Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

13 May 2025

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

Candidate session number

2 hours 30 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 **[80 marks]**.

23 pages

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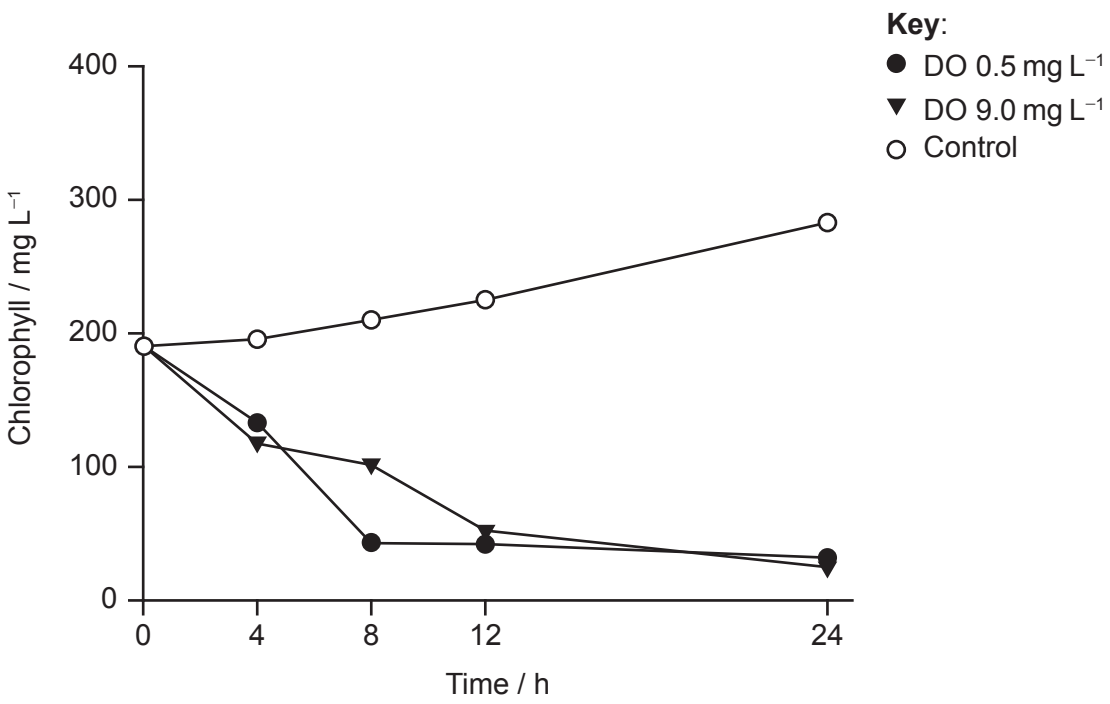
Section A

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

1. Freshwater mussels are molluscs found in rivers and lakes worldwide. They filter water for food and remove algae, bacteria and detritus, improving the water quality.

Researchers in South Korea placed mussels (*U. douglasiae*) in water containing cyanobacteria, a type of photosynthetic bacteria that cause eutrophication of rivers and lakes. The density of cyanobacteria is proportional to the concentration of chlorophyll in the water. The filtration rate by mussels can be determined by measuring the change in concentration of chlorophyll at various time intervals. The experiments were conducted with two different levels of dissolved oxygen in the water (DO). In the control experiment, no mussels were present and the DO level was 9.0 mg L^{-1}.



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(Question 1 continued)

(a) Estimate the concentration of chlorophyll in the water of the control after 18 hours. [1]

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(b) Distinguish between the density of cyanobacteria when mussels are absent (control) and when mussels are present at DO = 9.0 mg L^{-1}. [1]

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(c) Suggest a reason for the change in the chlorophyll concentration of the control during the experiment. [1]

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(d) Compare and contrast the filtration by the mussels at the different oxygen levels over the period of the experiment. [2]

