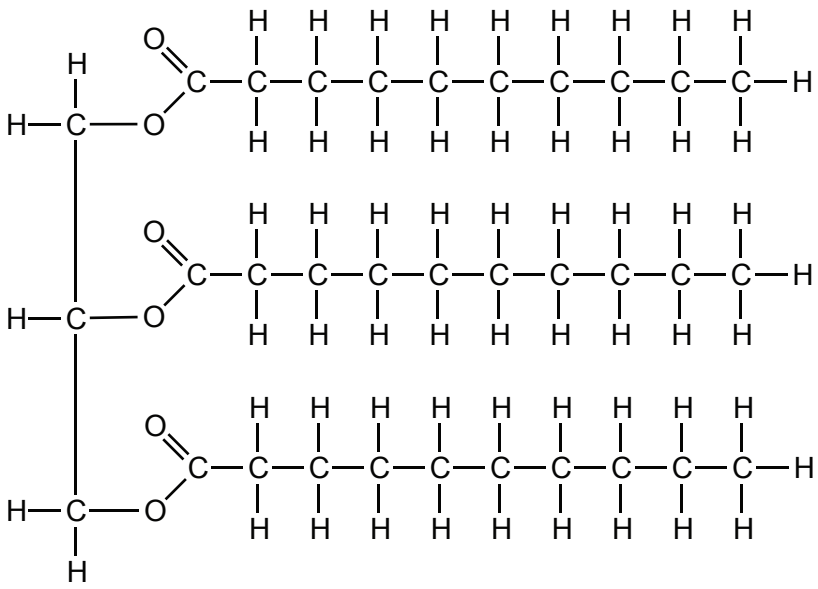
4. A triglyceride is shown.



(a) State the **two** types of molecules that combine to make a triglyceride. [1]

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(b) Annotate the diagram, using an arrow to show where a condensation bond has formed during formation of the triglyceride. [1]

(c) Triglycerides can be used in respiration when a process called beta oxidation produces acetyl coenzyme A. State the stage of respiration in which acetyl coenzyme A is used. [1]

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(Question 4 continued)

(d) Explain the reason that more energy is released from one gram of triglyceride than from one gram of glucose in respiration. [2]

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(e) Suggest possible health risks associated with the type of triglyceride shown in the diagram in the diet. [2]

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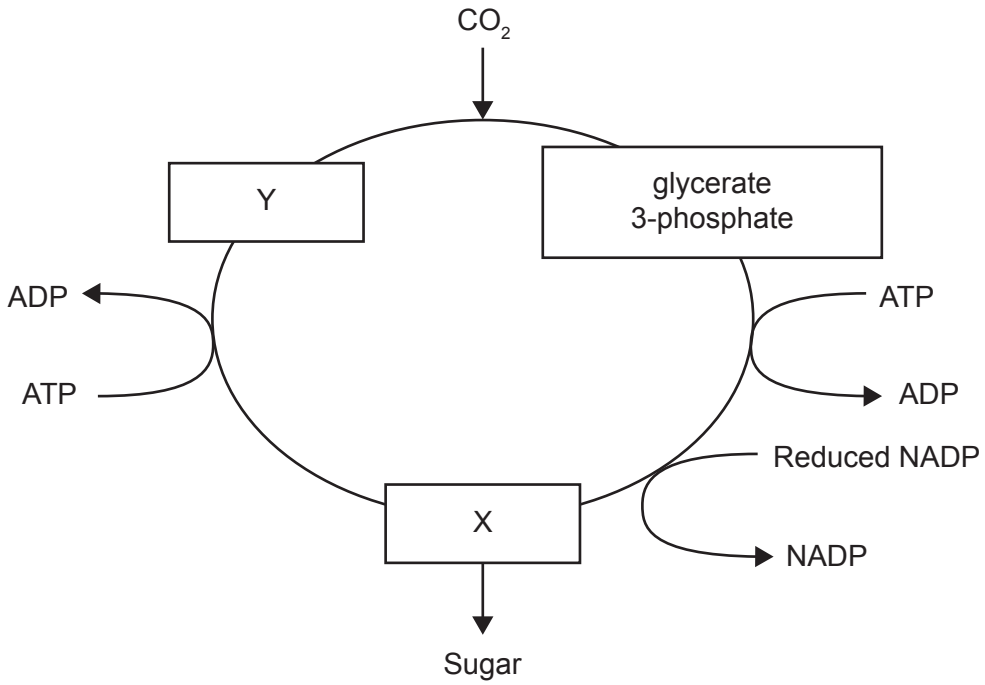
5. The diagram shows the Calvin cycle.



