Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

Friday 28 October 2022 (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]**.

8822 – 6002

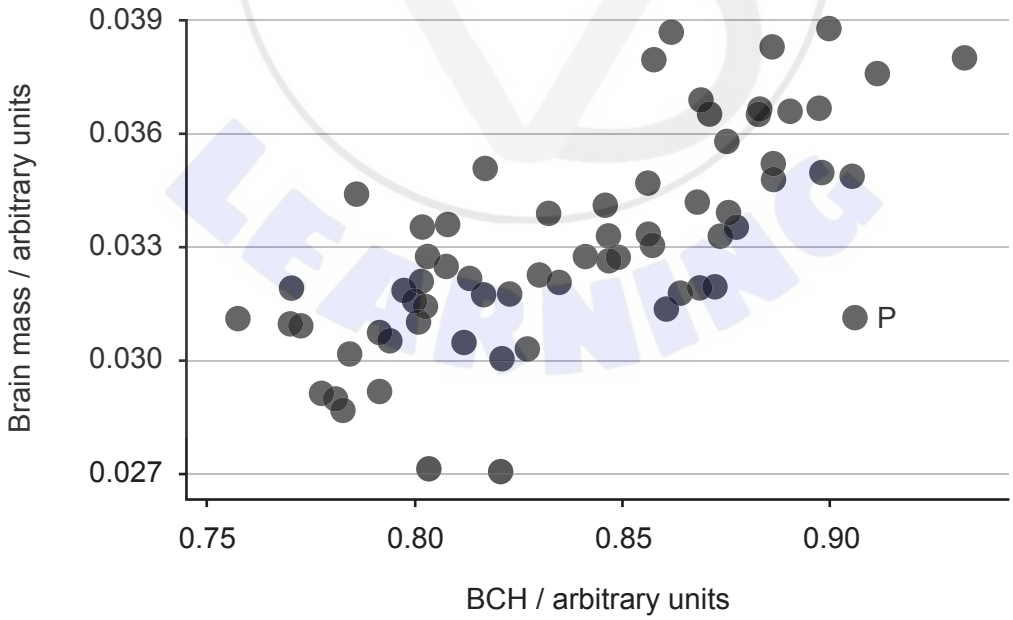
Section A

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

1. Common shrews (*Sorex araneus*) are small mammals found in Northern Europe. Their diet includes insects, slugs, spiders, worms and amphibians. They do not hibernate in winter because their bodies are too small to store sufficient fat reserves.

[Source: [*Shrew*], n.d. [image online] Available at: https://www.pxfuel.com/en/free-photo-jslkw [Accessed 29 October 2021].]

To study brain size in shrews, researchers anesthetize them, X-ray their skulls and measure the height of the braincase (BCH) where the brain is located. The graph shows the relationship between BCH and the brain mass of individual adult shrews.



[Source: adapted from Lázaro, J., Hertel, M., LaPoint, S., Wikelski, M., Stiehler, M. and Dechmann, D.K.N., 2018. *Journal of Experimental Biology* 221. http://doi.org/10.1242/jeb.166595.]

(This question continues on the following page)

(Question 1 continued)

(a) State the relationship between BCH and brain mass of shrews. [1]

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(b) Outline how the shrew labelled P differs from the normal relationship between BCH and brain mass. [1]

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(c) Suggest a reason that researchers use BCH rather than brain mass to indicate brain size. [1]

