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Biology
Higher level
Paper 2

Wednesday 11 May 2022 (afternoon)

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]**.

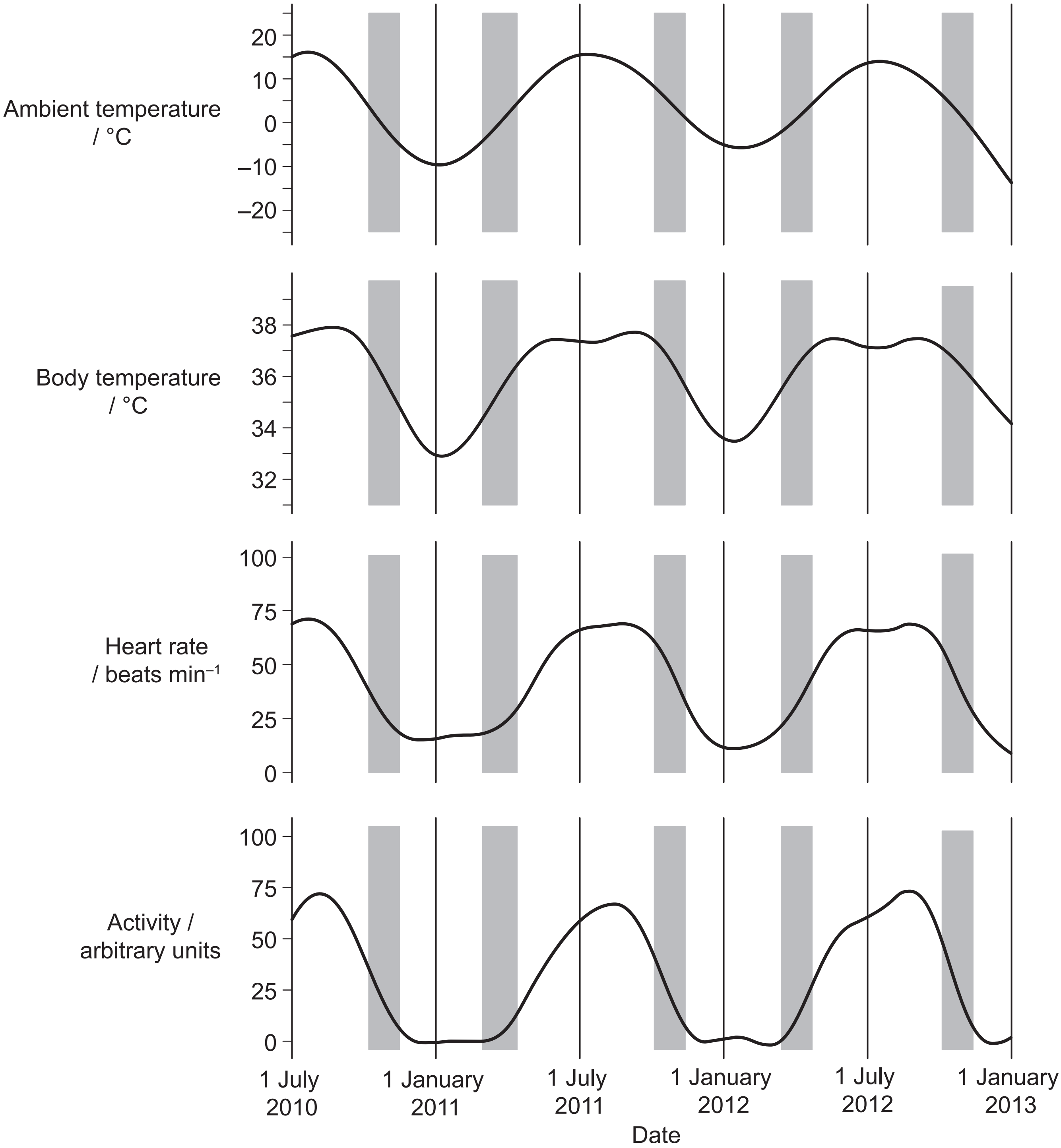
20 pages

2222 – 6008

Section A

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

1. In winter when temperatures drop, brown bears (*Ursus arctos*) enter a cave and hibernate. The graph shows the mean values for the body temperature, heart rate and activity of 14 brown bears throughout the year. The grey shaded areas indicate the periods when the bears are in transition between hibernation and normal activity.



