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**Biology**  
**Higher level**  
**Paper 2**

Wednesday 27 October 2021 (morning)

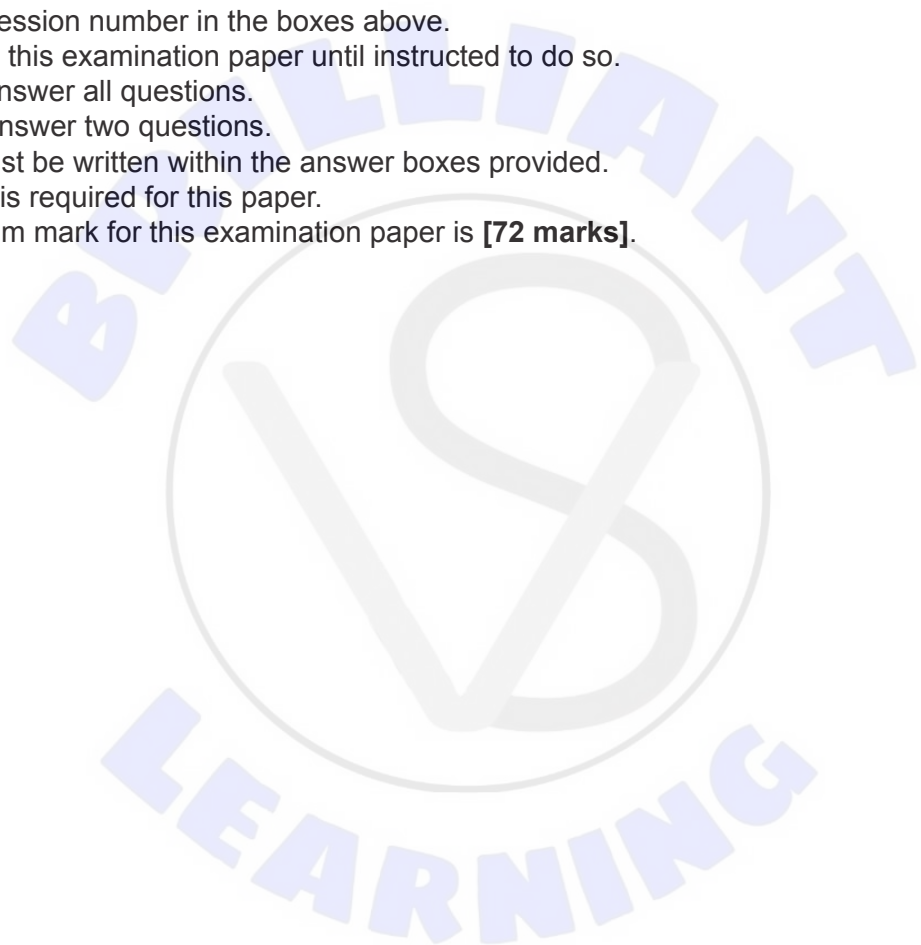
Candidate session number

2 hours 15 minutes

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**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]**.