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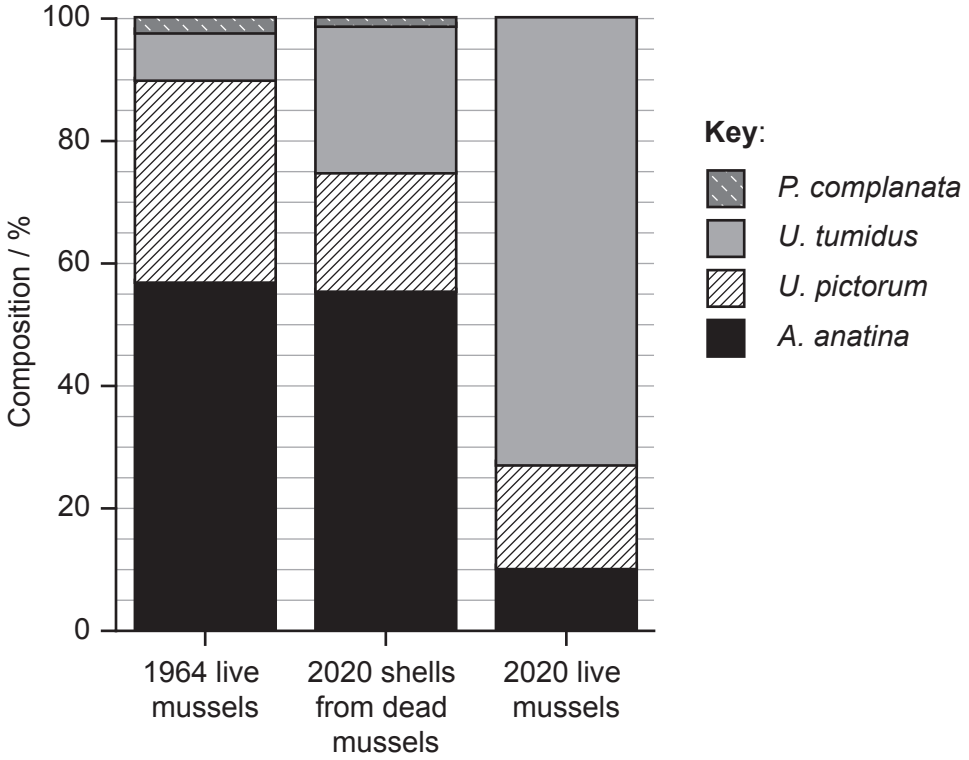
(Question 1 continued)

In 2020, scientists studied the population density of four species of mussel (*A. anatina*, *U. pictorum*, *U. tumidus* and *P. complanata*) in the River Thames in the United Kingdom. The results were compared with a previous study carried out at the same location in 1964. The chart shows the percentage of each type of live mussel found in both studies, as well as the percentage of shells from dead mussels found in 2020.



(e) Estimate the percentage of live mussels found in 1964 that were *U. pictorum*. [1]

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(f) State, giving **one** reason, whether the population of mussel shells found in 2020 more closely resembled the live percentage composition found in 1964 or 2020. [1]

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(Question 1 continued)

(g) Discuss whether the data shows that the population of *U. tumidus* has increased since 1964. [2]

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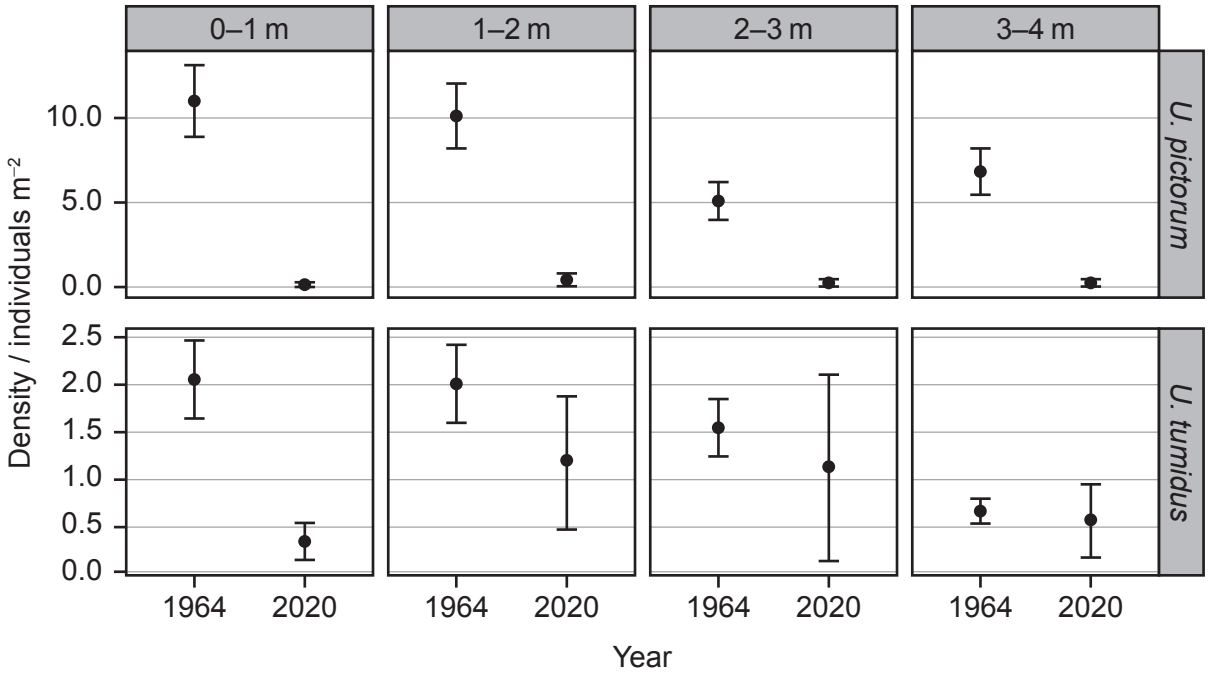
(Question 1 continued)