[Source: Adapted from Evans, A.L., Singh, N.J., Friebe, A., Arnemo, J.M., Laske, T.G., Fröbert, O., Swenson, J.E. and Blanc, S., 2016. Drivers of hibernation in the brown bear. *Frontiers in Zoology*, 13(7). This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/).]

(This question continues on the following page)

(Question 1 continued)

(a) Estimate the difference between the highest and lowest mean body temperatures. [1]

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(b) Compare and contrast the changes in mean ambient and body temperatures during 2012. [2]

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(c) Explain the change in heart rate during the period of hibernation. [2]

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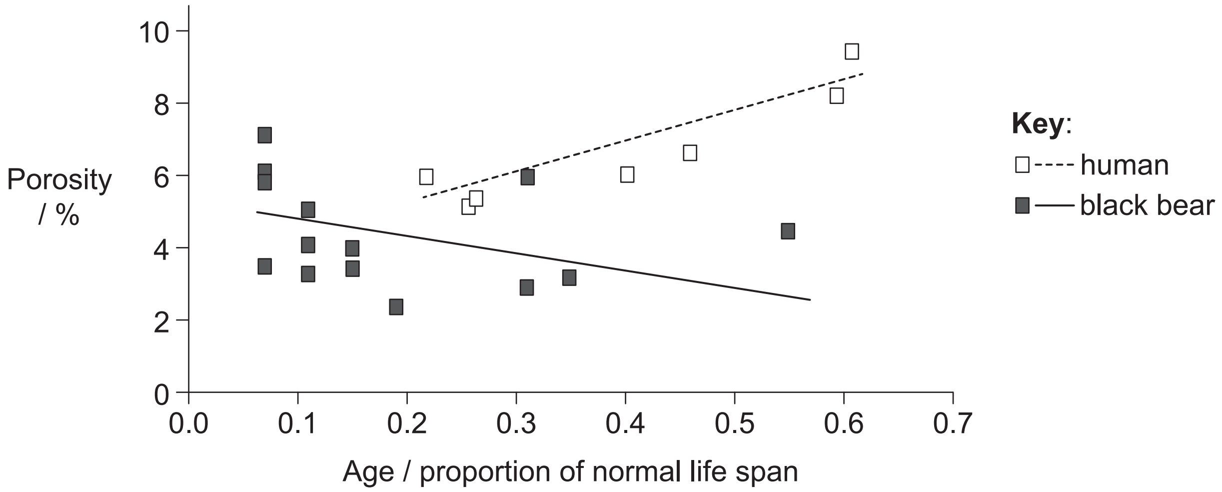
(This question continues on the following page)

(Question 1 continued)

It was observed that during hibernation bears are not susceptible to osteoporosis, a condition characterized by a decrease in the density of bone, resulting in porous and fragile bones. This condition may develop in humans during long periods of inactivity and with increasing age. The graph shows the porosity of the tibia bones of black bears (*Ursus americanus*) and humans at different ages. Age is expressed as the proportion of normal life span.



[Source: Adapted from *Journal of Biomechanics*, 39(8), Donahue, S.W., McGee, M.E., Harvey, K.B., Vaughan, M.R. and Robbins, T., Hibernating bears as a model for preventing disuse osteoporosis, pp.1480–1488. Copyright (2006), with permission from Elsevier.]

(d) Distinguish between the changes in porosity of the bones in humans and bears as age increases. [1]

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(e) The life expectancy of a human at the time of the study was 80 years. Estimate the porosity of the bones of the individual who was approximately 32 years old. [1]

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(f) The researchers assessed age as a proportion of normal life span, rather than in years. Suggest **one** reason for this. [1]

