

**Biology**  
**Higher level**  
**Paper 3**

Thursday 7 May 2015 (afternoon)

Candidate session number

1 hour 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.
- Answer all of the questions from two of the Options.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[40 marks]**.

Option	Questions
Option D — Evolution	1 – 3
Option E — Neurobiology and behaviour	4 – 6
Option F — Microbes and biotechnology	7 – 9
Option G — Ecology and conservation	10 – 12
Option H — Further human physiology	13 – 15

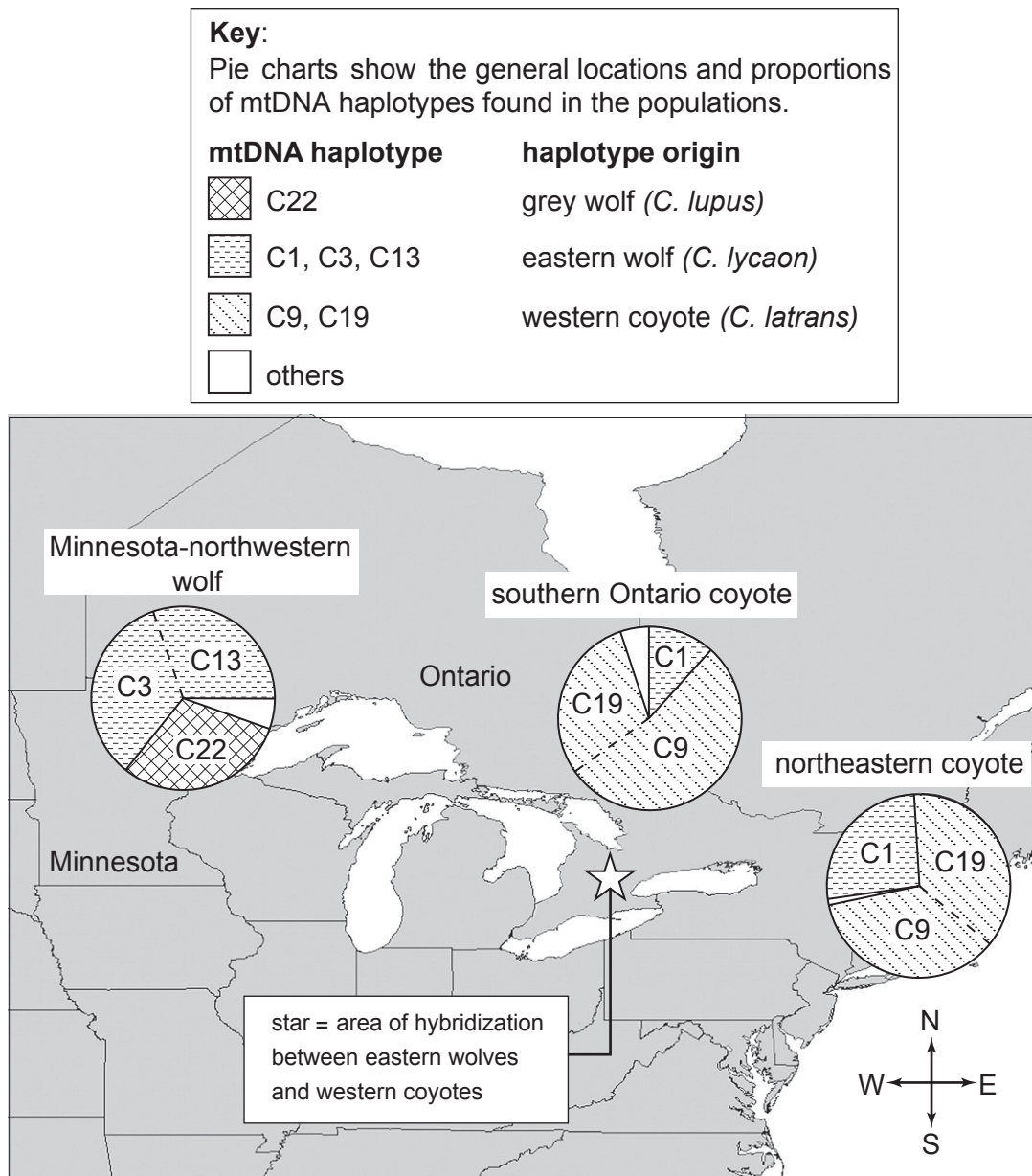


**Option D — Evolution**

1. There are many closely related *Canis* species in North America including the grey wolf (*C. lupus*), eastern wolf (*C. lycaon*) and western coyote (*C. latrans*). Hybridization can occur between members of these species.