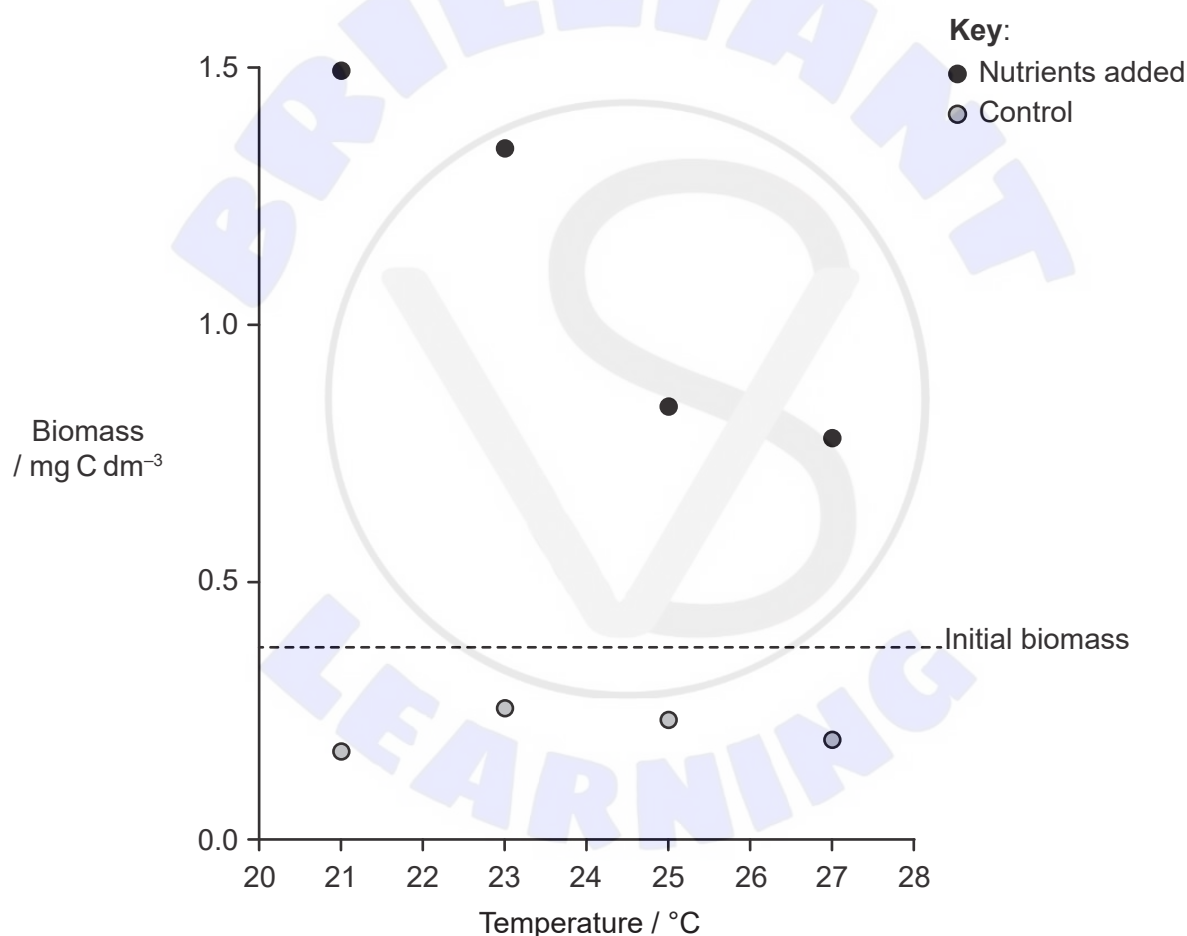


### Section A

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

1. A community living in the water of an estuary was used to investigate how climate change may affect ecological systems. The food web in this community included phytoplankton (producers), zooplankton (consumers) and saprotrophic bacteria. Small plastic mesocosms were set up with water from the estuary containing only these three groups of organisms. The mesocosms were subjected to four different temperatures and two nutrient levels (control and nutrients added) to replicate local variations of the conditions in the estuary during springtime warming.

The graph shows the biomass of the community for each of the eight mesocosms at the end of the experimental period. Biomass was measured in terms of the amount of carbon present. The horizontal line indicates the initial biomass.



[Source: adapted from O'Connor, M.I., Piehler, M.F., Leech, D.M., Anton, A. and Bruno, J.F., 2009. *PLOS Biology*, [e-journal] 7(9). <https://doi.org/10.1371/journal.pbio.1000178>.]

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**(Question 1 continued)**

(a) Describe the effect of temperature on the total biomass.