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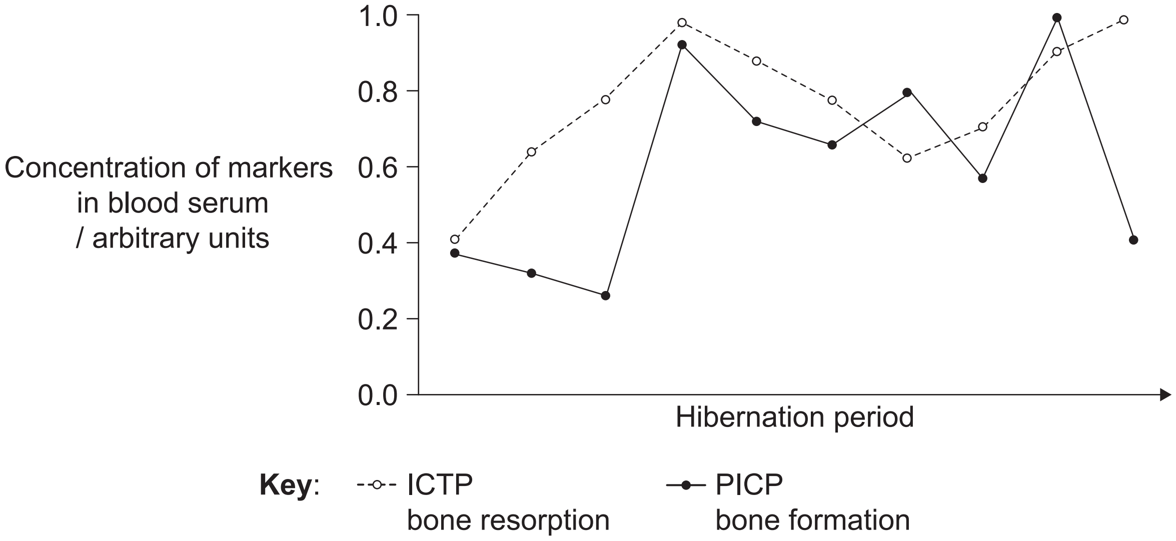
(This question continues on the following page)

(Question 1 continued)

Healthy bone is constantly being broken down (bone resorption) and at the same time being rebuilt (bone formation). Bone mass should therefore not normally change, nor bone diseases occur. To test whether these processes occurred during hibernation in black bears, blood serum was tested for the markers ICTP (indicating bone resorption) and PICP (indicating bone formation).



[Source: Republished with permission of Company of Biologists Ltd, from Parathyroid hormone may maintain bone formation in hibernating black bears (Ursus americanus) to prevent disuse osteoporosis. Donahue, Seth W; Galley, Sarah A; Vaughan, Michael R; Patterson-Buckendahl, Patricia; Demers, Laurence M; Vance, Josef L;McGee, Meghan E, *Journal of experimental biology*, 01 May 2006, Vol. 209, Issue Pt 9, pages 1630–1638; permission conveyed through Copyright Clearance Center, Inc.]

(g) Describe what is happening to the bone during hibernation. [2]

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(h) Suggest how the graph would differ for a human during a long period of inactivity. [1]

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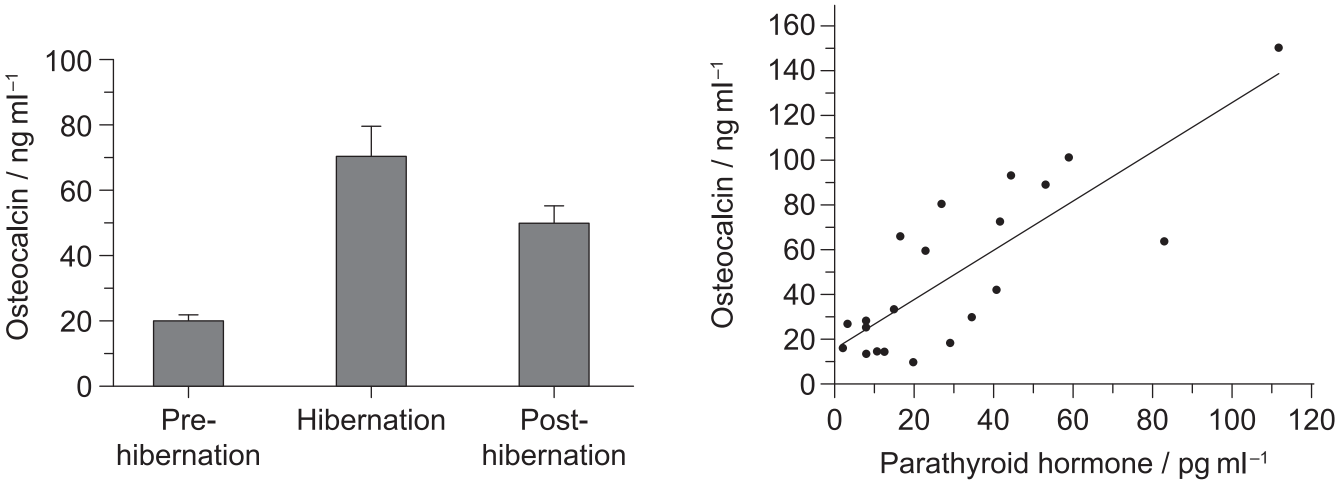
(This question continues on the following page)