For example, during the last 100 years, hybridization has occurred between western coyotes (*C. latrans*) and eastern wolves (*C. lycaon*) in the area of Ontario shown by a star in the map shown below.

Genetic evidence for hybridization is based on identification of haplotypes (combinations of linked alleles in clusters of similar genes) that exist in mitochondrial DNA (mtDNA) of *Canis* populations. The populations in this study were the Minnesota-northwestern wolf, southern Ontario coyote and northeastern coyote. Assume that all animals in each *Canis* population have the same mtDNA haplotypes.



[Source: T. Wheeldon *et al.* (2010) *Biology Letters*, 6 (2), pages 246–247. Colonization history and ancestry of northeastern coyotes. By permission of the Royal Society.]

(Option D continues on the following page)



**(Option D, question 1 continued)**

- (a) Outline the genetic evidence that *Canis* populations have hybridized. [2]

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- (b) Compare the genetic data for southern Ontario coyotes and northeastern coyotes. [2]

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- (c) State with a reason whether the genetic evidence shows that the western coyote and the grey wolf have overlapping ranges. [1]

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- (d) The northeastern coyote has more wolf-like skull features than the southern Ontario coyote. Suggest a reason for this difference. [1]

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**(Option D continues on the following page)**



**(Option D, question 1 continued)**

- (e) Discuss briefly whether there is genetic evidence to show a common ancestor for the Minnesota-northwestern wolf, the southern Ontario coyote and the northeastern coyote. [2]

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- 2. (a) State the name for primitive, phospholipid-enclosed structures that may have preceded cells. [1]

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- (b) Outline the endosymbiotic theory. [2]

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**(Option D continues on the following page)**



**(Option D, question 2 continued)**

(c) (i) In a non-evolving population, state **two** frequencies that remain constant. [2]

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(ii) Define *gene pool*. [1]

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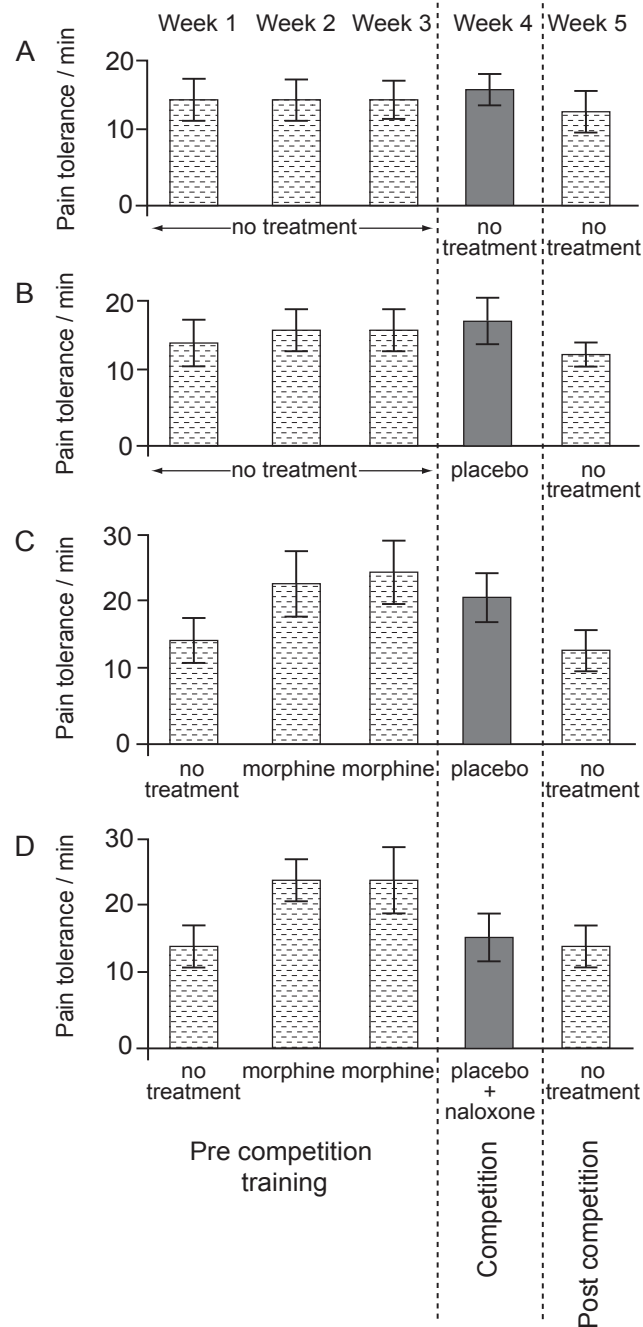
28EP07