[2]

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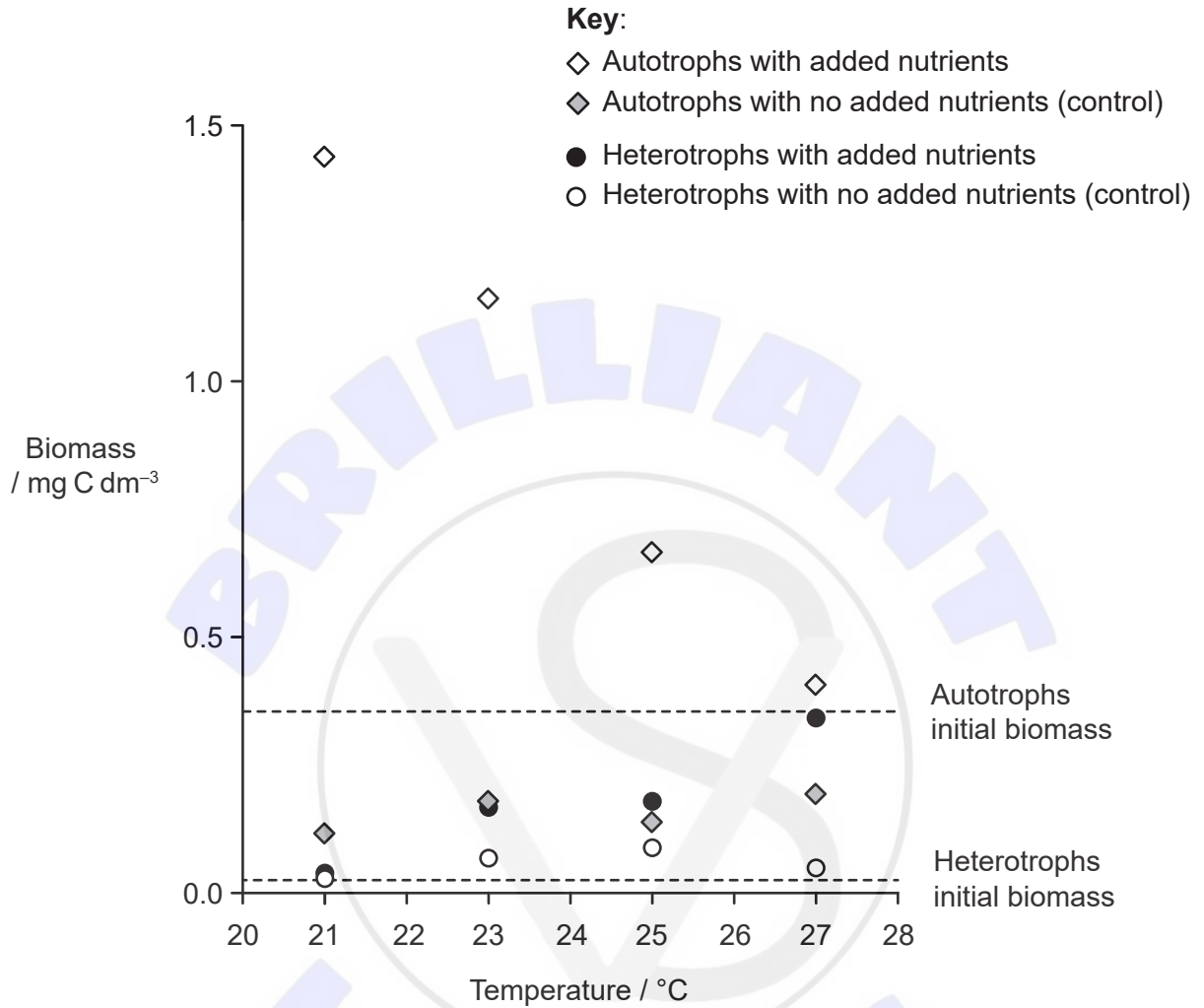
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**(Question 1 continued)**

The graph shows the mean biomass of autotrophs and heterotrophs in the eight mesocosms. The horizontal lines indicate the initial biomasses.



[Source: adapted from O'Connor, M.I., Piehler, M.F., Leech, D.M., Anton, A. and Bruno, J.F., 2009. *PLOS Biology*, [e-journal] 7(9). <https://doi.org/10.1371/journal.pbio.1000178>.]