(Question 1 continued)

Osteocalcin is a peptide hormone that causes calcium to bind in the bones, so is involved in bone formation and regeneration. Research shows that changes in the mean concentration of osteocalcin in blood serum occur before and after hibernation in bears. In this research, concentration of both osteocalcin and parathyroid hormone were measured in the blood serum of bears. Results are shown in the bar chart and graph.



[Source: Republished with permission of Company of Biologists Ltd, from Parathyroid hormone may maintain bone formation in hibernating black bears (Ursus americanus) to prevent disuse osteoporosis. Donahue, Seth W; Galley, Sarah A; Vaughan, Michael R; Patterson-Buckendahl, Patricia; Demers, Laurence M; Vance, Josef L;McGee, Meghan E, *Journal of experimental biology*, 01 May 2006, Vol. 209, Issue Pt 9, pages 1630–1638; permission conveyed through Copyright Clearance Center, Inc.]

(i) Calculate the percentage increase in the mean concentration of osteocalcin from pre-hibernation to hibernation. [1]

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(j) A hypothesis has been proposed that an increase in parathyroid hormone concentration causes an increase in osteocalcin in bears. Evaluate the evidence for this hypothesis provided by the data. [2]

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(This question continues on the following page)

(Question 1 continued)

(k) Discuss how helpful these studies of bears can be in developing an understanding of osteoporosis in humans. [2]

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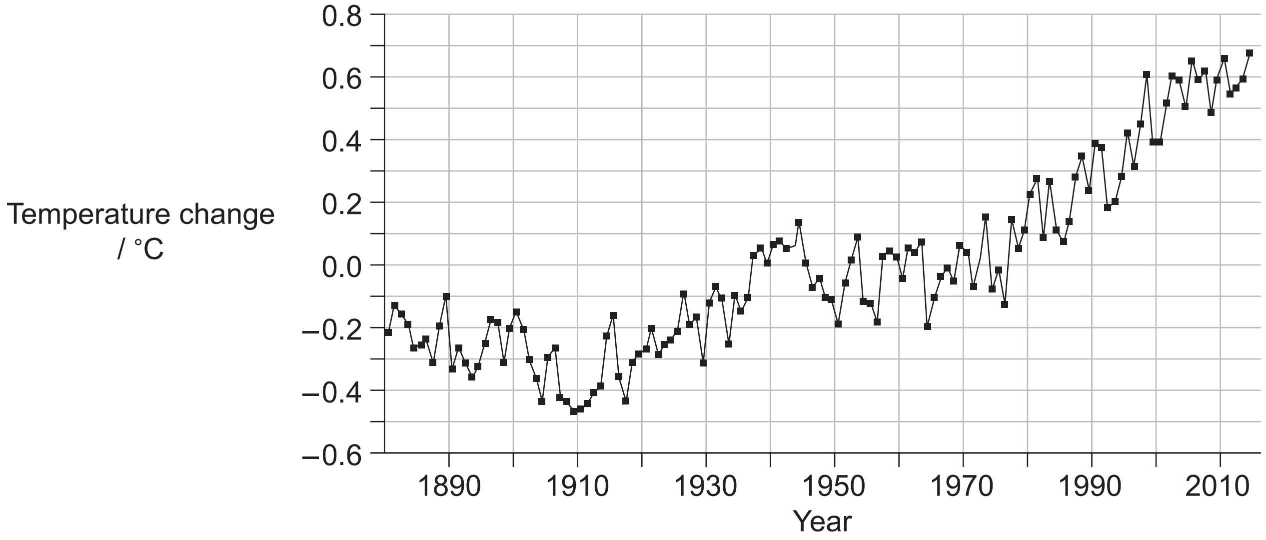
2. The graph shows the mean annual changes in global temperatures between 1880 and 2014. The mean temperature from 1951 to 1980 was used as the value of zero change in temperature.