Turn over

### Option E — Neurobiology and behaviour

4. Regions of the brain that perceive pain also contain receptors for pain-killers, such as morphine (from poppy plants) or endorphins (produced in the brain). Teams of young men competed in pain-endurance tests by repeatedly squeezing hand-springs until reaching unbearable pain.

During pre-competition training, some teams received injections of morphine. During competition, no morphine was administered. However, some teams thought they were receiving morphine injections. Instead, they were injected with a placebo (a saline solution) or the placebo plus naloxone (an endorphin blocking drug) as shown in the following data.



[Source: Figure 2 (A–D). “Opioid-Mediated Placebo Responses Boost Pain Endurance and Physical Performance: Is It Doping in Sport Competitions?” Fabrizio Benedetti, Antonella Pollo, and Luana Colloca. *The Journal of Neuroscience*, 31 October 2007, 27(44): 11934–11939; doi:10.1523/JNEUROSCI.3330-07.2007]

(Option E continues on the following page)





**(Option E, question 4 continued)**

(a) State the effect of morphine during pre-competition training for team C. [1]

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(b) Identify which team showed the greatest tolerance to pain on competition day. [1]

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(c) (i) Analyse the effect of the placebo as seen in the data. [2]

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(ii) Suggest a reason for the reduced pain tolerance in team D during competition. [1]

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(d) Analyse the data collected in the week following competition. [2]

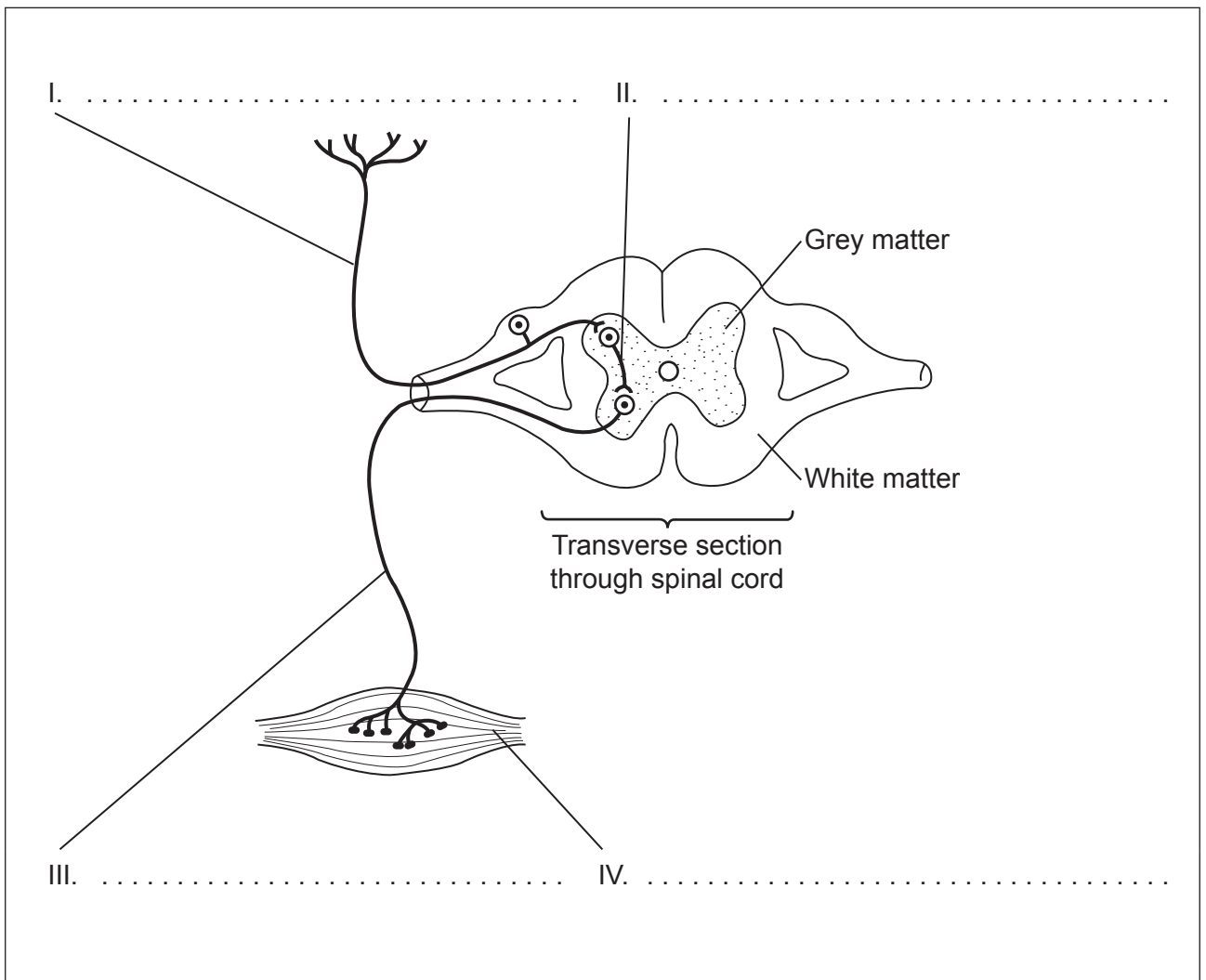
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(Option E continued)