(b) Compare and contrast the effects of temperature on the biomass of autotrophs and heterotrophs with added nutrients. [2]

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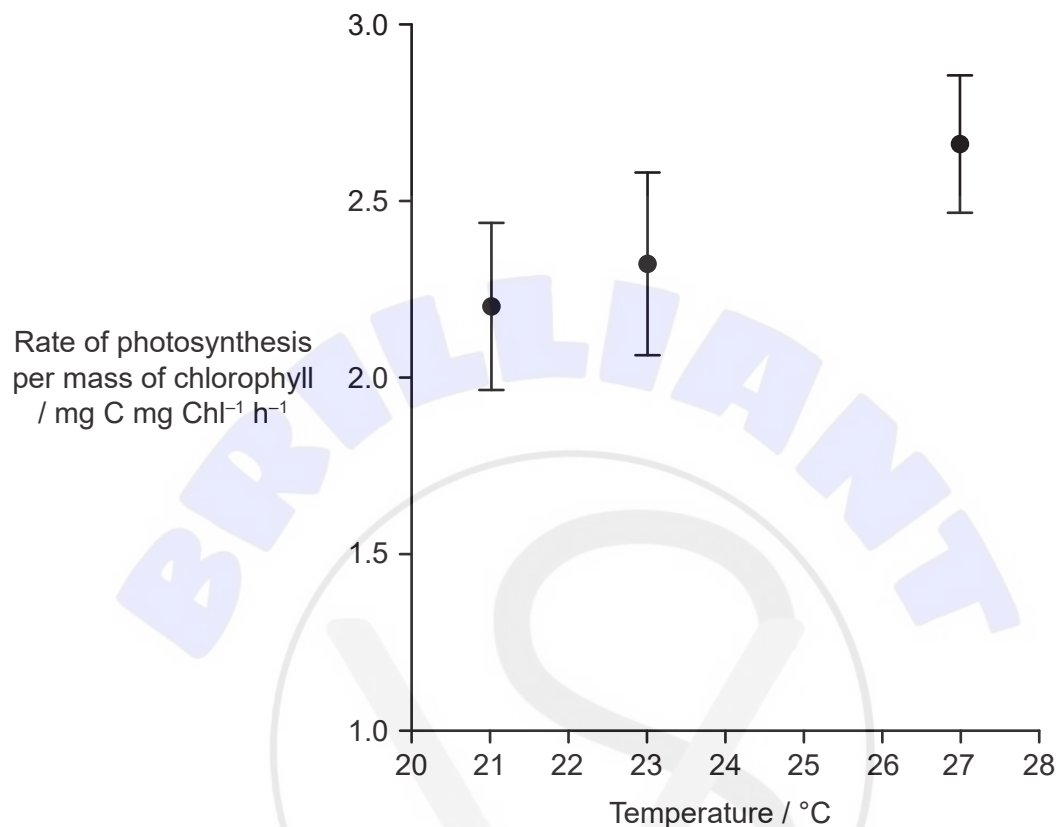
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**(Question 1 continued)**

Chlorophyll concentration was used as an estimate of the photosynthetic capacity of the community. The rate of photosynthesis and mass of chlorophyll per unit volume were measured in a mesocosm at three different temperatures.



[Source: adapted from O'Connor, M.I., Piehler, M.F., Leech, D.M., Anton, A. and Bruno, J.F., 2009. *PLOS Biology*, [e-journal] 7(9). <https://doi.org/10.1371/journal.pbio.1000178>.]