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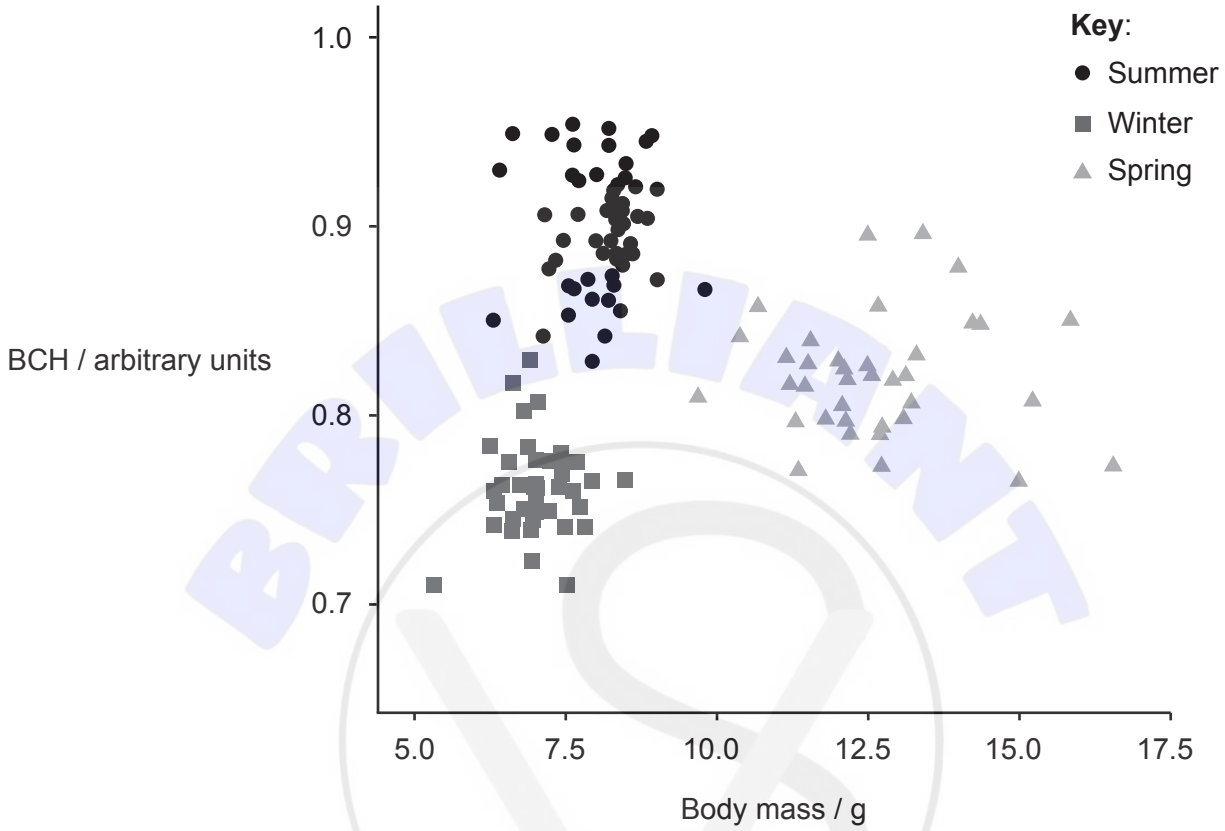
(This question continues on the following page)

(Question 1 continued)

The researchers found that the BCH of any individual adult shrew could vary seasonally. They collected shrews at different times of the year. The BCH of each shrew was compared with its body mass. The results are displayed in the chart.



[Source: adapted from Schaeffer, P.J., O'Mara, M.T., Breiholz, J., Keicher, L., Lázaro, J., Muturi, M., Dechmann, D.K.N., 2020. *R. Soc. Open Sci.* 7. http://dx.doi.org/10.1098/rsos.191989.]

(This question continues on the following page)

(Question 1 continued)

(d) State the season when shrew brain mass is greatest. [1]

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(e) Compare and contrast the results for winter and spring. [2]

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(f) Suggest a reason for the difference in BCH in summer and winter. [1]