5. (a) Label the numbered parts of the reflex arc. [2]



[Source: © International Baccalaureate Organization 2015]

(b) State the type of human sensory receptor that detects motion, gravity and stretch. [1]

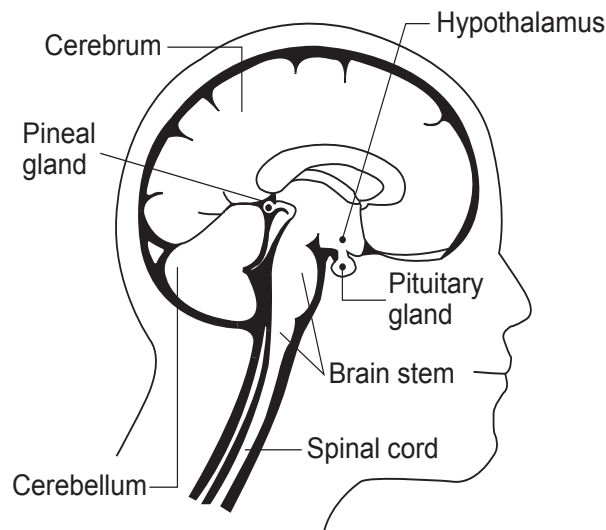
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(Option E, question 5 continued)



[Source: © International Baccalaureate Organization 2015]

- (c) (i) State the part of the brain responsible for coordination and balance, especially during athletic competition such as the Olympics. [1]

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- (ii) Outline control of heart rate by the medulla oblongata. [2]

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- (d) Male and female deer are only sexually active during fall (autumn). Outline the adaptive value of this type of behaviour pattern. [1]