(c) Explain the effect of temperature on the rate of photosynthesis in this mesocosm. [2]

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**(Question 1 continued)**

- (d) Suggest reasons for the decreases in biomass of autotrophs as temperature rises, despite the increases in photosynthesis. [2]

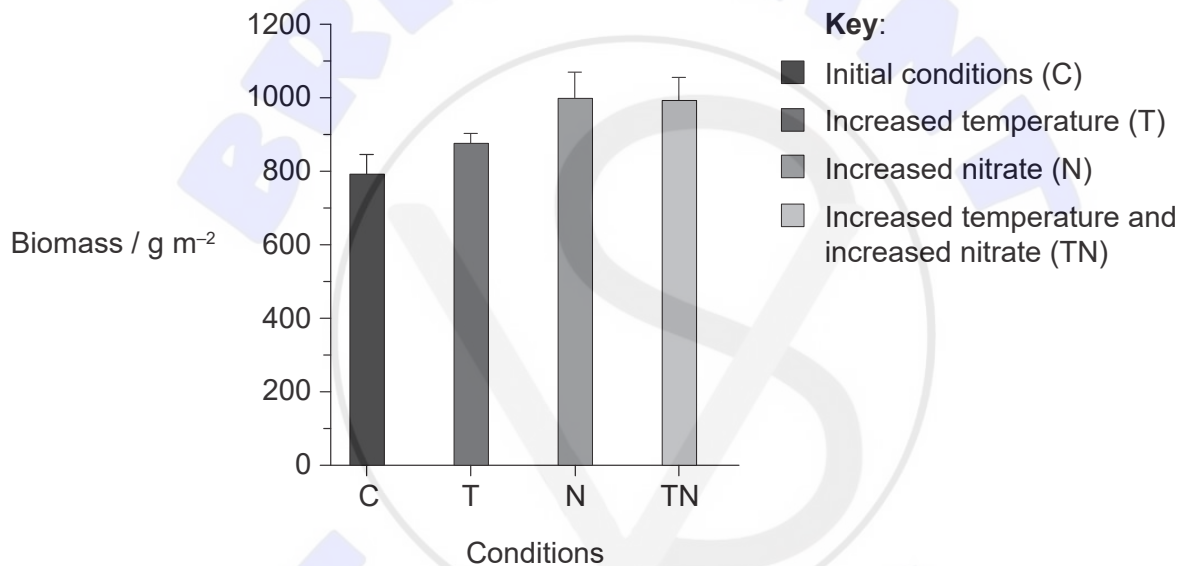
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In a larger study, California grassland was exposed to elevated temperature and nitrate concentration for five years. The graph shows the total biomass production in individual and in combined treatments. Error bars denote one standard error.



[Source: adapted from Dukes, J.S., Chiariello, N.R., Cleland, E.E., Moore, L.A., Shaw, M.R., Thayer, S., Tobeck, T., Mooney, H.A. and Field, C.B., 2005. *PLOS Biology*, 3(10), e319. <https://doi.org/10.1371/journal.pbio.0030319>.]

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**(Question 1 continued)**

(e) Describe the effects of temperature and nitrate concentration on biomass. [3]

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(f) Suggest **two** abiotic factors, other than temperature and nutrient supply, that may affect the production of biomass of the grasslands. [2]

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(g) The first study used mesocosms and the second study was carried out in natural grassland. Discuss the use of mesocosms as opposed to a study in a natural environment. [2]