(a) Calculate the increase in mean global temperature between 1880 and 2010. [1]

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(b) Outline how changes in temperature over short time periods could give a misleading impression of changes to the Earth's climate. [1]

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(c) Explain how increased carbon dioxide in the air leads to the greenhouse effect. [3]

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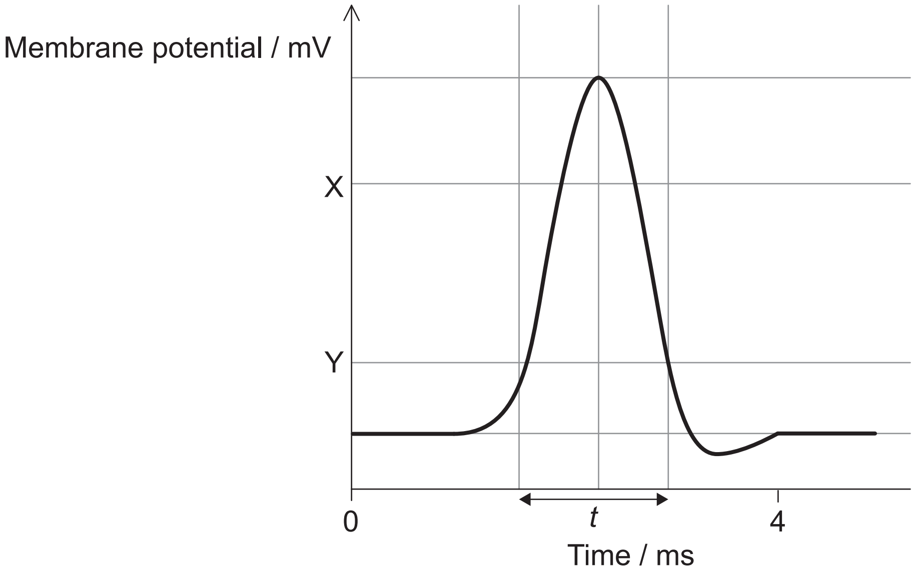
3. The graph shows the change in the membrane potential of an axon during an action potential.



(a) State the approximate value of the membrane potential at X. [1]

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(b) Y is the threshold potential. State what happens when the threshold potential is reached. [1]

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(c) Describe the movements in ions that occur during time *t*. [2]

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(This question continues on the following page)

(Question 3 continued)

(d) Explain how a nerve impulse is passed on to other neurons. [3]

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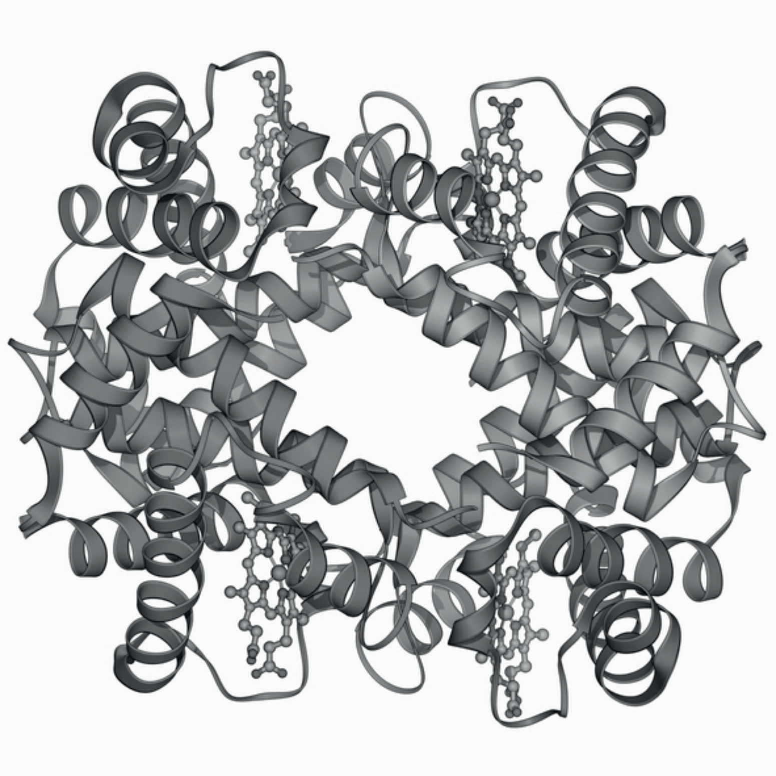
4. Hemoglobin is a conjugated protein consisting of four polypeptide chains with attached heme groups.