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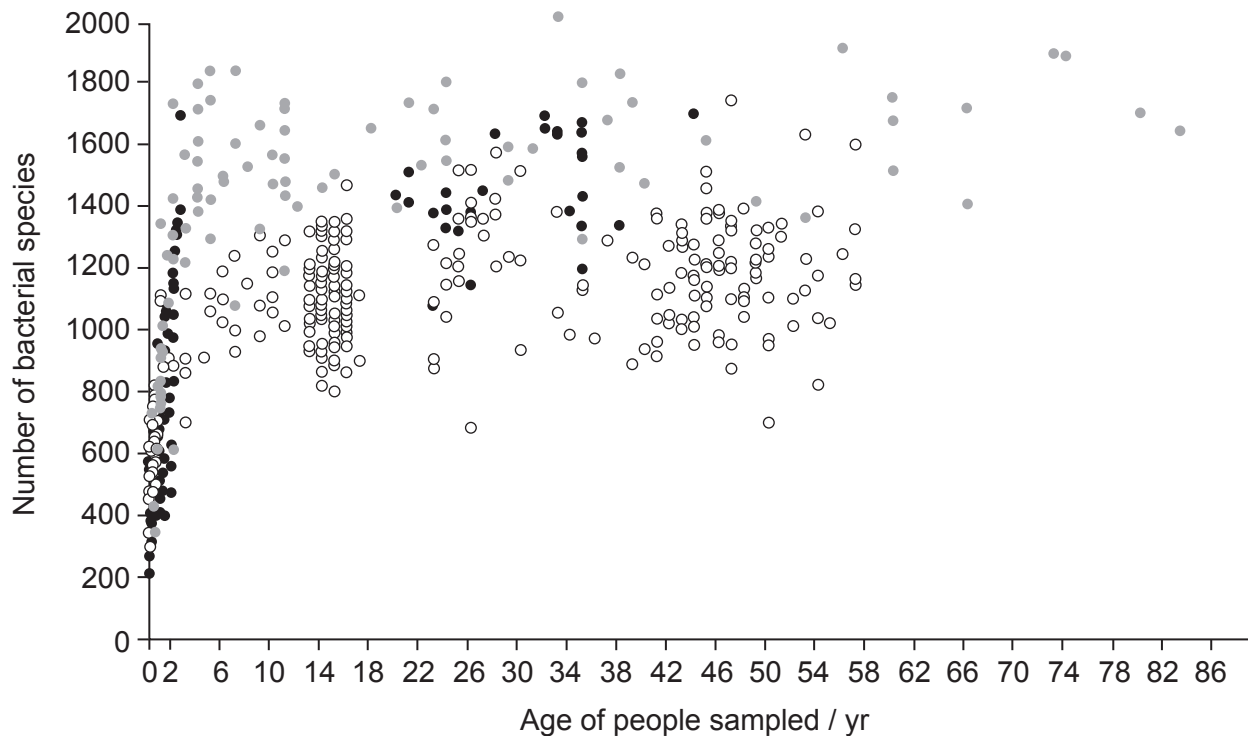


28EP13

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**Option F — Microbes and biotechnology**

7. Over a thousand bacterial species occupy the human gut. The gut bacteria show much larger genetic diversity than the host cells. Gut bacteria are vital to proper food digestion and vitamin synthesis. Fecal samples were collected from people in various locations so the genomes of their gut bacteria could be analysed. Bacteria with the same unique DNA sequences were identified as species. The graph shows the number of bacterial species in the digestive tract of people in three different parts of the world.

**Key:**

- Malawians (from rural communities in Malawi in southeast Africa)
- Amerindians (from villages in Amazon region of Venezuela)
- US (from across the United States)

[Source: Reprinted by permission from Macmillan Publishers Ltd: Yatsunenکو T., Rey, F.E., Manary, M.J., Trehan, I., Dominguez-Bello, M.G., Contreras, M., Magris, M., Hidalgo, G., Baldassano, R.N., Anokhin, A.P., Heath, A.C., Warner, B., Reeder, J., Kuczynski, J., Caporaso, J.G., Lozupone, C.A., Lauber, C., Clemente, J.C., Knights, D., Knight, R. and Gordon, J.I., "Human gut microbiome viewed across age and geography", *Nature*, 2012, May 9; **486**(7402): 222–7. © 2012. doi:10.1038/nature11053]

- (a) Identify the age and ethnic group of the individual with the highest diversity of gut bacterial species.

[1]

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(Option F continues on the following page)



28EP14

(Option F, question 7 continued)

- (b) (i) Outline the trends in the number of bacterial species in the digestive tracts of Amerindians. [1]

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- (ii) Distinguish between the trends seen in the three populations. [2]

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- (c) Suggest **two** reasons for how the different environments of the three human populations affect the number of bacterial species in their digestive tracts after the age of four. [2]

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- (d) A century ago, it was discovered that each person belonged to one of four blood types. Now some researchers are reporting that human gut ecosystems fall into three distinct types, each involving a great number of similar bacterial species.