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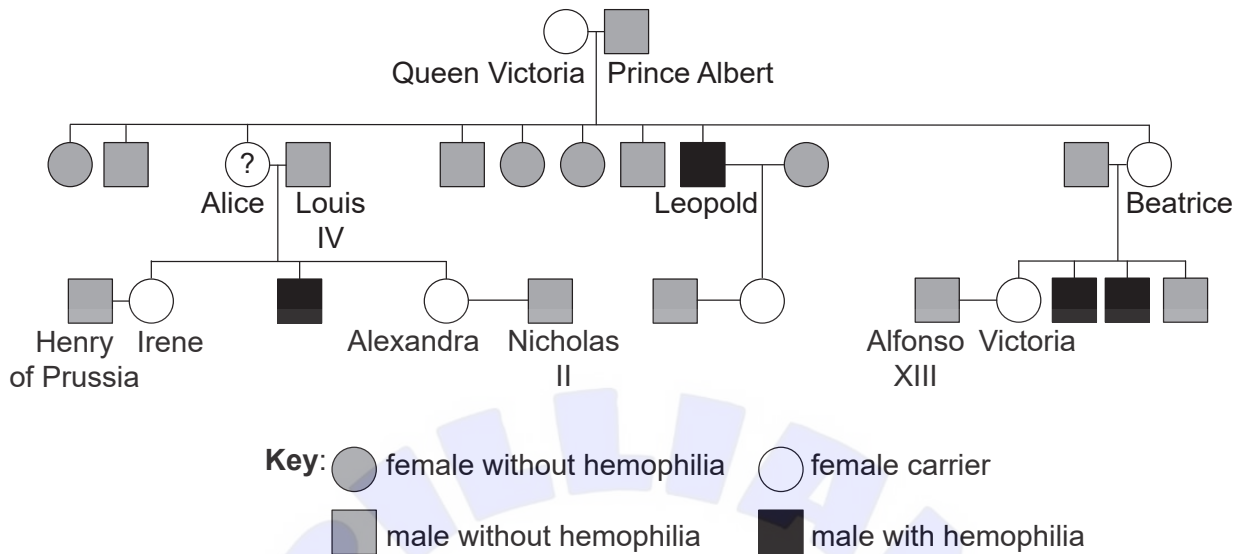
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2. Hemophilia is a sex-linked disease that affected some members of royal families in Europe during the 19th and 20th centuries.



- (a) (i) Draw a Punnett square to show all the possible genotypes of Queen Victoria's children. [2]

- (ii) Deduce the genotype of Queen Victoria's daughter Alice. [1]

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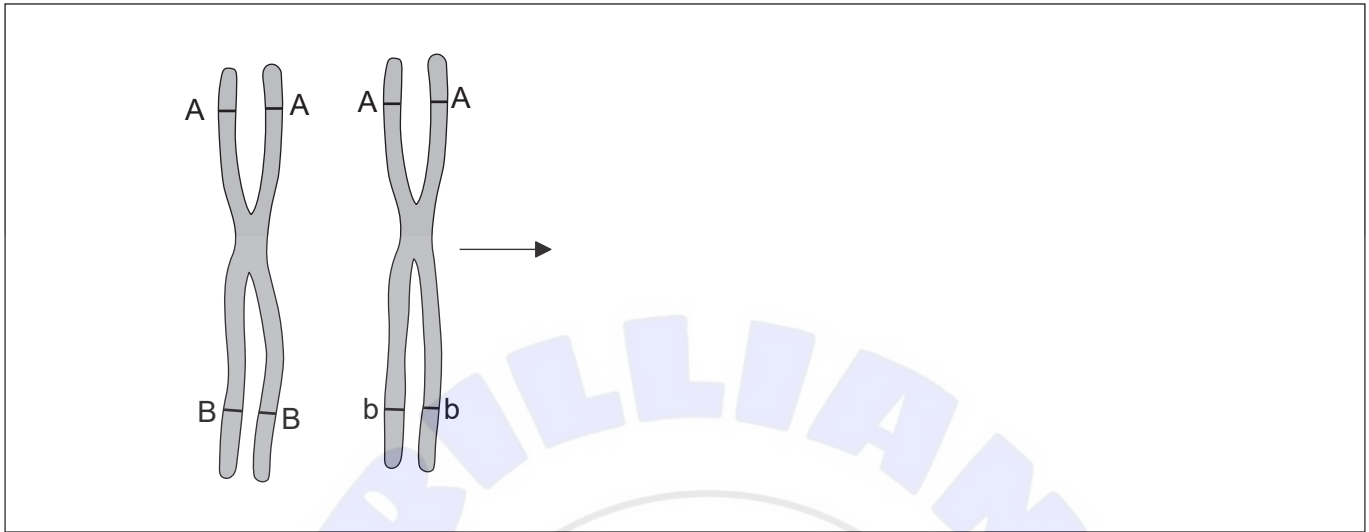
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**(Question 2 continued)**

- (b) The diagram shows the structure of two chromosomes after the first division of meiosis, assuming that there was no crossing over or chiasmata formation.