The researchers also studied the density of mussels at ranges of different water depths. The graph shows the results for two species, *U. pictorum* and *U. tumidus*.



(h) Calculate the mean percentage decrease in *U. pictorum* density in 1964 when increasing depth from 1–2m to 2–3m. [1]

. . . . . %

(i) Compare and contrast changes in mean density of both species between 1964 and 2020. [2]

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(Question 1 continued)

(j) Using all the data, deduce with reasons whether the water quality of the River Thames changed from 1964 to 2020. [2]

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2. (a) State the products of a condensation reaction between two amino acids. [1]

amino acid + amino acid → . . . . . + ...

(b) Describe how the diversity of amino acids gives proteins a broad range of forms. [2]

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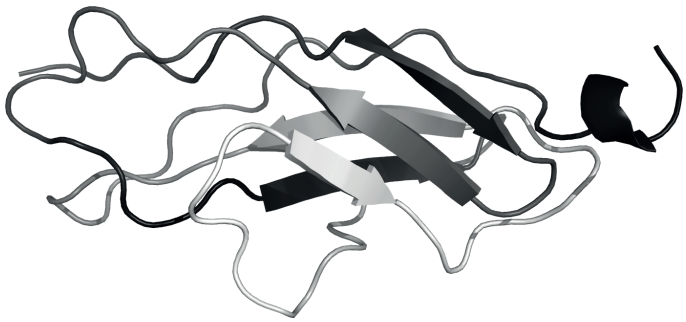
Titin is the longest protein in the human body, consisting of a single strand of over 34 000 amino acids.



(c) (i) Describe the secondary structures represented by the arrows in the diagram. [2]

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(ii) Explain the role of titin in sarcomeres. [2]

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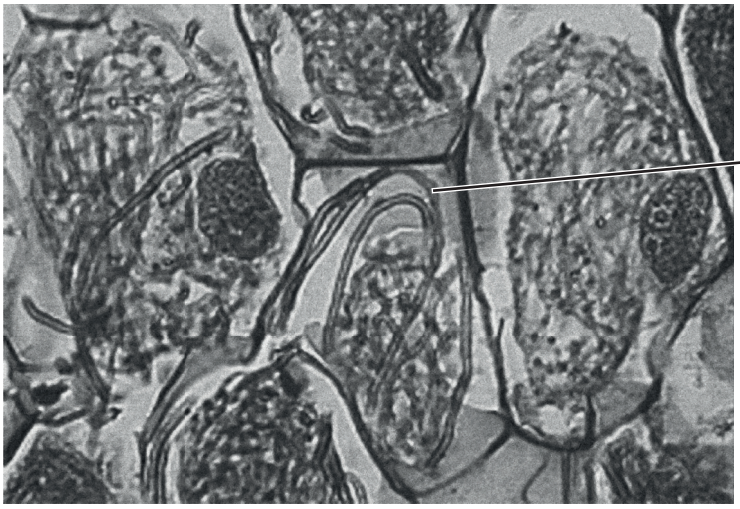
3. The image shows mycorrhizal fungi growing between the cells of a recently germinated orchid plant.