(a) Identify the molecules X and Y. [2]

X: . . . . . .
Y: . . . . . .

(b) A product of the Calvin cycle is transported in the phloem.

(i) State the name of the molecule that is transported. [1]

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(ii) Explain how this molecule is transported from leaves to roots. [3]

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Section B

Answer **two** questions. Up to one additional mark is available for the construction of your answers for each question. Answers must be written within the answer boxes provided.

6. Chemicals are involved at all levels of biology: cell functions, structure of organisms, interactions with the environment.

(a) Distinguish between competitive and non-competitive enzyme inhibition. [4]

(b) Outline the process of micropropagation in plants and its benefits. [4]

(c) Rising levels of carbon dioxide pose threats to marine life. Explain the causes of increased carbon dioxide and its effects in oceans. [7]

7. Proteins play essential roles in all forms of life.

(a) Outline how mRNA is translated in the cytoplasm of a cell. [4]

(b) Describe how a protein that is common to many organisms can be used in evolutionary studies. [4]

(c) Explain the roles of proteins in muscle contraction. [7]

8. Hormones are produced in plants and animals and cause changes in the organism.

(a) Describe the role of the plant hormone auxin in phototropism. [4]

(b) Outline hormone feedback mechanisms in the menstrual cycle. [4]

(c) Explain how ADH and the loop of Henle work to control the concentration of urine. [7]

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References:

1. Purkis, J.M., Bardos, R.P., Graham, J. and Cundy, A.B., 2022. Developing field-scale, gentle remediation options for nuclear sites contaminated with 137Cs and 90Sr: The role of Nature-Based Solutions. *Journal of Environmental Management* 308, 114620. Source adapted.

1.a, c, f Guthrie Nichols, E., Cook, R.L., Landmeyer, J.E., Atkinson, B, Malone, D.R., Shaw, G. and Woods, L., 2014. Phytoremediation of a Petroleum-Hydrocarbon Contaminated Shallow Aquifer in Elizabeth City, North Carolina, USA. *Remediation* 24(2), pp. 29–46. Source adapted.

1.h Aitchison, E. W., Kelley, S. L., Alvarez, P. J. J., & Schnoor, J. L. (2000). Phytoremediation of 1,4-Dioxane by Hybrid Poplar Trees. *Water Environment Research*, 72(3), 313–321. http://www.jstor.org/stable/25045381. Source adapted.

2. Rothman, J.E. (2014), The Principle of Membrane Fusion in the Cell (Nobel Lecture). *Angew. Chem. Int. Ed.*, 53: 12676–12694. https://doi.org/10.1002/anie.201402380. Source adapted.

3.a Reprinted from *Modern Pathology*, 23(8), Agoston, A.T., Liang, C.-W., Richkind, K.E., Fletcher, J.A. and Vargas, S.O., Trisomy 18 is a Consistent Cytogenetic Feature in Pilomatricoma, pp. 1147–1150, Copyright (2010), with permission from Elsevier. Source adapted.

3.b bazilfoto, n.d. *Green budgie*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/green-budgie-royalty-free-image/661474666?phrase=budgie&adppopup=true [Accessed 12 February 2024]. Source adapted.