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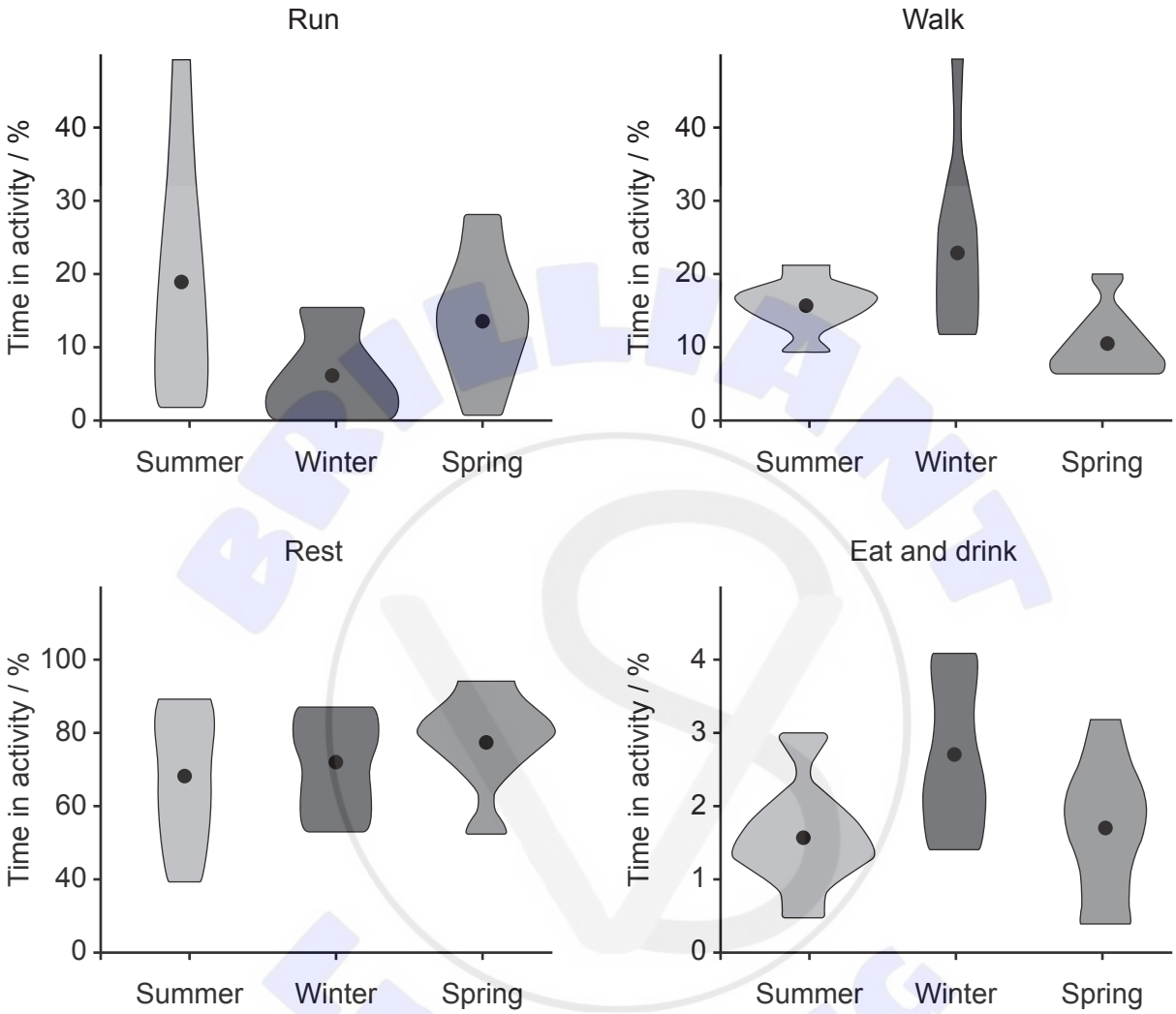
(This question continues on the following page)

(Question 1 continued)

Shrews were observed in different seasons and the time they spent on a particular activity was recorded and expressed as a percentage of the total observation time. The circles in the kite shapes represent the mean value of time for each activity.