(a) (i) State the type of interspecific relationship shown by mycorrhizal fungi and plants in the orchid family (*Orchidaceae*). [1]

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(ii) State **one** benefit of the relationship experienced by the orchid. [1]

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(b) Explain how a **named** plant can reduce competition by allelopathy. [3]

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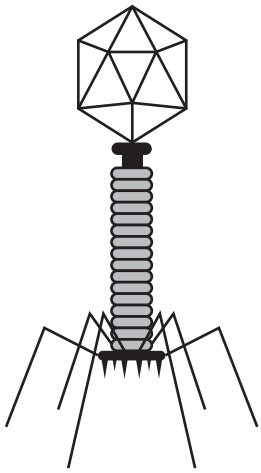
4. The diagram shows the structure of a bacteriophage lambda virus.



(a) On the image, label the capsid. [1]

(b) Describe **one** reason that viruses are not considered to be living. [1]

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(c) Explain how the bacteriophage lambda reproduces in the lysogenic cycle. [3]

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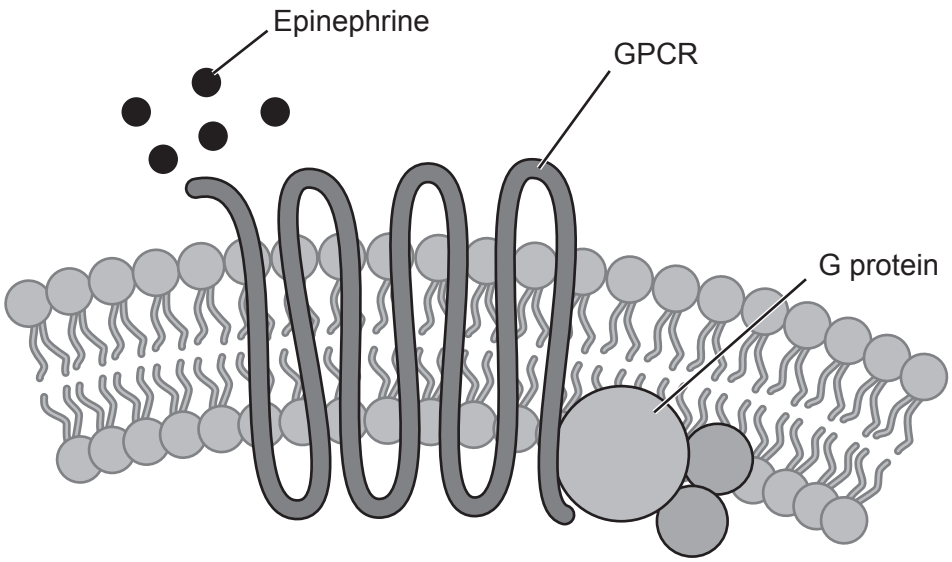
5. The diagram shows a G protein, bound to a G protein-coupled receptor (GPCR), a transmembrane receptor which responds to epinephrine (adrenaline).



(a) State which molecule is the ligand. [1]

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(b) Explain how epinephrine exerts its effects in the cell. [3]

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(c) Describe **two** ways in which epinephrine in the body facilitates intense muscle contraction. [2]

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2. . . . . .

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Answers written on this page
will not be marked.

6. Glucose is converted to pyruvate during the glycolysis stage of respiration.

glucose

↓

fructose 1,6-bisphosphate

↓

2 × triose phosphate

↓

2 × pyruvate

(a) On the diagram, label

(i) with P where phosphorylation occurs; [1]

(ii) with O where oxidation occurs. [1]

(b) State where in the cell glycolysis takes place. [1]

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(c) Outline how NAD is made available for glycolysis during anaerobic respiration in animal cells. [2]