Suggest **one** medical application based on the knowledge that humans could be typed according to their gut ecosystem. [1]

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(Option F continues on the following page)



(Option F continued)

8. (a) (i) Using the table, distinguish between Archaea and Eubacteria. [3]

	Archaea	Eubacteria
Peptidoglycan in cell wall		
Membrane lipids		
Histones associated with DNA		

(ii) List **two** roles for microbes in ecosystems. [1]

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(Option F continues on the following page)



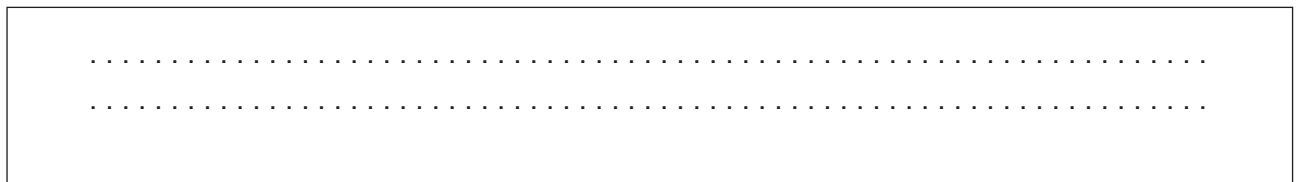


(Option F, question 8 continued)

(iii) Draw a labelled diagram of a filamentous cyanobacterium. [2]



(b) Endotoxins are lipopolysaccharides. State where endotoxins are found. [1]



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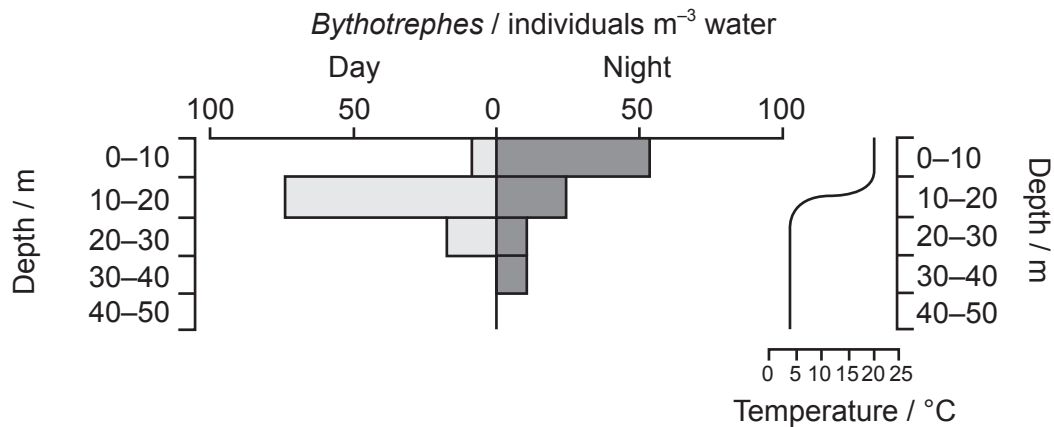


28EP19

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**Option G — Ecology and conservation**

10. During the 1980s, a tiny invasive crustacean *Bythotrephes cederstroemii* entered the eastern Great Lakes from Europe (probably via freshwater or mud in the ballast water of merchant ships) and eventually colonized Lake Michigan. *Bythotrephes* reproduces very quickly and eats common zooplankton, disrupting the food web by directly competing with small juvenile resident fish. *Bythotrephes* avoids predation by larger fish through the timing of its activities which have been investigated in offshore waters of Lake Michigan at various depths during the day and night.



[Source: Courtesy of Professor John T. Lehman, University of Michigan.]

- (a) State the depth range showing the most *Bythotrephes* during the night. [1]

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- (b) Describe the distribution of *Bythotrephes* during the day. [2]

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(Option G continues on the following page)



**(Option G, question 10 continued)**

- (c) Deduce the responses of *Bythotrephes* to temperature and light. [2]

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- (d) Explain the change in distribution of *Bythotrephes* between day and night in terms of its position in the lake food chain. [2]

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**(Option G continues on the following page)**



(Option G continued)

11. (a) Distinguish between the use of a quadrat and a transect in gathering field data. [2]

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(b) (i) State the change in species diversity and the change in production during primary succession. [1]

Species diversity: .....

Production: .....

(ii) State **one** difficulty in classifying organisms into trophic levels. [1]

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(c) (i) State **one** effect of UV radiation on living tissue. [1]

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(ii) Outline the environmental conditions that favour an r-strategist. [2]

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(Option G continues on the following page)



(Option G continued)

12. The Simpson diversity index and the biotic indices of water pollution are widely used in ecological research and environmental monitoring. Explain the use of such indices.