(a) State the level of protein structure at which the polypeptide chains of hemoglobin are combined. [1]

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(This question continues on the following page)

(Question 4 continued)

(b) Explain the shape of the polypeptide chain at X. [2]

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(c) Outline the role of tRNA in hemoglobin synthesis. [2]

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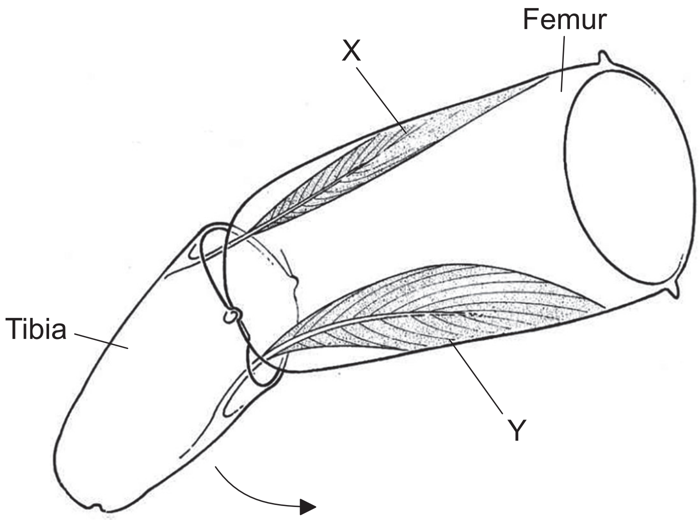
5. The diagram shows a section through part of the leg of an insect and antagonistic muscles X and Y. The tibia moves in the direction shown by the arrow when the muscle is flexing.



(a) Outline a reason for the muscles being described as antagonistic. [1]

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(b) Describe the role of muscle Y. [2]

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(c) Outline how the muscle attachment of insects differs from humans. [1]

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(This question continues on the following page)

(Question 5 continued)

(d) Explain the role of calcium ions in muscle contraction. [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. (a) Outline how the properties of water make it an effective coolant for the body. [3]

(b) Describe how changes in weather conditions affect the transport and loss of water in plants. [5]

(c) Explain how water balance is restored in mammals when they are dehydrated. [7]

7. (a) Outline reasons for the therapeutic use of stem cells. [3]

(b) Describe how monoclonal antibodies are produced. [5]

(c) Explain the role of the electron transport chain in the generation of ATP by cell respiration. [7]

8. (a) Draw a labelled diagram to show the structure of a single nucleotide of RNA. [3]

(b) Describe how DNA profiling can be used to establish paternity. [5]

(c) Explain the reasons for variation in human height. [7]

References:

1. (a) Adapted from Evans, A.L., Singh, N.J., Friebe, A., Arnemo, J.M., Laske, T.G., Fröbert, O., Swenson, J.E. and Blanc, S., 2016. Drivers of hibernation in the brown bear. *Frontiers in Zoology*, 13(7). This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/).

1. (d) Adapted from *Journal of Biomechanics*, 39(8), Donahue, S.W., McGee, M.E., Harvey, K.B., Vaughan, M.R. and Robbins, T., Hibernating bears as a model for preventing disuse osteoporosis, pp.1480–1488. Copyright (2006), with permission from Elsevier.

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1. (i) (left) Republished with permission of Company of Biologists Ltd, from Parathyroid hormone may maintain bone formation in hibernating black bears (Ursus americanus) to prevent disuse osteoporosis. Donahue, Seth W; Galley, Sarah A; Vaughan, Michael R; Patterson-Buckendahl, Patricia; Demers, Laurence M; Vance, Josef L;McGee, Meghan E, *Journal of experimental biology*, 01 May 2006, Vol. 209, Issue Pt 9, pages 1630–1638; permission conveyed through Copyright Clearance Center, Inc.

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2. National Aeronautics and Space Administration, n.d. GISS Surface Temperature Analysis (v3). [online] Available at: https://data.giss.nasa.gov/gistemp/graphs_v3/ [Accessed 20 August 2019].

4. LAGUNA DESIGN/Science Photo Library via Getty Images.

5. D G Mackean www.biology-resources.com.