[Source: adapted from Schaeffer, P.J., O'Mara, M.T., Breiholz, J., Keicher, L., Lázaro, J., Muturi, M., Dechmann, D.K.N., 2020. *R. Soc. Open Sci.* 7. http://dx.doi.org/10.1098/rsos.191989.]

(This question continues on the following page)

(Question 1 continued)

(g) State the activity and season that occupied the greatest mean percentage of observation time. [1]

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(h) Suggest a reason for the difference in the time observed eating and drinking. [2]

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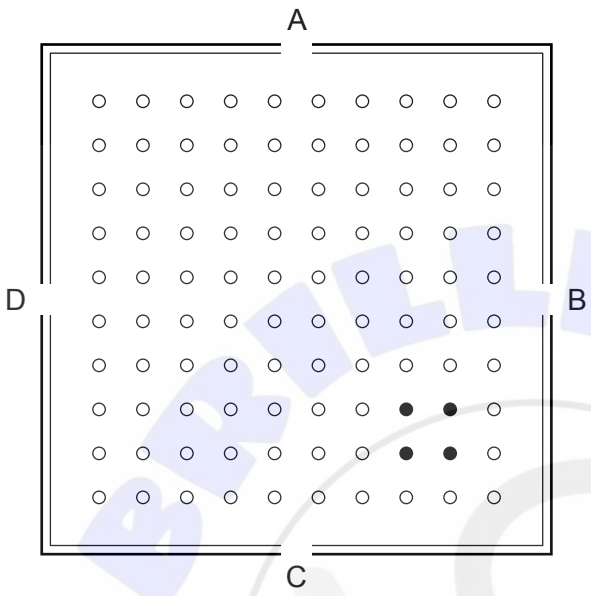
(Question 1 continued)

The researchers were interested in the seasonal differences in searching for food. They set up a square arena with sides of 110 cm and four entrances (A, B, C and D). Containers were placed in the arena, some with food and others with no food. The diagram shows a top-down view of the arena.



Key:

○ Container with no food

● Container with food

[Source: adapted from Lázaro, J., Hertel, M., LaPoint, S., Wikelski, M., Stiehler, M. and Dechmann, D.K.N., 2018. *Journal of Experimental Biology* 221. http://doi.org/10.1242/jeb.166595.]

Each shrew was starved of food for two hours before its cage was opened at one of the entrances to the arena. The length of the path taken by the shrew to obtain food was measured. This was standardized by dividing the path length by the straight-line distance from the entrance to the containers with food. Each shrew was used for 10 trials.

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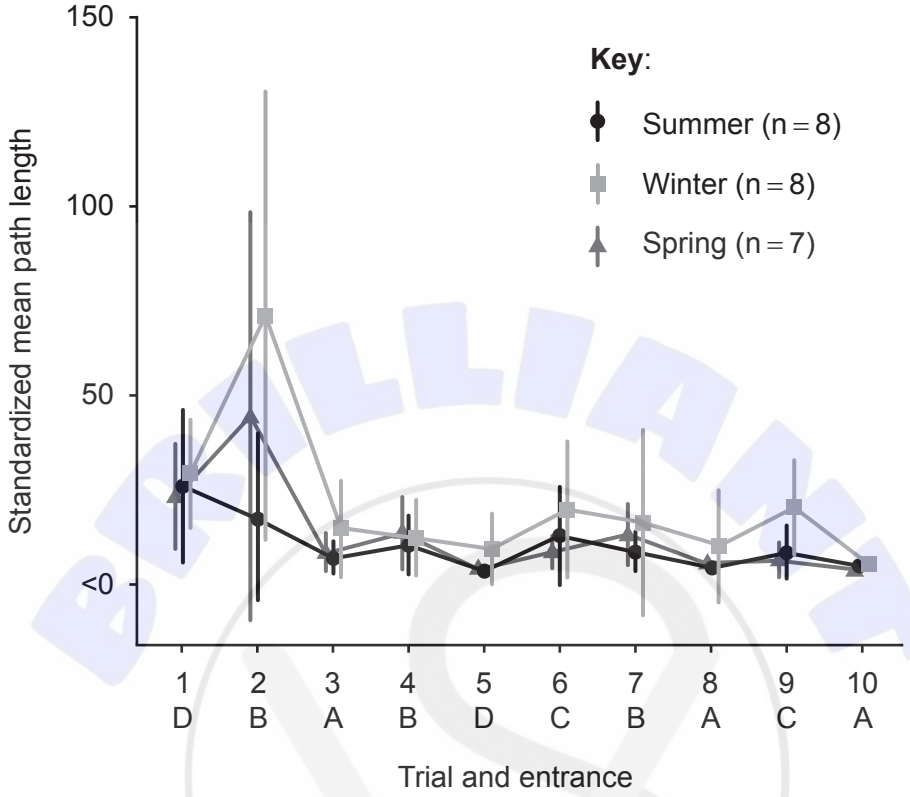
(Question 1 continued)