[6]

A large rectangular area containing horizontal dotted lines for writing the answer to question 12.

End of Option G

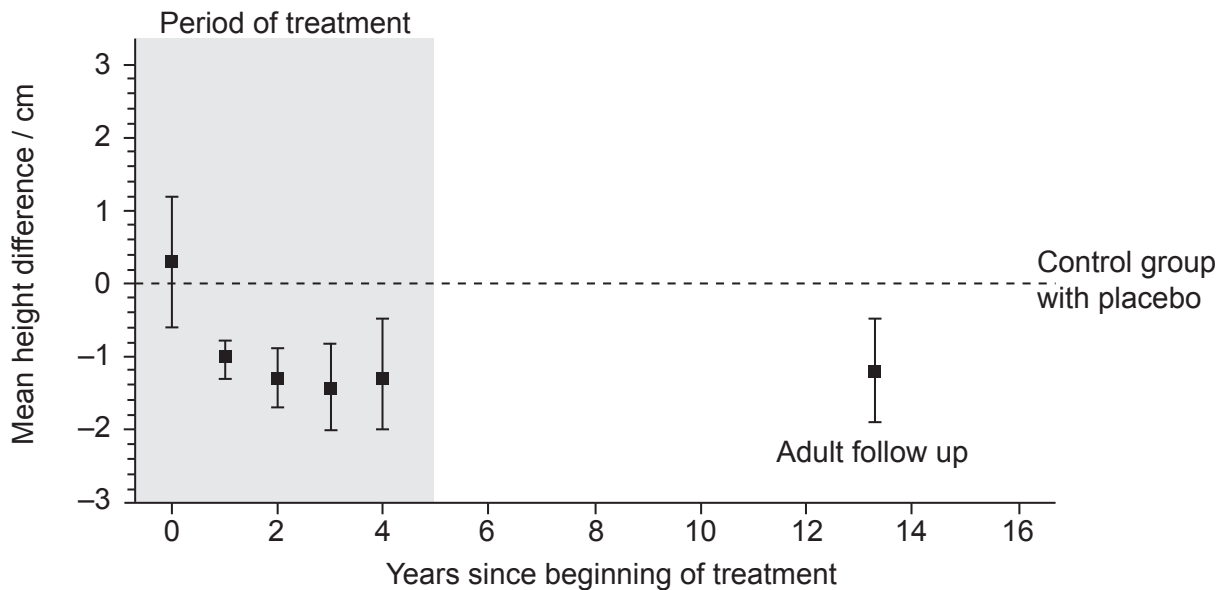


28EP23

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**Option H — Further human physiology**

13. For children suffering from persistent asthma, budesonide may be used in inhalers to suppress airway inflammation. This therapy may continue for many years, so its long-term effect on growth was studied. One thousand children were randomly assigned to receive either budesonide or a placebo, a neutral substance used as the control, and were monitored until adulthood. The graph shows the difference in height between the group who received the drug and others who received the placebo (the control group). The same treatment group was measured at the start of the treatment period, four times during the treatment period and then once again about eight years later.



[Source: H Kelly *et al.*, (2012), *New England Journal of Medicine*, **367** (10), pages 904–908]

- (a) State the mean height difference between the budesonide group and the placebo group at the start of the study. [1]

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- (b) The mean age for starting the treatment was nine years. Suggest a reason for the choice of this age. [1]

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(Option H continues on the following page)





(Option H, question 13 continued)

- (c) Describe the effect of budesonide on the mean difference in height, during the period of treatment. [2]

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- (d) Evaluate the long-term after-effect of budesonide treatment on height. [2]

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- (e) Suggest **one** significant shortcoming in the data. [1]

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- 14. (a) (i) State **one** mechanism the ileum uses to absorb digested food into the bloodstream. [1]

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- (ii) State the role of the hepatic portal vein. [1]