- (i) Draw the same chromosomes to show their structure at the same stage of meiosis if there had been one chiasma between two gene loci. [1]
- (ii) State the stage of meiosis where chiasmata formation may occur. [1]

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- (c) Explain gene linkage and its effects on inheritance. [2]

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- (d) Explain the mechanism that prevents polyspermy during fertilization. [2]

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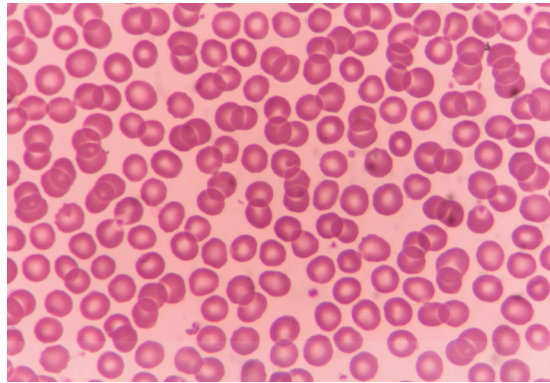
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3. The image shows human red blood cells.



(a) Outline what will happen to human red blood cells if transferred to distilled water. [1]

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(b) Stem cells can be used to treat Stargardt's disease. State **one** other condition treated using stem cells. [1]

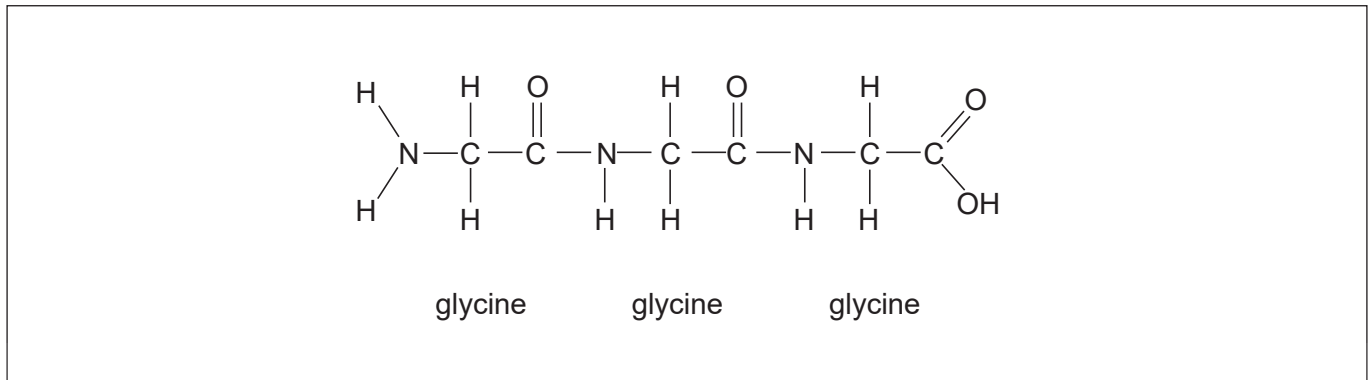
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(c) Explain the propagation of nerve impulses along the membrane of a neuron. [3]

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4. The figure shows a tripeptide.



- (a) Label **one** peptide bond in this molecule. [1]
- (b) Describe the secondary structure of proteins. [2]