The graph shows the standardized mean path length taken by all the shrews at different seasons of the year. The letters show where the cages were placed for each trial.



[Source: adapted from Lázaro, J., Hertel, M., LaPoint, S., Wikelski, M., Stiehler, M. and Dechmann, D.K.N., 2018. *Journal of Experimental Biology* 221. http://doi.org/10.1242/jeb.166595.]

(i) Calculate the percentage of containers that contained food. [1]

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(j) Outline a reason that the path length was standardized. [1]

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(This question continues on the following page)

(Question 1 continued)

(k) Compare and contrast the results for trials 2 and 9. [2]

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(l) With reference to all the data, suggest a reason for the difference in standardized mean path length for summer and winter. [2]

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2. When performing dihybrid crosses with fruit flies (*Drosophila*), Morgan discovered that his results did not correspond to the expected Mendelian ratios. He explained this by suggesting that there is an exchange of genetic material between chromosomes. The image shows his diagram for three gene loci on a pair of homologous chromosomes during meiosis.

(a) Identify the stage of meiosis shown where exchange of genetic material occurs. [1]

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(b) Explain the reason that Morgan's results did not agree with expected Mendelian ratios in a dihybrid cross. [2]

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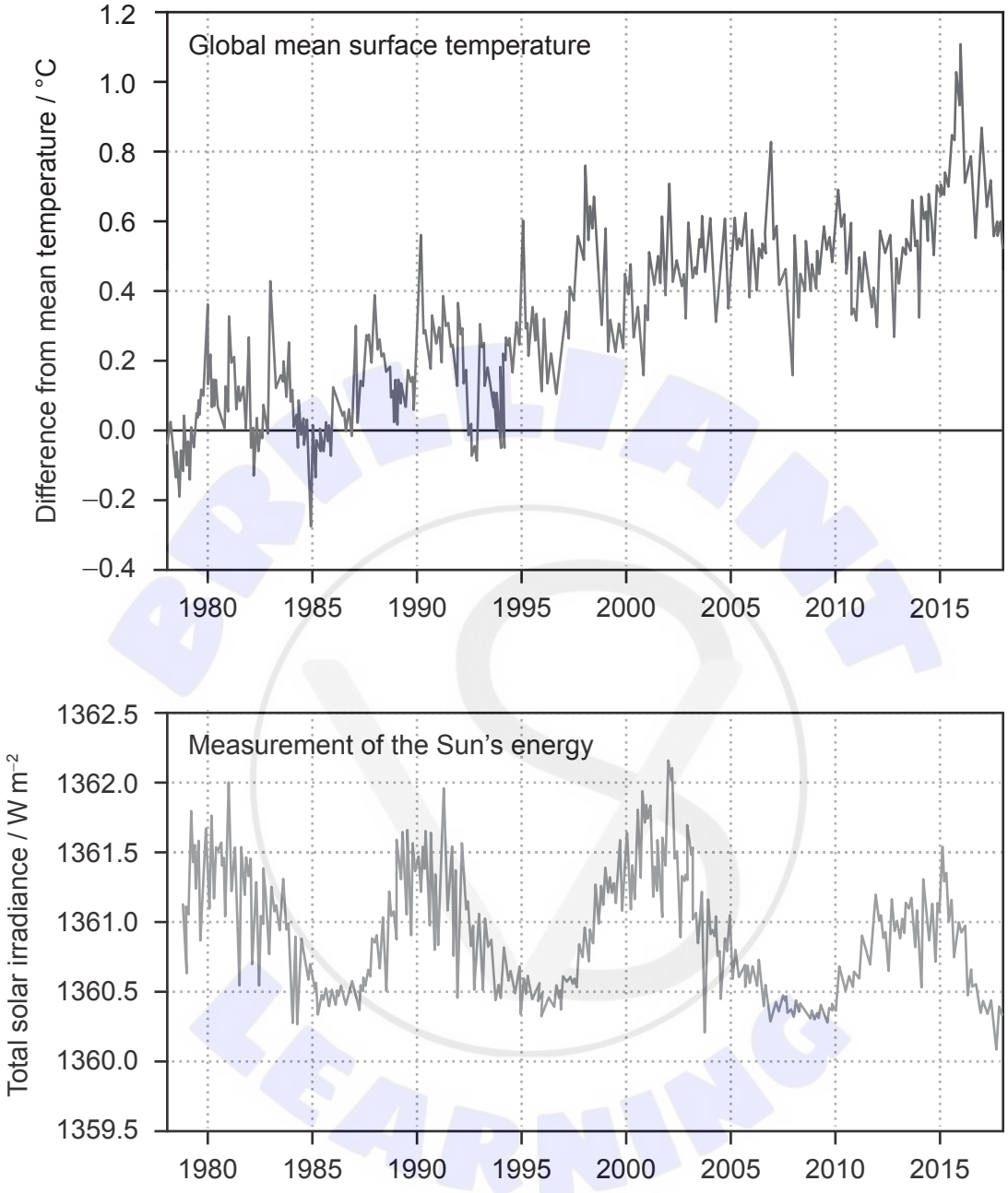
3. The graphs show how the global mean surface temperature changed from 1978 to 2018, as well as the amount of energy reaching the surface of the Earth from the Sun.



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(Question 3 continued)

(a) It has been argued that variation in the global mean surface temperature has been caused by variation in energy from the Sun. Analyse whether evidence from the graphs supports this argument. [2]

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(b) Explain how increased levels of atmospheric carbon dioxide contribute to global warming. [3]

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(c) State **one** other gas that contributes to global warming. [1]

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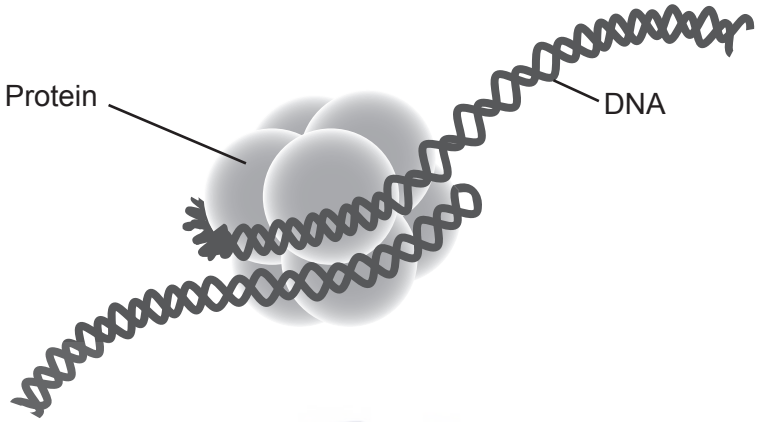
4. The diagram shows a nucleosome from the nucleus of a eukaryotic cell.