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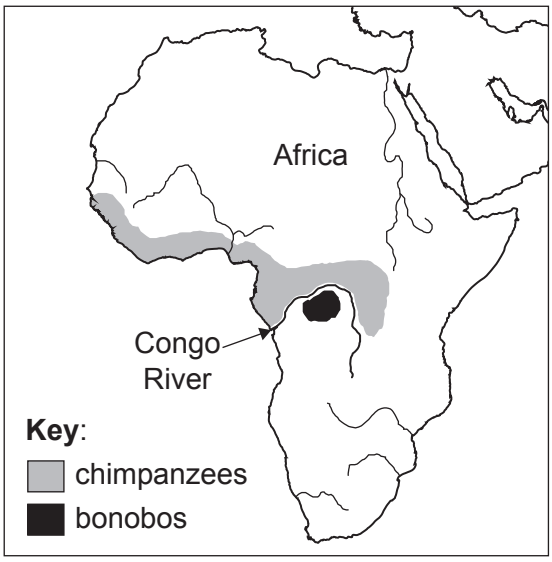
7. The map shows the distribution of chimpanzees (*Pan troglodytes*) and bonobos (*Pan paniscus*) on either side of the Congo River as it flows towards the Atlantic Ocean in the Democratic Republic of Congo. Bonobos occupy the dense wet forest south of the Congo River, whereas chimpanzees occupy a forested habitat north of the river. Both species are descended from a common ancestor.



(a) State the type of speciation shown by the two species. [1]

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(b) Describe how both species evolved from the common ancestor. [3]

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(Question 7 continued)

(c) The bonobo is classified as an endangered species. Explain how deforestation could contribute to the decline in the population size of bonobos. [2]

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Section B

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

8. Water has unique properties and is needed by all living organisms to survive. Without water, life on Earth as we know it would not exist.

(a) Outline how the cohesive properties of water benefit living organisms. [4]

(b) Describe how the melting of ice and changes in ocean currents can lead to ecological changes. [4]

(c) Explain the hormonal control of osmoregulation in the kidney by negative feedback. [7]

9. The genome is the total of all the DNA in an organism, containing all the genetic information required for development and growth.

(a) Describe the possible causes and consequences of a substitution mutation in DNA. [4]

(b) Distinguish between cell division by mitosis and by meiosis in eukaryote cells. [4]

(c) Explain how gene expression can be regulated during transcription to determine an organism's phenotype. [7]

10. Emergent properties exist when many different components, such as cells, tissues, organs and body systems, integrate in a multicellular living organism.

(a) Outline how cell organelles interact to produce and secrete proteins from cells. [4]

(b) Describe how muscles interact to carry out inhalation in the lungs. [4]

(c) Explain how the cells in the blood work together to provide adaptive immunity. [7]

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References:

1.a image Gary Meszaros / Science Source.

1.a graph Park, B., Kim, B.-H. and Um, H.-Y., 2008. *Effects of Dissolved Oxygen and Depth on the Survival and Filtering Rate and Pseudofeces Production of a Filter-feeding Bivalve (Unio douglasiae) in the Cyanobacterial*. [online] Available at: https://www.researchgate.net/publication/272746975_Effects_of_Dissolved_Oxygen_and_Depth_on_the_Survival_and_Filtering_Rate_and_Pseudofeces_Production_of_a_Filter-feeding_Bivalve_Unio_douglasiae_in_the_Cyanobacterial [Accessed 25 June 2024]. Source adapted.

1.e and h Ollard, I. and Aldridge, D.C., 2022. *Journal of Animal Ecology* 92(1), pp. 112–123. https://doi.org/10.1111/1365-2656.13835. Reference redacted. Source adapted.

2. Boghog2, 2008. *1BPV*. [image online] Available at: https://commons.wikimedia.org/wiki/File:1BPV.png [Accessed 25 June 2024]. Source adapted. Public domain.

3. Kamal, S. and Varma, A., 2008. Peatland Microbiology. In: Dion, P. and Chandra Shekhar Nautiyal, 2008. *Microbiology of Extreme Soils*, pp. 177–203. https://doi.org/10.1007/978-3-540-74231-9_9. Springer Nature. Source adapted.

4. ALI DAMOUH/SCIENCE PHOTO LIBRARY, 2024. *Bacteriophage, illustration*. [image online] Available at: https://www.gettyimages.co.uk/detail/illustration/bacteriophage-illustration-royalty-free-illustration/2080360644?adppopup=true [Accessed 29 July 2024]. Source adapted.

5. Joshua Li et al, The Molecule Pages database, *Nature*, Dec 12, 2002, Springer Nature.

7. *The regions of Africa where the chimpanzee and the bonobo are found*, n.d. [online] Available at: https://www.chrismadden.co.uk/where-are-we/chapters/chapter-16.html [Accessed 1 May 2024]. Source adapted.