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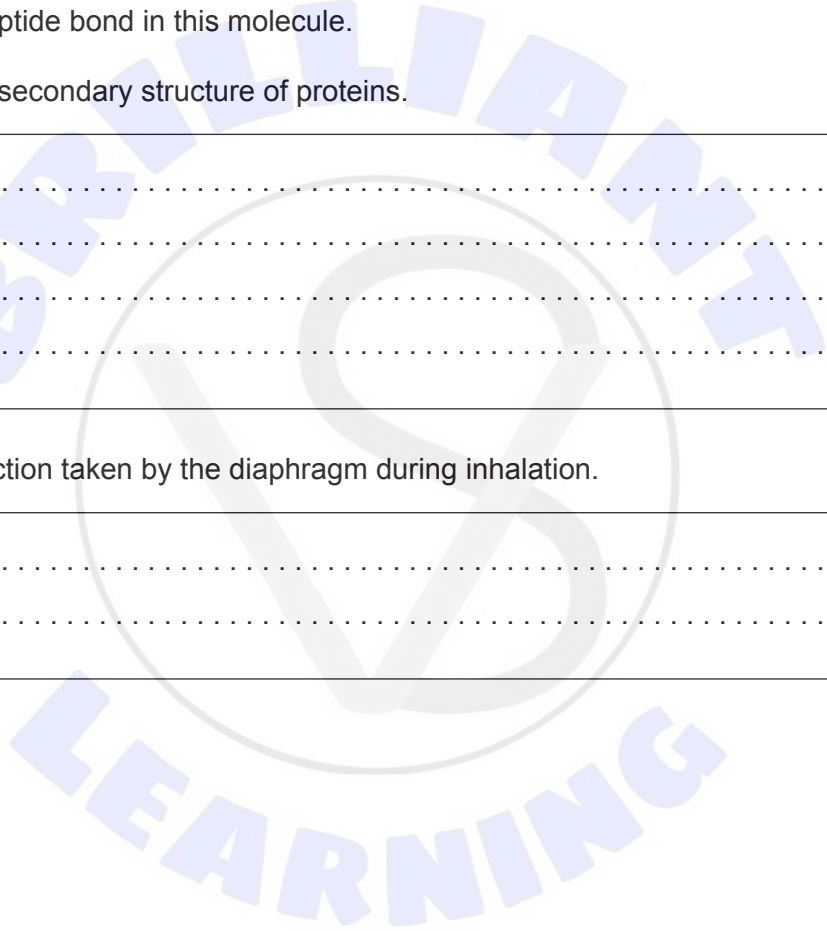
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- (c) Outline the action taken by the diaphragm during inhalation. [1]

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5. (a) Compare and contrast the mode of nutrition of detritivores and saprotrophs. [2]

	Detritivores	Saprotrophs
Similarity		
Difference		

- (b) Explain how some plant species are able to respond to changes in their abiotic environment and flower at a precise time of the year. [3]

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- (c) Outline the extension of the stem in plants. [2]

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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. RNA molecules play numerous roles in gene expression and so contribute to variation.
- (a) Draw labelled diagrams to show the structure of RNA nucleotides and how they are linked together to form a molecule of RNA. [4]
  - (b) Explain transcription. [7]
  - (c) Distinguish between continuous and discrete variation, using examples. [4]
7. Plants have developed efficient methods for transport and for synthesis of foods.
- (a) Outline how the properties of water make it an ideal transport medium in plants. [4]
  - (b) Distinguish between the xylem and phloem of plants. [4]
  - (c) Explain how the light-independent reactions of photosynthesis rely on the light-dependent reactions. [7]
8. Proteins carry out many important functions in cells and in organisms.
- (a) Outline the process of protein denaturation. [4]
  - (b) Explain the production of antibodies in humans. [7]
  - (c) Distinguish between competitive and non-competitive enzyme inhibition. [4]

















**References:**

1. (a) (b) (c) O'Connor, M.I., Piehler, M.F., Leech, D.M., Anton, A. and Bruno, J.F., 2009. *PLOS Biology*, [e-journal] 7(9). <https://doi.org/10.1371/journal.pbio.1000178>.
1. (e) Dukes, J.S., Chiariello, N.R., Cleland, E.E., Moore, L.A., Shaw, M.R., Thayer, S., Tobeck, T., Mooney, H.A. and Field, C.B., 2005. *PLOS Biology*, 3(10), e319. <https://doi.org/10.1371/journal.pbio.0030319>.
3. someoneice/123rf.com.

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