(a) Identify the protein labelled in the diagram. [1]

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(b) Outline how nucleosomes affect the transcription of DNA. [1]

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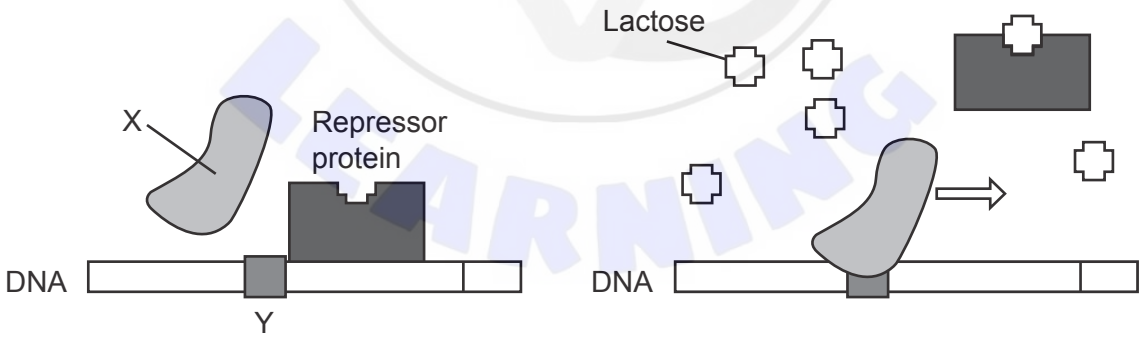
The image shows the regulation of the gene responsible for producing lactase.



Lactose absent Lactose present

(This question continues on the following page)

(Question 4 continued)

(c) Identify:

(i) X, the enzyme which copies a DNA sequence [1]

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(ii) Y, non-coding DNA at the start of a gene. [1]

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(d) Explain the role of lactose in the expression of the gene for lactase production. [3]

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(e) State **one** reason that identical twins may show different methylation patterns as they grow older. [1]

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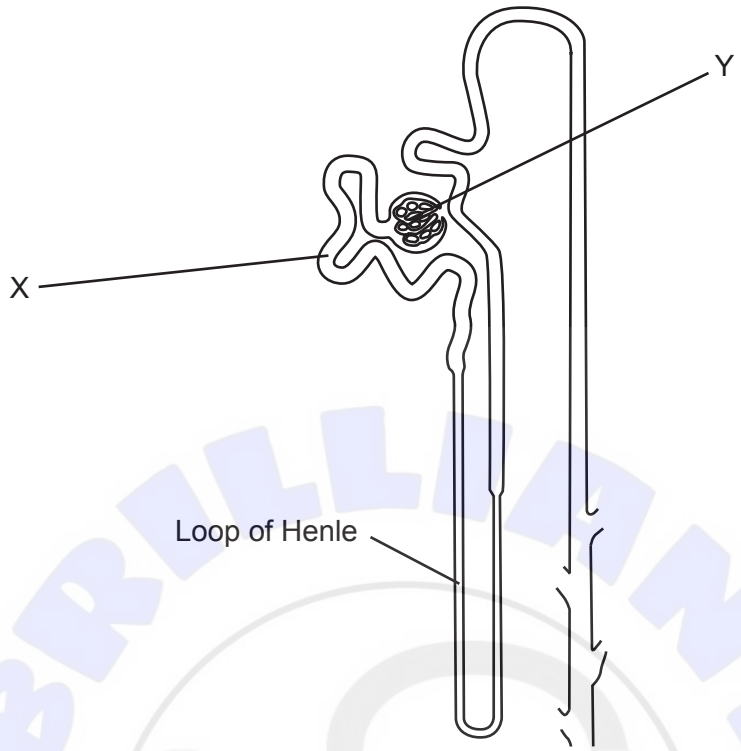
5. The diagram shows a nephron from a mammal.



(a) Identify:

(i) structure X [1]

. . . . . .
. . . . . .