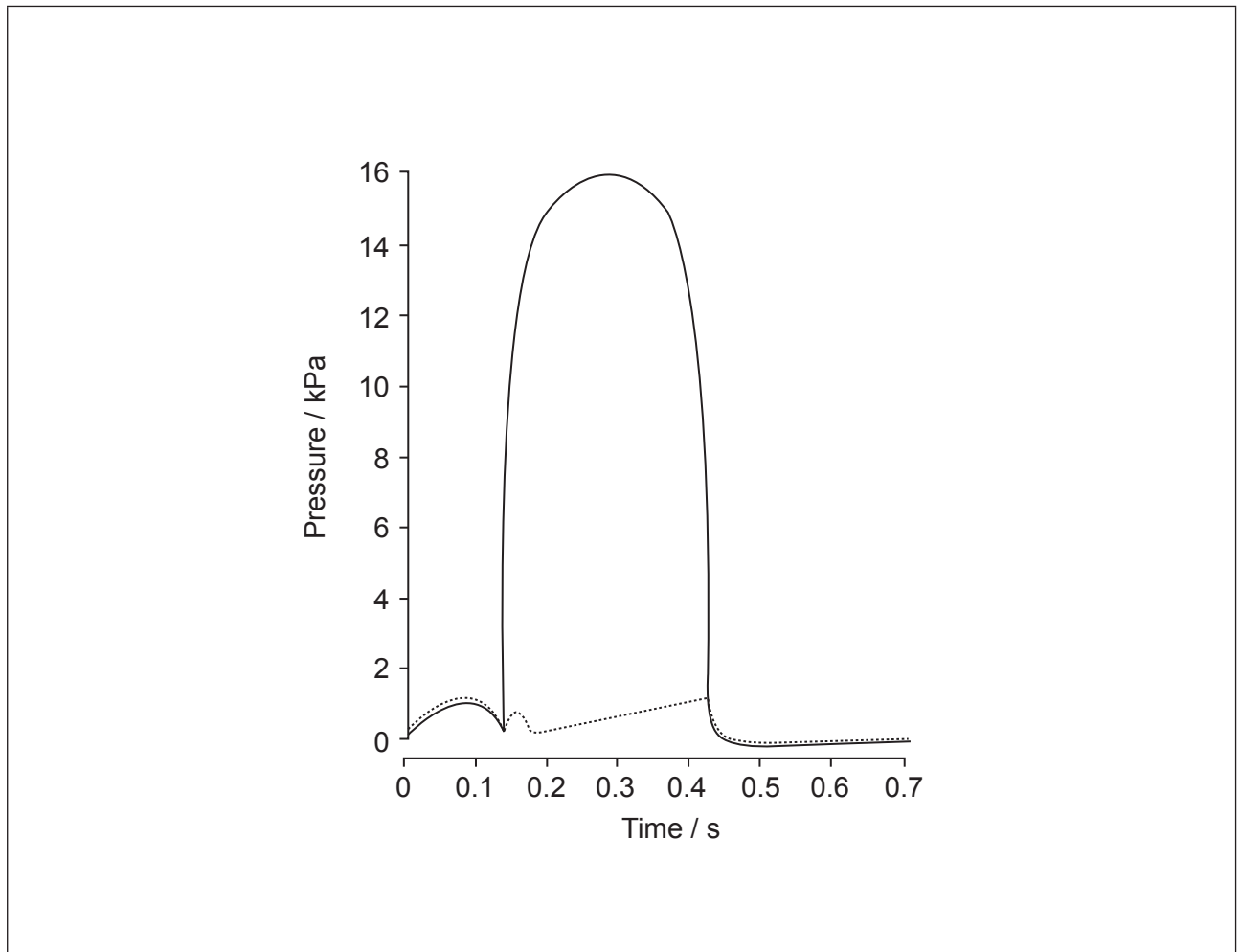
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(Option H, question 14 continued)

- (b) This diagram illustrates pressure changes in the left side of the heart during the cardiac cycle.



- (i) Label the line that represents the ventricle. [1]
- (ii) Estimate the total time the atrioventricular valves are open. [1]

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(Option H continues on the following page)



**(Option H, question 14 continued)**

(c) Although some CO<sub>2</sub> entering the blood simply dissolves in the plasma, most enters the erythrocytes (red blood cells).

(i) Outline how CO<sub>2</sub> interacts with hemoglobin once it enters erythrocytes. [1]

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(ii) Describe the formation of HCO<sub>3</sub><sup>-</sup> in erythrocytes. [2]

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**(Option H continues on the following page)**