(ii) structure Y. [1]

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(b) State the region of the kidney in which the loop of Henle is situated. [1]

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(Question 5 continued)

(c) Explain the role of the hormone ADH in osmoregulation. [2]

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(d) Outline **two** adaptations for water conservation in leaves of desert 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. Multicellular organisms benefit from cell specialization and division of labour.

(a) Outline the processes occurring during interphase in the cell cycle. [4]

(b) Describe what occurs in a neuron when an action potential is propagated along the axon. [4]

(c) Explain how cells in the bloodstream cause a specific immune response. [7]

7. A wide variety of organic compounds are used by living organisms.

(a) Draw a diagram to show the ring structure of D-ribose. [3]

(b) Describe how ATP is produced by Photosystem II in the light-dependent stage of photosynthesis. [5]

(c) Explain how carbohydrates are transported from plant leaves. [7]

8. Evolution causes gene pools to change over time and new species to be formed.

(a) Outline how adaptive radiation provides evidence for evolution. [3]

(b) Describe polyploidy and how it can lead to speciation. [5]

(c) Explain how a newly discovered plant species would be classified and named. [7]

Disclaimer:

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References:

1.a [*Shrew*], n.d. [image online] Available at: https://www.pxfuel.com/en/free-photo-jslkw [Accessed 29 October 2021].

[graph] Adapted from Lázaro, J., Hertel, M., LaPoint, S., Wikelski, M., Stiehler, M. and Dechmann, D.K.N., 2018. *Journal of Experimental Biology* 221. http://doi.org/10.1242/jeb.166595.

1.d [chart] Adapted from Schaeffer, P.J., O'Mara, M.T., Breiholz, J., Keicher, L., Lázaro, J., Muturi, M., Dechmann, D.K.N., 2020. *R. Soc. Open Sci.* 7. http://dx.doi.org/10.1098/rsos.191989.

1.g [charts] Adapted from Schaeffer, P.J., O'Mara, M.T., Breiholz, J., Keicher, L., Lázaro, J., Muturi, M., Dechmann, D.K.N., 2020. *R. Soc. Open Sci.* 7. http://dx.doi.org/10.1098/rsos.191989.

1.i [diagram] Adapted from Lázaro, J., Hertel, M., LaPoint, S., Wikelski, M., Stiehler, M. and Dechmann, D.K.N., 2018. *Journal of Experimental Biology* 221. http://doi.org/10.1242/jeb.166595.

[graph] Adapted from Lázaro, J., Hertel, M., LaPoint, S., Wikelski, M., Stiehler, M. and Dechmann, D.K.N., 2018. *Journal of Experimental Biology* 221. http://doi.org/10.1242/jeb.166595.

2. Morgan, T.H., 1916. Scheme to illustrate double crossing over. [diagram online] Available at: https://upload.wikimedia.org/wikipedia/commons/0/0e/Morgan_crossover_1.jpg.

3. Used with permission of The National Academies Press from *Climate Change: Evidence and Causes: Update 2020*, National Research Council, Washington, DC 2020, permission conveyed through Copyright Clearance Center, Inc. Available at: https://doi.org/10.17226/25733 [Accessed 29 October 2021].

Physikalisch-Meteorologisches Observatorium Davos. VIRGO scale from 1978 to mid-2018. https://royalsociety.org/topics-policy/projects/climate-change-evidence-causes/question-4/.

4.a Weissman Lab at UCSF. *UCSF Team Views Genome as it Turns On and Off Inside Cells*. [diagram online] Available at https://www.ucsf.edu/news/2011/01/98118/ucsf-team-views-genome-it-turns-and-inside-cells [Accessed 1 December 2022].

4.c *Lac Operon*, n.d. [diagram online] T A RAJU. Available at: https://commons.wikimedia.org/wiki/File:Lac_Operon.svg [Accessed 29 October 2021].

5. Brody, T., 1999. *The nephron*. [diagram online] Available at: https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/nephron [Accessed 29 October 2021].